SECTION 210500
COMMON WORK RESULTS FOR FIRE SUPPRESSION

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. Piping materials and installation instructions common to most piping systems.
   2. Grout.
   3. Fire-suppression equipment and piping demolition.
   4. Equipment installation requirements common to equipment sections.
   5. Painting and finishing.
   6. Concrete bases.
   7. Supports and anchorages.

1.3 DEFINITIONS

A. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe chases, unheated spaces immediately below roof, and 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 chases.

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 BASIS-OF-DESIGN

A. Equipment manufacturers listed on the equipment schedules are the basis-of-design. Manufactures listed in the specification other than the basis-of design manufacture are acceptable substitutions. Equipment schedules are on the drawings. Refer to specifications for unscheduled equipment.

1.5 SUBMITTALS

A. Product Data: For the following:
   1. Mechanical sleeve seals.
   2. Escutcheons.

B. Welding certificates.

C. Grooved joint couplings and fittings shall be referred to on drawings and product submittals, and be identified by the manufacturer’s listed model or series designation.

1.6 QUALITY ASSURANCE

A. Comply with ASHRAE Guideline 4 – 2008 Preparation of operating and maintenance documentation for building systems.

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

C. 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.

D. All grooved couplings, and fittings, valves and specialties shall be the products of a single manufacturer. Grooving tools shall be of the same manufacturer as the grooved components.

1. All castings used for coupling housings, fittings, valve bodies, etc., shall be date stamped for quality assurance and traceability.

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

F. Multiple Units: When two or more units of materials or equipment of the same type or class are required, these units shall be products of one manufacturer.

G. Nameplates: Nameplate bearing manufacturer's name or identifiable trademark shall be securely affixed in a conspicuous place on equipment, or name or trademark cast integrally with equipment, stamped or otherwise permanently marked on each item of equipment.

H. Comply with requirements of Owner's insurance underwriter for submittals, approvals, materials, installation, inspections, and testing.

1.7 GUIDELINES, CODES AND STANDARDS

A. Refer to the most recently published edition for references to guidelines, and standards (examples: ASHRAE, NFPA, AWWA, ASTM) unless a specific edition is listed.

B. Installation and materials shall comply with applicable national, state, and local codes and ordinances.

1.8 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.

1.9 COORDINATION

A. Arrange for pipe spaces, chases, slots, and openings in building structure during progress of construction, to allow for fire-suppression installations.

B. Coordinate installation of required supporting devices and set sleeves in poured-in-place concrete and other structural components as they are constructed.

C. Coordinate requirements for access panels and doors for fire-suppression items requiring access that are concealed behind finished surfaces. Access panels and doors are specified in Division 08 Section "Access Doors and Frames."

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 21 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.

C. Standard Mechanical Couplings: Manufactured in two segments of cast ductile iron, conforming to ASTM A-536, Grade 65-45-12. Gaskets shall be pressure-responsive synthetic rubber, grade to suit the intended service, conforming to ASTM D-2000. Mechanical Coupling bolts shall be zinc plated (ASTM B-633) heat treated carbon steel track head conforming to ASTM A-449 and ASTM A-183. Couplings shall comply with ASTM F1476 – Standard Specification for Performance of Gasketed Mechanical Couplings for Use in Piping Applications.
   1. Rigid Type: Coupling housings with offsetting, angle-pattern bolt pads shall be used to provide system rigidity and support and hanging in accordance with NFPA-13. Couplings shall be fully installed at visual pad-to-pad offset contact. Couplings that require exact gapping of bolt pads at specific torque ratings are not permitted. Installation-ready, for direct stab installation without field disassembly.
   2. Flexible Type: Use in locations where vibration attenuation and stress relief are required.

2.3 JOINING MATERIALS

A. Refer to individual Division 21 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. Grooved Joint Lubricants: Lubricate gaskets in accordance with the manufacturer’s published installation instructions, using lubricant compatible with the gasket elastomer and fluid media.

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.

2.4 CONCRETE BASES

A. Refer to Division 03 Section "Cast-in-Place Concrete” or Miscellaneous Cast-in-Place Concrete."

2.5 GROUT

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

PART 3 EXECUTION

3.1 PREPARATION

A. Obtain current fire-hydrant flow test results from the local authority having jurisdiction. Use results for system design calculations required in "Quality Assurance" Article.

3.2 FIRE-SUPPRESSION DEMOLITION

A. Refer to Division 01 Section "Cutting and Patching" and Division 02 Section "Selective Structure Demolition" for general demolition requirements and procedures. Coordinate demolition with other disciplines, including architecture, electrical, structural and controls.

B. Where system shutdowns are required, schedule demolition work with building management.

C. Disconnect, demolish, and remove fire-suppression 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: Abandoned piping is to be removed in its entirety. Do not abandon piping in place.
   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.

D. 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.

E. Where work is required on an active system engage the alarm company or management company to ensure that the section being worked on is disabled or bypassed.

3.3 PIPING SYSTEMS - COMMON REQUIREMENTS

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

B. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on 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. Verify final equipment locations for roughing-in.

M. 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 21 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. Grooved Joints: Grooved joints shall be installed in accordance with the manufacturer’s latest published installation instructions. Grooved ends shall be clean and free from indentations, projections, and roll marks. Gaskets shall be molded and produced by the coupling manufacturer, and shall be verified as suitable for the intended service. A factory-trained field representative (direct employee) of the mechanical joint manufacture shall provide on-site training for contractor's field personnel in the proper use of grooving tools and installation of grooved piping products. The factory-trained representative shall periodically review the product installation and ensure best practices are being followed. Contractor shall remove and replace any improperly installed products. A distributor’s representative is not considered qualified to conduct the training.

G. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:

   1. Apply appropriate tape or thread compound to external pipe threads 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.

H. Welded Joints: Construct joints according to AWS D10.12, using qualified processes and welding operators according to Part 1 "Quality Assurance" Article.

   1. Shop weld pipe joints where welded piping is indicated. Do not use welded joints for galvanized-steel pipe.

I. 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 PAINTING

A. Painting of fire-suppression systems, equipment, and components is specified in Division 09 Sections "Interior Painting" and "Exterior Painting."

B. Damage and Touchup: Repair marred and damaged factory-painted finishes with materials and procedures to match original factory finish.

3.6 CONCRETE BASES

A. Concrete Bases and Curbs: Cast-in-place concrete bases and curbs are specified in Division 03 Section "Cast-in-Place Concrete” or Miscellaneous Cast-in-Place Concrete."

   1. Provide scaled layouts of bases and curbs with sizes and locations dimensioned to concrete walls and columns.
   2. Determine base and curb sizes and locations based on “Accepted” equipment shop drawings. Base and curb sizes shall not be scaled from the Drawings.
   3. Anchor equipment to concrete base according to equipment manufacturer's written instructions and according to seismic requirements at Project.

B. Construction Details: Refer to Architectural Details for base and curb construction types. If not indicated, construct as follows:

   1. Provide concrete bases sized 4 inches larger in both directions than the supported equipment.
   2. Provide 4-inch high curbs and bases with finished edges, unless otherwise indicated.

3. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of the base.
4. Install epoxy-coated anchor bolts for supported equipment that extend through concrete base, and anchor into structural concrete floor.
5. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
6. Install anchor bolts to elevations required for proper attachment to supported equipment.
7. Install anchor bolts according to anchor-bolt manufacturer's written instructions.
8. Use 3000-psi, 28-day compressive-strength concrete and reinforcement as specified in Division 03 Section "Cast-in-Place Concrete" or Miscellaneous Cast-in-Place Concrete."

3.7 ERECTION OF METAL SUPPORTS AND ANCHORAGES

A. Refer to Division 05 Section "Metal Fabrications" for structural steel.

B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor fire-suppression materials and equipment.

C. Field Welding: Comply with AWS D1.1.

3.8 GROUTING

A. Mix and install grout for fire-suppression equipment base bearing surfaces, pump and other equipment base plates, and anchors.

B. Clean surfaces that will come into contact with grout.

C. Provide forms as required for placement of grout.

D. Avoid air entrapment during placement of grout.

E. Place grout, completely filling equipment bases.

F. Place grout on concrete bases and provide smooth bearing surface for equipment.

G. Place grout around anchors.

H. Cure placed grout.

3.9 SEALANTS

A. Comply with Joint-sealant materials and applications specified in Section 078400 “Firestopping,” Section 078443 “Fire-resistant Joint Sealants,” Section 079000 “Joint Protection,” and Section 092900 “Gypsum Board: Acoustical sealants.”

END OF SECTION

SECTION 210517
SLEEVES AND SLEEVE SEALS FOR FIRE-SUPPRESSION PIPING

PART 1 GENERAL

1.1 SUMMARY

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

1.2 ACTION SUBMITTALS

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

PART 2 PRODUCTS

2.1 SLEEVES

A. Cast-Iron Wall Pipes: Cast or fabricated of cast or ductile iron and equivalent to ductile-iron pressure pipe, with plain ends and integral water stop unless otherwise indicated.

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

C. Galvanized-Steel-Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, zinc coated, with plain ends.

D. Galvanized-Steel-Sheet Sleeves: 0.0239-inch minimum thickness; round tube closed with welded longitudinal joint.

2.2 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 interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
   2. Pressure Plates: Stainless steel.
   3. Connecting Bolts and Nuts: Stainless steel of length required to secure pressure plates to sealing elements.

2.3 SLEEVE-SEAL FITTINGS

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

B. Description: Manufactured plastic, sleeve-type, water stop assembly made for imbedding in concrete slab or wall. Unit has plastic or rubber water stop collar with center opening to match piping OD.

2.4 GROUT

A. Standard: ASTM C 1107/C 1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.

B. Characteristics: Non-shrink; 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 in walls.

C. Install sleeves in concrete floors, concrete roof slabs, and concrete walls as new slabs and walls are constructed.

   1. Cut sleeves to length for mounting flush with both surfaces.
      a. Exception: Extend sleeves installed in floors of mechanical equipment areas, pipe chases, or other wet areas 2 inches above finished floor level.
   2. Using grout, seal the space outside of sleeves in slabs and walls without sleeve-seal system.

D. Install sleeves for pipes passing through interior partitions.

   1. Cut sleeves to length for mounting flush with both surfaces.
   2. Install sleeves that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation.
   3. Seal annular space between sleeve and piping or piping insulation; use joint sealants appropriate for size, depth, and location of joint. Comply with requirements for sealants specified in Section 079200 "Joint Sealants."

E. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with fire stop materials. Comply with requirements for fire stopping specified in Section 078413 "Penetration Firestopping."

3.2 SLEEVE-SEAL-SYSTEM INSTALLATION

A. Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at service piping entries into building.

B. Select type, size, and number of sealing elements required for piping material and size and for sleeve ID or hole size. Position piping in center of sleeve. Center piping in penetration, assemble sleeve-seal system components, and install in annular space between piping and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make a watertight seal.

3.3 SLEEVE-SEAL-FITTING INSTALLATION

A. Install sleeve-seal fittings in new walls and slabs as they are constructed.

B. Assemble fitting components of length to be flush with both surfaces of concrete slabs and walls. Position water stop flange to be centered in concrete slab or wall.

C. Secure nailing flanges to concrete forms.

D. Using grout, seal the space around outside of sleeve-seal fittings.

3.4 SLEEVE AND SLEEVE-SEAL SCHEDULE

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

END OF SECTION

SECTION 210518 ESCUTCHEONS FOR FIRE-SUPPRESSION PIPING

PART 1 GENERAL

1.1 SUMMARY

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

1.2 ACTION SUBMITTALS

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

PART 2 PRODUCTS

2.1 ESCUTCHEONS

A. One-Piece, Cast-Brass Type: With polished, chrome-plated and rough-brass finish and setscrew fastener One-Piece, Deep-Pattern Type: Deep-drawn, box-shaped brass with chrome-plated finish and spring-clip fasteners.

B. One-Piece, Stamped-Steel Type: With chrome-plated finish and spring-clip fasteners.

C. Split-Casting Brass Type: With polished, chrome-plated and rough-brass finish and with concealed hinge and setscrew.

D. Split-Casting Brass Type: With polished, chrome-plated and rough-brass finish and with concealed hinge and setscrew.

E. Split-Plate, Stamped-Steel Type: With chrome-plated finish, concealed and exposed-rivet hinge, and spring-clip fasteners.

2.2 FLOOR PLATES

A. One-Piece Floor Plates: Cast-iron flange with holes for fasteners.

B. Split-Casting Floor Plates: Cast brass with concealed hinge.

PART 3 EXECUTION

3.1 INSTALLATION

A. Install escutcheons for exposed piping penetrations of walls, ceilings, and finished floors.

B. Install escutcheons with ID to closely fit around pipe, tube, and insulation of piping and with OD that completely covers opening. Escutcheons are to fit tightly to the surface with minimal gap and are to be sealed with the appropriate caulk.
   1. Escutcheons for New Piping:
      a. Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep-pattern type.
      b. Chrome-Plated Piping: One-piece, cast-brass or split-casting brass type with polished, chrome-plated finish.
      c. Insulated Piping: One-piece, stamped-steel type or split-plate, stamped-steel type with concealed hinge.
      d. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, cast-brass or split-casting brass type with polished, chrome-plated finish.
      e. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece, cast-brass or split-casting brass type with polished, chrome-plated finish.
      f. Bare Piping in Unfinished Service Spaces: One-piece, cast-brass or split-casting brass type with polished, chrome-plated rough-brass finish.

g. Bare Piping in Equipment Rooms: One-piece, cast-brass or split-casting brass type with polished, chrome-plated rough-brass finish.

C. Install floor plates for piping penetrations of equipment-room floors.

D. Install floor plates with ID to closely fit around pipe, tube, and insulation of piping and with OD that completely covers opening.

1. New Piping: One-piece, floor-plate type.

3.2 FIELD QUALITY CONTROL

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

END OF SECTION

SECTION 210529
HANGERS AND SUPPORTS FOR FIRE SUPPRESSION 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 hangers and supports for fire suppression systems piping and equipment:
   1. Steel pipe hangers and supports.
   2. Trapeze pipe hangers.
   3. Metal framing systems.
   4. Fastener systems.
   5. Pipe stands.
   6. Pipe positioning systems.
   7. Equipment supports.

B. Related Sections include the following:
   1. Division 05 Section "Metal Fabrications" for structural-steel shapes and plates for trapeze hangers for pipe and equipment support.

1.3 DEFINITIONS

A. MSS: Manufacturers Standardization Society for the Valve and Fittings Industry Incorporated

B. Terminology: As defined in MSS SP-90, "Guidelines on Terminology for Pipe Hangers and Supports."

1.4 PERFORMANCE REQUIREMENTS

A. Design supports for multiple pipes, including pipe stands, capable of supporting combined weight of supported systems, system contents, and test water.

B. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.

1.5 SUBMITTALS

A. Product Data: For the following:
   1. Steel pipe hangers and supports.
   2. Powder-actuated fastener systems.
   3. Pipe positioning systems.

B. Shop Drawings: Show fabrication and installation details and include calculations for the following:
   1. Trapeze pipe hangers. Include Product Data for components.
   2. Metal framing systems. Include Product Data for components.
   3. Pipe stands. Include Product Data for components.
   4. Equipment supports.

C. Welding certificates.

1.6 QUALITY ASSURANCE

A. Welding: Qualify procedures and personnel according to [AWS D1.1, "Structural Welding Code--Steel."] [AWS D1.4, "Structural Welding Code--Reinforcing Steel."] [ASME Boiler and Pressure Vessel Code: Section IX.]

B. Welding: Qualify procedures and personnel according to the following:

1. AWS D1.1, "Structural Welding Code--Steel."
2. AWS D1.2, "Structural Welding Code--Aluminum."
3. AWS D1.4, "Structural Welding Code--Reinforcing Steel."
4. ASME Boiler and Pressure Vessel Code: Section IX.

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:

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

2.2 STEEL PIPE HANGERS AND SUPPORTS

A. Description: MSS SP-58, Types 1 through 58, factory-fabricated components. Refer to Part 3 "Hanger and Support Applications" Article for where to use specific hanger and support types.

B. Manufacturers:

1. AAA Technology & Specialties Company, Incorporated (www.aaatech.com)
2. Anvil International (www.anvilintl.com)
3. Bergen-Power Pipe Supports (www.pipesupports.com)
4. B-Line Systems, Incorporated; a division of Cooper Industries (www.cooperindustries.com)
5. Carpenter & Paterson, Incorporated; a division of Cooper Industries (www.carpenterandpaterson.com)
6. Empire Industries, Incorporated (www.empireindustries.com)
7. ERICO/Michigan Hanger Company (www.erico.com)
8. Globe Pipe Hanger Products, Incorporated (www.globepipehanger.com)
9. National Pipe Hanger Corporation (www.nationalpipehanger.com)
10. PHD Manufacturing, Incorporated (www.phd-mfg.com)
11. PHS Industries, Incorporated
12. Piping Technology & Products, Incorporated (www.pipingtech.com)
13. Tolco Incorporated; a division of Cooper Industries (www.cooperindustries.com)

C. Galvanized, Metallic Coatings: Pre-galvanized or hot dipped.

D. Nonmetallic Coatings: Plastic coating, jacket, or liner.

2.3 TRAPEZE PIPE HANGERS

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

2.4 METAL FRAMING SYSTEMS

A. Description: MFMA-4, shop- or field-fabricated pipe-support assembly made of steel channels and other components.

B. Manufacturers:

1. B-Line Systems, Incorporated; a division of Cooper Industries (www.cooperindustries.com)
2. ERICO/Michigan Hanger Company (www.erico.com)
3. Power-Strut Division; Tyco International, Ltd. (www.powerstrut.com)
4. Thomas & Betts Corporation (www.tnb.com)
5. Tolco Incorporated; a division of Cooper Industries (www.cooperindustries.com)
6. Unistrut Corporation; a part of Atkore International (www.unistrut.us)

C. Coatings: Manufacturer's standard finish unless bare metal surfaces are indicated.

D. Nonmetallic Coatings: Plastic coating, jacket, or liner.

2.5 FASTENER SYSTEMS

A. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened Portland cement concrete with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

1. Manufacturers:
   a. Hilti, Incorporated (www.us.hilti.com)
   b. ITW Ramset/Red Head (www.ramset.com)
   c. MKT Fastening, LLC (www.mktfastening.com)
   d. Powers Fasteners (www.powers.com)

B. Mechanical-Expansion Anchors: Insert-wedge-type stainless steel, for use in hardened Portland cement concrete with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

1. Manufacturers:
   a. B-Line Systems, Incorporated; a division of Cooper Industries (www.cooperindustries.com)
   b. Empire Industries, Incorporated (www.empireindustries.com)
   c. Hilti, Incorporated (www.us.hilti.com)
   d. ITW Ramset/Red Head (www.ramset.com)
   e. MKT Fastening, LLC (www.mktfastening.com)
   f. Powers Fasteners (www.powers.com)

2.6 MISCELLANEOUS MATERIALS

A. Structural Steel: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.

B. Grout: ASTM C 1107, factory-mixed and -packaged, dry, hydraulic-cement, non-shrink and non-metallic grout; suitable for interior and exterior applications.

1. Properties: Non-staining, noncorrosive, and nongaseous.
2. Design Mix: 5000-psi, 28-day compressive strength.

PART 3 EXECUTION

3.1 HANGER AND SUPPORT APPLICATIONS

A. Attachments to metal roof decks will not be permitted.

B. Comply with MSS SP-69 for pipe hanger selections and applications that are not specified in piping system Sections.

C. Use hangers and supports with galvanized, metallic coatings for piping and equipment that will not have field-applied finish.

D. Horizontal-Piping Hangers and Supports: Unless otherwise indicated; install the following types:

1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of non-insulated stationary pipes, NPS 1/2 to NPS 30.
2. Adjustable, Steel Band Hangers (MSS Type 7): For suspension of non-insulated stationary pipes, NPS 1/2 to NPS 8.
3. Extension Hinged or 2-Bolt Split Pipe Clamps (MSS Type 12): For suspension of non-insulated stationary pipes, NPS 3/8 to NPS 3.
4. U-Bolts (MSS Type 24): For support of heavy pipes, NPS 1/2 to NPS 30.
5. 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.

E. Vertical-Piping Clamps: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers, NPS 3/4 to NPS 20.
2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers, NPS 3/4 to NPS 20, if longer ends are required for riser clamps.

F. Hanger-Rod Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Steel Turnbuckles (MSS Type 13): For adjustment up to 6 inches for heavy loads.

2. Steel Clevises (MSS Type 14): For 120 to 450 deg F piping installations.
3. Swivel Turnbuckles (MSS Type 15): For use with MSS Type 11, split pipe rings.
4. Malleable-Iron Sockets (MSS Type 16): For attaching hanger rods to various types of building attachments.
5. Steel Weldless Eye Nuts (MSS Type 17): For 120 to 450 deg F piping installations.

G. Building Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Steel or Malleable Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.
2. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joist construction to attach to top flange of structural shape.
3. 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.
4. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.

H. Comply with MSS SP-69 for trapeze pipe hanger selections and applications that are not specified in piping system Sections.

I. Comply with MFMA-102 for metal framing system selections and applications that are not specified in piping system Sections.

J. Use powder-actuated fasteners or mechanical-expansion anchors instead of building attachments where required in concrete construction.

3.2 HANGER AND SUPPORT INSTALLATION

A. Steel Pipe Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Install hangers, supports, clamps, and attachments as required to properly support piping from building structure.

B. Trapeze Pipe Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Arrange for grouping of parallel runs of horizontal piping, and support together on field-fabricated trapeze pipe hangers.

1. Pipes of Various Sizes: Support together and space trapezes for smallest pipe size or install intermediate supports for smaller diameter pipes as specified above for individual pipe hangers.
2. Field fabricate from ASTM A 36/A 36M, carbon-steel shapes selected for loads being supported. Weld steel according to AWS D1.1/D1.1M.

C. Metal Framing System Installation: Arrange for grouping of parallel runs of piping, and support together on field-assembled metal framing systems.

D. Fastener System Installation:

1. Install powder-actuated fasteners for use in lightweight concrete or concrete slabs greater than 4 inches thick in concrete after concrete is placed and completely cured. Use operators that are licensed by powder-actuated tool manufacturer. Install fasteners according to powder-actuated tool manufacturer's operating manual.
2. Install mechanical fasteners for use in lightweight concrete or concrete slabs less than 4 inches thick in concrete after concrete is placed and completely cured.
3. Install mechanical-expansion anchors in concrete after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.

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

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

G. Install lateral bracing with pipe hangers and supports to prevent swaying.

H. Install building attachments within concrete slabs or attach to structural steel. Install additional attachments at concentrated loads, including valves, flanges, and strainers, NPS 2-1/2 and larger and at changes in direction of piping. Install concrete inserts before concrete is placed; fasten inserts to forms and install reinforcing bars through openings at top of inserts.

I. Load Distribution: Install hangers and supports so piping live and dead loads and stresses from movement will not be transmitted to connected equipment.

J. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and to not exceed maximum pipe deflections allowed by ASME B31.9 for building services piping.

3.3 EQUIPMENT SUPPORTS

A. Fabricate structural-steel stands to suspend equipment from structure overhead or to support equipment above floor.

B. Grouting: Place grout under supports for equipment and make smooth bearing surface.

C. Provide lateral bracing, to prevent swaying, for equipment supports.

3.4 METAL FABRICATIONS

A. Cut, drill, and fit miscellaneous metal fabrications for trapeze pipe hangers and equipment supports.

B. Fit exposed connections together to form hairline joints. Field weld connections that cannot be shop welded because of shipping size limitations.

C. Field Welding: Comply with AWS D1.1/D1.1M procedures for shielded, metal arc welding, appearance and quality of welds, and methods used in correcting welding work, and with the following:

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

3.5 ADJUSTING

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

B. Trim excess length of continuous-thread hanger and support rods to 1-1/2 inches.

3.6 PAINTING

A. Touch Up: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.

1. Apply paint by brush or spray to provide minimum dry film thickness of 2.0 mils.

B. Touch Up: Cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal are specified in Division 09 painting Sections.

C. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

3.7 CLEANING

A. Clean exposed hangers and supports located finished spaces.

END OF SECTION

SECTION 210553
IDENTIFICATION FOR FIRE SUPPRESSION PIPING AND EQUIPMENT

PART 1 GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
   1. Stencils.
   2. Valve tags.
   3. Warning tags.

1.3 SUBMITTALS

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

B. Samples: For color, letter style, and graphic representation required for each identification material and device.

C. Equipment Label Schedule: Include a listing of all equipment to be labeled with the proposed content for each label.

D. Valve numbering scheme.

E. Valve Schedules: For each piping system to include in maintenance manuals.

PART 2 PRODUCTS

2.1 STENCILS

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

2.2 VALVE TAGS

A. Valve Tags: Stamped or engraved with 1/4-inch letters for piping system abbreviation and 1/2-inch numbers.
   1. Tag Material: Brass, 0.032-inch minimum thickness, and having predrilled or stamped holes for attachment hardware.
   2. Fasteners: Brass wire-link or beaded chain; or S-hook.

B. Valve Schedules: For each piping system, on 8-1/2-by-11-inch bond paper. Tabulate valve number, piping system, system abbreviation (as shown on valve tag), location of valve (room or space), normal-operating position (open, closed, or modulating), and variations for identification. Mark valves for emergency shutoff and similar special uses.
   1. Valve-tag schedule shall be included in operation and maintenance data.

2.3 WARNING TAGS

A. Warning Tags: Preprinted or partially preprinted, accident-prevention tags, of plasticized card stock with matte finish suitable for writing.
   1. Size: Approximately 4 by 7 inches.

2. Fasteners: Brass grommet and wire.
3. Nomenclature: Large-size primary caption such as "DANGER," "CAUTION," or "DO NOT OPERATE."
4. Color: Red background with white lettering.

PART 3 EXECUTION

3.1 PREPARATION

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

3.2 EQUIPMENT LABEL INSTALLATION

A. Install or permanently fasten labels on each major item of fire suppression equipment.

B. Locate equipment labels where accessible and visible.

3.3 PIPE LABEL INSTALLATION

A. Stenciled Pipe Label Option: Install stenciled pipe, complying with ASME A13.1, on each piping system.
   1. Identification Paint: Red.
   2. Stencil Paint: white.

B. Locate pipe labels where piping is exposed or above accessible ceilings in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior exposed locations as follows:
   1. Near each valve and control device.
   2. Near each branch connection.
   3. Near penetrations through walls, floors, ceilings, and inaccessible enclosures.
   4. At access doors, manholes, and similar access points that permit view of concealed piping.
   5. Near major equipment items and other points of origination and termination.
   6. Spaced at maximum intervals of 50 feet along each run. Reduce intervals to 25 feet in areas of congested piping and equipment.
   7. On piping above removable acoustical ceilings. Omit intermediately spaced labels.

C. Pipe Label Color Schedule:
   1. Fire Suppression Piping:
      a. Background Color: Red.
      b. Letter Color: White.

3.4 VALVE-TAG INSTALLATION

A. Install tags on valves and control devices in piping systems. List tagged valves in a valve schedule.

B. Valve-Tag Application Schedule: Tag valves according to size, shape, and color scheme and with captions similar to those indicated in the following subparagraphs:
   1. Valve-Tag Size and Shape:
      a. Cold Water: 1-1/2 inches round.
      b. Hot Water: 1-1/2 inches round.
      c. Low-Pressure Compressed Air: 1-1/2 inches round.
      d. High-Pressure Compressed Air: 1-1/2 inches round.
   2. Valve-Tag Color: Red
   3. Letter Color: White.

3.5 WARNING-TAG INSTALLATION

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

END OF SECTION

SECTION 211313
WET-PIPE SPRINKLER SYSTEMS

PART 1 GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
  1. Pipes, fittings, and specialties.
  2. Specialty valves.
  3. Sprinklers.
  4. Pressure gages.

B. Protection Limits:
  1. Provide 100 percent coverage for spaces within the limits of construction.

1.3 DEFINITIONS

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

1.4 SYSTEM DESCRIPTIONS

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

1.5 ACTION SUBMITTALS

A. Product Data: For each type of product.
  1. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

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

1.6 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Sprinkler systems, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
  1. Domestic water piping.
  2. Compressed air piping.
  3. HVAC hydronic piping.
  4. Items penetrating finished ceiling include the following:
     a. Lighting fixtures.
     b. Air outlets and inlets.

B. Qualification Data: For qualified Installer and professional engineer.

C. Approved Sprinkler Piping Drawings: Working plans, prepared according to NFPA 13, that have been approved by authorities having jurisdiction, including hydraulic calculations if applicable.
  1. Sprinklers shall be referred to on drawings, submittals, and other documentation, by the sprinkler identification or model number as specifically published in the appropriate agency listing or approval. Trade names or other abbreviated designations shall not be allowed.

D. Welding certificates.

E. Grooved joint couplings and fittings shall be referred to on drawings and product submittals and shall be identified by the manufacturer's style or series designation. Trade names and abbreviations are not acceptable.

F. Fire-hydrant flow test report.

G. Field Test Reports and Certificates: Indicate and interpret test results for compliance with performance requirements and as described in NFPA 13. Include "Contractor's Material and Test Certificate for Aboveground Piping."

H. Field quality-control reports.

1.7 CLOSEOUT SUBMITTALS

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

1.8 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Sprinkler Cabinets: Finished, wall-mounted, steel cabinet with hinged cover, and with space for minimum of six spare sprinklers plus sprinkler wrench. Include number of sprinklers required by NFPA 13 and sprinkler wrench. Include separate cabinet with sprinklers and wrench for each type of sprinkler used on Project.

1.9 QUALITY ASSURANCE

A. Installer Qualifications:

1. Installer's responsibilities include designing, fabricating, and installing sprinkler systems and providing professional engineering services needed to assume engineering responsibility. Base calculations on results of fire-hydrant flow test.
    a. Engineering Responsibility: Preparation of working plans, calculations, and field test reports by a qualified professional engineer.

B. Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code.

C. All grooved joint couplings, fittings, valves, and specialties shall be of a single manufacturer. Grooving tools shall be of the same manufacturer as the grooved components.

1. All castings used for fittings, couplings, valve bodies, etc., shall include a cast date stamp for quality assurance and traceability.

D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

E. NFPA Standards: Sprinkler system equipment, specialties, accessories, installation, and testing shall comply with the following:

1. NFPA 13, "Installation of Sprinkler Systems."

1.10 PROJECT CONDITIONS

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

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

PART 2 PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Sprinkler system equipment, specialties, accessories, installation, and testing shall comply with the following:
   1. NFPA 13.

B. Standard-Pressure Piping System Component: Listed for 175-psig minimum working pressure.

C. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design wet-pipe sprinkler systems.
   1. Static and residual water pressure and water flow data shall be obtained from the local authority having jurisdiction.
   2. Minimum Pipe Sizes: Pipes shall not be smaller than sizes indicated on the drawings for connection to water supply piping, standpipes, and branches from standpipes to sprinklers.
   3. Maxinum Water Velocity: Design water velocities shall not exceed 20 (FPS) feet per second in any fire protection piping.
   4. Sprinkler system design shall be approved by authorities having jurisdiction.
      a. Margin of Safety for Available Water Flow and Pressure: 20 percent (to be confirmed by the authority having jurisdiction), including losses through water-service piping, valves, and backflow preventers.
      b. Sprinkler Occupancy Hazard Classifications (to be confirmed by the authority having jurisdiction):
         1) Automobile Parking Areas: Ordinary Hazard, Group 1.
         2) Building Service Areas: Ordinary Hazard, Group 1.
         3) Electrical Equipment Rooms: Ordinary Hazard, Group 1.
         4) General Storage Areas: Ordinary Hazard, Group 1.
         5) Laundries: Ordinary Hazard, Group 1
         6) Libraries except Stack Areas: Light Hazard.
         7) Library Stack Areas: Ordinary Hazard, Group 2.
         8) Mechanical Equipment Rooms: Ordinary Hazard, Group 1.
         9) Office and Public Areas: Light Hazard.
         10) Restaurant Service Areas: Ordinary Hazard, Group 1.
   5. Minimum Density for Automatic-Sprinkler Piping Design:
      a. Light-Hazard Occupancy: 0.10 gpm over 1500-sq. ft. area.
      b. Ordinary-Hazard, Group 1 Occupancy: 0.15 gpm over 1500-sq. ft. area.
      c. Ordinary-Hazard, Group 2 Occupancy: 0.20 gpm over 1500-sq. ft. area.
      d. Extra-Hazard, Group 1 Occupancy: 0.30 gpm over 2500-sq. ft. area.
      e. Extra-Hazard, Group 2 Occupancy: 0.40 gpm over 2500-sq. ft. area.
      f. Special Occupancy Hazard: As determined by authorities having jurisdiction.
   6. Maximum Protection Area per Sprinkler: According to UL listing.
   7. Maximum Protection Area per Sprinkler: Revised the following to suit requirements of authorities having jurisdiction for specific project requirements.
      a. Office Spaces: 120 sq. ft.
      b. Storage Areas: 130 sq. ft.
      c. Mechanical Equipment Rooms: 130 sq. ft.
      d. Electrical Equipment Rooms: 130 sq. ft.
      e. Other Areas: According to NFPA 13 recommendations unless otherwise indicated.

2.2 PIPING MATERIALS

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

2.3 STEEL PIPE AND FITTINGS

A. Standard Weight, Galvanized and Black Steel Pipe: ASTM A 53/A 53M, Type E, Grade B. Pipe ends may be factory or field formed to match joining method.

B. Schedule 30, Galvanized- and Black-Steel Pipe: ASTM A 135/A 135M; ASTM A 795/A 795M, Type E; or ASME B36.10M wrought steel, with wall thickness not less than Schedule 30 and not more than Schedule 40. Pipe ends may be factory or field formed to match joining method.

A. Schedule 10, Black-Steel Pipe: ASTM A 135/A 135M or ASTM A 795/A 795M, Schedule 10 in NPS 5 and smaller; and NFPA 13-specified wall thickness in NPS 6 to NPS 10, plain end.

B. Galvanized and Black-Steel Pipe Nipples: ASTM A 733, made of ASTM A 53/A 53M, standard-weight, seamless steel pipe with threaded ends.

C. Galvanized and Uncoated, Steel Couplings: ASTM A 865/A 865M, threaded.

D. Galvanized and Uncoated, Gray-Iron Threaded Fittings: ASME B16.4, Class 125, standard pattern.

E. Cast-Iron Flanges: ASME 16.1, Class 125.

F. Steel Flanges and Flanged Fittings: ASME B16.5, Class 150.

   1. Pipe-Flange Gasket Materials: AWWA C110, rubber, flat face, 1/8 inch thick; ASME B16.21, nonmetallic and asbestos free or EPDM rubber gasket.
      a. Class 125 and Class 250, Cast-Iron, Flat-Face Flanges: Full-face gaskets.
      b. Class 150 and Class 300, Ductile-Iron or -Steel, Raised-Face Flanges: Ring-type gaskets.
   2. Metal, Pipe-Flange Bolts and Nuts: Carbon steel unless otherwise indicated.

G. Steel Welding Fittings: ASTM A 234/A 234M and ASME B16.9.

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

H. Grooved-Joint, Steel-Pipe Appurtenances:

   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Anvil International, Incorporated. (www.anvilintl.com)
      b. Corcoran Piping System Co. (www.american-marsh.com)
      c. Shurjoint Piping Products. (www.shurjoint.com)
      d. Smith-Cooper International (www.smithcooper.com)
      e. Tyco Fire & Building Products LP. (tyco-fire.com)
      f. Victaulic Company. (www.victaulic.com)
   2. Pressure Rating: 175 psig minimum.
   3. Galvanized and Uncoated, Grooved-End Fittings for Steel Piping: ASTM A 536, ductile-iron casting; with dimensions matching steel pipe. Short pattern, with flow equal to standard pattern fittings.
   4. Grooved-End-Pipe Couplings for Steel Piping: AWWA C606 and UL 213, rigid pattern, unless otherwise indicated, for steel-pipe dimensions. Include ferrous housing sections, EPDM-rubber gasket, and ASTM A449 bolts and nuts.
      a. Rigid Type: Coupling housings with offsetting, angle-pattern bolt pads shall be used to provide system rigidity and support and hanging in accordance with NFPA-13. Installation ready rigid coupling for direct stab installation without field disassembly. Couplings shall be fully installed at visual pad-to-pad offset contact. Tongue and recess type couplings, which require the use of a torque wrench to achieve the exact required gap between housings, are not permitted.
      b. Flexible Type: Use in locations where vibration attenuation and stress relief are required.

2.4 SPECIALTY VALVES

A. Listed in UL's "Fire Protection Equipment Directory" or FM Global's "Approval Guide."

B. Pressure Rating:

   1. Standard-Pressure Piping Specialty Valves: 175-psig minimum.
   2. High-Pressure Piping Specialty Valves: 250-psig minimum.

C. Body Material: Cast or ductile iron.

D. Size: Same as connected piping.

E. End Connections: Flanged or grooved.

F. Alarm Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Victaulic Company (www.victaulic.com)
   b. Viking Corporation (www.vikingcorp.com)
2. Standard: UL 193.
3. Design: For vertical installation.
4. Internal components shall be replaceable without removing the valve from the installed position.
5. Include trim sets for bypass, drain, electrical sprinkler alarm switch, pressure gages and fill-line attachment with strainer.
6. Drip Cup Assembly: Pipe drain without valves and separate from main drain piping.
7. Drip Cup Assembly: Pipe drain with check valve to main drain piping.
8. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application

G. Automatic (Ball Drip) Drain Valves:

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

2.5 SPRINKLER PIPING SPECIALTIES

A. Branch Outlet Fittings:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Anvil International (www.anvilintl.com)
   b. Shurjoint Piping Products (www.shurjoint.com)
   c. Tyco Fire & Building Products (tyco-fire.com)
   d. Victaulic Company (www.victaulic.com)
2. Standard: UL 213.
3. Pressure Rating: 175-psig minimum.
4. Body Material: Ductile-iron housing with EPDM seals and bolts and nuts.
5. Type: Mechanical-tee and -cross fittings.
6. Configurations: Snap-on and strapless, ductile-iron housing with branch outlets.
7. Size: Of dimension to fit onto sprinkler main and with outlet connections as required to match connected branch piping.
8. Branch Outlets: Grooved, plain-end pipe, or threaded.

B. Flow Detection and Test Assemblies:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Reliable Automatic Sprinkler Co. Inc. (www.reliablesprinkler.com)
   b. Tyco Fire & Building Products (tyco-fire.com)
   c. Victaulic Company (www.victaulic.com)
2. Standard: UL's "Fire Protection Equipment Directory" or FM Global's "Approval Guide."
3. Pressure Rating: 175-psig minimum.
4. Body Material: Cast- or ductile-iron housing with orifice, sight glass, and integral test valve.
5. Size: Same as connected piping.
6. Inlet and Outlet: Threaded or grooved.

C. Branch Line Testers:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Elkhart Brass Manufacturing Co, Inc. (www.elkhartbrass.com)
   b. Fire-End & Croker Corporation (www.croker.com)

c. Potter Roemer LLC (www.potterroemer.com)
2. Standard: UL 199.
3. Pressure Rating: 175 psig.
4. Body Material: Brass.
5. Size: Same as connected piping.
6. Inlet: Threaded.
7. Drain Outlet: Threaded and capped.
8. Branch Outlet: Threaded, for sprinkler.

D. Sprinkler Inspector's Test Fittings:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Victaulic Company (www.victaulic.com)
   b. Viking Corporation (www.vikingcorp.com)
2. Standard: UL's "Fire Protection Equipment Directory" or FM Global's "Approval Guide."
3. Pressure Rating: 175-psig minimum.
4. Body Material: Cast- or ductile-iron housing with sight glass.
5. Size: Same as connected piping.
6. Inlet and Outlet: Threaded.

E. Adjustable Drop Nipples:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Aegis Technologies, Inc. (aegistechnologiesinc.com)
   b. CECE, LLC (www.cecaforge.com)
   c. Corcoran Piping System Co.
   d. Merit Manufacturing
2. Standard: UL 1474.
3. Pressure Rating: 250-psig minimum.
4. Body Material: Steel pipe with EPDM-rubber O-ring seals.
5. Size: Same as connected piping.
6. Length: Adjustable.
7. Inlet and Outlet: Threaded.

F. Flexible Sprinkler Hose Fittings:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Fivalco Inc. (www.fivalcoinc.com)
   b. FlexHead Industries, Inc. (www.flexhead.com)
   c. Gateway Tubing, Inc. (www.gatewaytubing.com)
   d. Victaulic Company (www.victualic.com)
2. Standard: UL 1474.
3. Type: Flexible hose for connection to sprinkler, and with open-gate bracket for connection to ceiling grid. The bracket shall allow installation before the ceiling tile is in place.
4. Pressure Rating: 175-psig minimum.
5. Size: Same as connected piping, for sprinkler.
6. The drop shall include a UL approved Series AH2 braided hose with a bend radius to 2” to allow for proper installation in confined spaces. The hose shall be listed for (4) bends at 31” length, (5) bends at 36” length, (8) bends at 48” length, (10) bends at 60” length, (12) bends at 72” length.
7. Union joints shall be provided for ease of installation.

2.6 SPRINKLERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Reliable Automatic Sprinkler Co. Inc (www.reliablesprinkler.com)
   b. Victaulic Company (www.victaulic.com)
   c. Viking Corporation (www.vikingcorp.com)

B. Sprinkler body shall be integrally cast with a hex shaped wrench boss to reduce the risk of damage during installation. Wrenches shall be provided by the sprinkler manufacturer that directly engage the wrench boss. (Sprinklers shall not contain rubber O-rings.)

C. Listed in UL's "Fire Protection Equipment Directory" or FM Global's "Approval Guide."

D. Pressure Rating for Residential Sprinklers: 175-psig maximum.

E. Pressure Rating for Automatic Sprinklers: 175-psig minimum.

F. Pressure Rating for High-Pressure Automatic Sprinklers: 250-psig minimum.

G. Automatic Sprinklers with Heat-Responsive Element:

1. Early-Suppression, Fast-Response Applications: UL 1767
2. Nonresidential Applications: UL 199
3. Characteristics: Nominal 1/2-inch orifice with Discharge Coefficient K of 5.6, and for "Ordinary" temperature classification rating unless otherwise indicated or required by application.

H. Open Sprinklers with Heat-Responsive Element Removed: UL 199.

1. Nominal Orifice: 1/2 inch, with discharge coefficient K between 5.3 and 5.8

I. Sprinkler Finishes: Refer to specific project requirements:

1. Chrome plated
2. Bronze
3. Painted

J. Special Coatings: Refer to specific project requirements:

1. Wax
2. Lead
3. corrosion-resistant paint

K. Sprinkler Escutcheons: Materials, types, and finishes for the following sprinkler mounting applications. Escutcheons for concealed, flush, and recessed-type sprinklers are specified with sprinklers.

1. Ceiling Mounting: Chrome-plated steel, one piece, flat
2. Sidewall Mounting: Chrome-plated steel, one piece, flat.

L. Sprinkler Guards:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Reliable Automatic Sprinkler Co. Inc (www.reliablesprinkler.com)
   b. Victaulic Company (www.victaulic.com)
   c. Viking Corporation (www.vikingcorp.com)
2. Standard: UL 199.
3. Type: Wire cage with fastening device for attaching to sprinkler.

M. Guards and escutcheons shall be listed, supplied, and approved for use with the sprinkler by the sprinkler manufacturer.

2.7 PRESSURE GAGES

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

1. AGF Manufacturing Inc. (www.testanddrain.com)
2. AMETEK, Inc. (www.ametek.com)
3. Ashcroft, Inc. (www.ashcroft.com)
4. Brecco Corporation
5. WIKA Instrument Corporation (www.wika.us)

B. Standard: UL 393.

C. Dial Size: 3-1/2- to 4-1/2-inch diameter.

D. Pressure Gage Range: 0- to 250-psig minimum

E. Label: Include "WATER" label on dial face.

PART 3 EXECUTION

3.1 PREPARATION

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

B. Report test results promptly and in writing.

3.2 PIPING INSTALLATION

A. Locations and Arrangements: Drawing plans, schematics, and diagrams indicate general location and arrangement of piping. Install piping as indicated, as far as practical.

   1. Deviations from approved working plans for piping require written approval from authorities having jurisdiction. File written approval with Architect before deviating from approved working plans.

B. Piping Standard: Comply with requirements for installation of sprinkler piping in NFPA 13.

C. Use listed fittings to make changes in direction, branch takeoffs from mains, and reductions in pipe sizes.

D. Install unions adjacent to each valve in pipes NPS 2 and smaller.

E. Install flanges, flange adapters, or couplings for grooved-end piping on valves, apparatus, and equipment having NPS 2-1/2 and larger end connections.

F. Install "Inspector's Test Connections" in sprinkler system piping, complete with shutoff valve, and sized and located according to NFPA 13.

G. Install sprinkler piping with drains for complete system drainage.

H. Install sprinkler control valves, test assemblies, and drain risers adjacent to standpipes when sprinkler piping is connected to standpipes.

I. Install automatic (ball drip) drain valve at each check valve for fire-department connection, to drain piping between fire-department connection and check valve. Install drain piping to and spill over floor drain or to outside building.

J. Install alarm devices in piping systems.

K. Install hangers and supports for sprinkler system piping according to NFPA 13. Comply with requirements for hanger materials in NFPA 13.

L. Install pressure gages on riser or feed main, at each sprinkler test connection, and at top of each standpipe. Include pressure gages with connection not less than NPS 1/4 and with soft metal seated globe valve, arranged for draining pipe between gage and valve. Install gages to permit removal, and install where they will not be subject to freezing.

M. Fill sprinkler system piping with water.

N. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 210517 "Sleeves and Sleeve Seals for Fire-Suppression Piping."

O. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 210517 "Sleeves and Sleeve Seals for Fire-Suppression Piping."

P. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 210518 "Escutcheons for Fire-Suppression Piping."

3.3 JOINT CONSTRUCTION

A. Install couplings, flanges, flanged fittings, unions, nipples, and transition and special fittings that have finish and pressure ratings same as or higher than system's pressure rating for aboveground applications unless otherwise indicated.

B. Install unions adjacent to each valve in pipes NPS 2 and smaller.

C. Install flanges, flange adapters, or couplings for grooved-end piping on valves, apparatus, and equipment having NPS 2-1/2 and larger end connections.

D. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.

E. Remove scale, slag, dirt, and debris from inside and outside of pipes, tubes, and fittings before assembly.

F. Flanged Joints: Select appropriate gasket material in size, type, and thickness suitable for water service. Join flanges with gasket and bolts according to ASME B31.9.

G. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:

1. Apply appropriate tape or thread compound to external pipe threads.
2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged.

H. Welded Joints: Construct joints according to AWS D10.12M/D10.12, using qualified processes and welding operators according to "Quality Assurance" Article.

1. Shop weld pipe joints where welded piping is indicated. Do not use welded joints for galvanized-steel pipe.

I. Steel-Piping, Roll-Grooved Joints: Roll rounded-edge groove in end of pipe according to AWWA C606. Assemble coupling with housing, gasket, lubricant, and bolts. Join steel pipe and grooved-end fittings according to AWWA C606 for steel-pipe grooved joints in accordance with the manufacturer's published instructions. A factory trained representative (direct employee) shall provide on-site training for contractor's field personnel in the use of grooving tools, application of groove, and product installation. The representative shall periodically visit the job site and review installation. Contractor shall remove and replace any improperly installed products.

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

3.4 VALVE AND SPECIALTIES INSTALLATION

A. Install listed fire-protection valves, trim and drain valves, specialty valves and trim, controls, and specialties according to NFPA 13 and authorities having jurisdiction.

B. Install listed fire-protection shutoff valves supervised open, located to control sources of water supply except from fire-department connections. Install permanent identification signs indicating portion of system controlled by each valve.

C. Install check valve in each water-supply connection. Install backflow preventers instead of check valves in potable-water-supply sources.

D. Specialty Valves:

1. General Requirements: Install in vertical position for proper direction of flow, in main supply to system.
2. Alarm Valves: Include bypass check valve and retarding chamber drain-line connection.

3.5 SPRINKLER INSTALLATION

A. Sprinklers shall be located in a regular pattern, perpendicular and parallel with building lines, in perfect alignment with other ceiling components such as lights, air diffusers, grilles, and speakers.

B. Where sprinkler locations are indicated on Architectural Drawings and the coverage is inadequate, provide additional sprinklers heads located as directed by the Architect. Additional sprinklers (in excess of NFPA minimum requirements) may be required for aesthetics.

1. Acoustical Ceiling Tile: Sprinklers shall be located in the center of tile; fully within a 4-inch diameter circle at the center of the tile. Locations shall be in the center of a 2-ft. x 2-ft. tile or in a 2 ft. x 2 ft. half of a 2 ft. x 4-ft. tile.
2. Sprinklers shall be located no closer than 4 inches from any ceiling edge or from any other ceiling component.
3. Sprinkler locations shall be reviewed and accepted by the Architect before any piping is fabricated or installed.

C. Install sprinklers into flexible, sprinkler hose fittings and install hose into bracket on ceiling grid.

D. Do not install sprinklers that have been dropped or show a visible loss of fluid. Never install sprinklers with cracked bulbs.

E. Sprinkler bulb protector must remain in place until the sprinkler is completely installed and before the system is placed in service. Remove bulb protectors carefully by hand after installation. Do not use any tools to remove bulb protectors.

3.6 IDENTIFICATION

A. Install labeling and pipe markers on equipment and piping according to requirements in NFPA 13.

B. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.7 FIELD QUALITY CONTROL

A. Perform the following tests and inspections
   1. Flush, test, and inspect sprinkler systems according to NFPA 13, "Systems Acceptance" Chapter.
   2. Leak Test: After installation, charge systems and test for leaks. Repair leaks and retest until no leaks exist.
      a. When systems are being hydrostatically tested, tests shall be permitted to be conducted with pendent or horizontal sidewall sprinklers or plugs installed in fittings. Any plugs shall be replaced with pendent or horizontal sidewall sprinklers are the test is completed.
   3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
   4. Energize circuits to electrical equipment and devices.
   5. Verify that equipment hose threads are same as local fire department equipment.

B. Sprinkler piping system will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports.

3.8 CLEANING

A. Clean dirt and debris from sprinklers.

B. Only sprinklers with their original factory finish are acceptable. Remove and replace any sprinklers that are painted or have any other finish than their original factory finish.

3.9 PIPING SCHEDULE

A. Piping between Fire-Department Connections and Check Valves: Galvanized, standard-weight steel pipe with grooved ends; grooved-end fittings; grooved-end-pipe couplings; and grooved joints.

B. Sprinkler specialty fittings may be used, downstream of control valves, instead of specified fittings.

C. Standard-pressure, wet-pipe sprinkler system, NPS 2 and smaller, shall be one of the following:
   1. Standard-weight or Schedule 30, black-steel pipe with threaded ends; uncoated, gray-iron threaded fittings; and threaded joints.
   2. Standard-weight or Schedule 30, galvanized-steel pipe with threaded ends; galvanized, gray-iron threaded fittings; and threaded joints.
   3. Standard-weight or Schedule 30, black-steel pipe with roll-grooved ends; uncoated, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.
   4. Standard-weight or Schedule 30, galvanized-steel pipe with roll-grooved ends; galvanized, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.
   5. Standard-weight or Schedule 30, black-steel pipe with plain ends; steel welding fittings; and welded joints.
   6. Schedule 10 black-steel pipe with roll-grooved ends; uncoated, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.

D. Standard-pressure, wet-pipe sprinkler system, NPS 2-1/2 to NPS 8, shall be one of the following:

1. Standard-weight or Schedule 30, black-steel pipe with roll-grooved ends; uncoated, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.
2. Standard-weight or Schedule 30, galvanized-steel pipe with roll-grooved ends; galvanized, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.
3. Standard-weight or Schedule 30, black-steel pipe with plain ends; steel welding fittings; and welded joints.
4. Schedule 10 black-steel pipe with roll-grooved ends; uncoated, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.

3.10 SPRINKLER SCHEDULE

A. Use sprinkler types in subparagraphs below for the following applications:
   1. Rooms without Ceilings: Upright sprinklers.
   2. Rooms with Suspended Ceilings: Concealed sprinklers.
   3. Wall Mounting: Sidewall sprinklers.
   4. Spaces Subject to Freezing: Upright, pendent, dry sprinklers; and sidewall, dry sprinklers as indicated.

B. Provide sprinkler types in subparagraphs below with finishes indicated.
   1. Concealed Sprinklers: Rough brass, with factory-painted cover plate. Cover plate cover shall be selected by architect.
   2. Upright, Pendent, and Sidewall Sprinklers: Chrome plated in finished spaces exposed to view; rough bronze in unfinished spaces not exposed to view; wax coated where exposed to acids, chemicals, or other corrosive fumes.

END OF SECTION

SECTION 220500
COMMON WORK RESULTS FOR PLUMBING

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. Piping materials and installation instructions common to most piping systems.
2. Transition fittings.
3. Dielectric fittings.
4. Grout.
5. Plumbing demolition.
6. Equipment installation requirements common to equipment sections.
7. Painting and finishing.
8. Concrete bases.
9. Supports and anchorages.

1.3 BASIS-OF-DESIGN

A. Equipment manufacturers listed on the equipment schedules are the basis-of-design. Manufactures listed in the specification other than the basis-of design manufacture are acceptable substitutions. Equipment schedules are on the drawings. Refer to specifications for unscheduled equipment.

1.4 DEFINITIONS

A. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe chases, unheated spaces immediately below roof, spaces above ceilings, unexcavated spaces, crawlspaces, and tunnels.

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 chases.

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.

1.5 SUBMITTALS

A. Product Data: For the following:

1. Transition fittings.

2. Dielectric fittings.

B. Welding certificates.

C. Equipment Startup Reports.

D. Coordination Drawings: Submit one copy for the engineers use. Division 22 coordination drawings will not be returned.

1. Detail major elements, components, and systems of plumbing equipment and materials in relationship with other systems, installations, and building components. Show space requirements for installation and access. Indicate if sequence and coordination of installations are important to efficient flow of the Work. Include the following:
   a. Planned piping layout, including valve and specialty locations and valve-stem movement.
   b. Clearances for installing and maintaining insulation.
   c. Clearances for servicing and maintaining equipment, accessories, and specialties, including space for disassembly required for periodic maintenance.
   d. Equipment and accessory service connections and support details
   e. Exterior wall and foundation penetrations.
   f. Fire- and smoke-rated wall and floor penetration.
   g. Sizes and locations of required concrete equipment curbs and bases.
   h. Scheduling, sequencing, movement, and positioning of large equipment into building during construction.
   i. Floor plans, elevations, and details to indicate penetrations in floors, walls, and ceilings and their relationship to other penetrations and installations.
   j. Access door and panel locations.

1.6 QUALITY ASSURANCE

A. Comply with ASHRAE Guideline 4 – 2008 Preparation of operating and maintenance documentation for building systems.

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

C. 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.

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

1.7 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.

1.8 COORDINATION

A. Arrange for pipe spaces, chases, slots, and openings in building structure during progress of construction, to allow for plumbing installations.

B. Coordinate installation of required supporting devices and set sleeves in poured-in-place concrete and other structural components as they are constructed.

C. Coordinate requirements for access panels and doors for plumbing items requiring access that are concealed behind finished surfaces. Access panels and doors are specified in Division 08 Section "Access Doors and Frames."

D. Coordinate plumbing equipment installation with other building components.

E. Sequence, coordinate, and integrate installations of plumbing materials and equipment for efficient flow of the Work. Coordinate installation of large equipment requiring positioning prior to closing in the building.

F. Coordinate connection of plumbing systems with exterior underground and overhead utilities and services. Comply with requirements of governing regulations, franchised service companies, and controlling agencies.

G. Coordinate connection of plumbing equipment and systems with building electrical systems.

1.9 GUIDELINES, CODES AND STANDARDS

A. Refer to the most recently published edition for references to guidelines, and standards (examples: ASHRAE, NFPA, AWWA, ASTM) unless a specific edition is listed.

B. Installation and materials shall comply with applicable national, state, and local codes and ordinances.

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. Company
      b. Dresser Industries, Incorporated; DMD Division
      c. Ford Meter Box Company, Incorporated (The); Pipe Products Division
      d. JCM Industries.
      e. Smith-Blair, Incorporated
      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, Incorporated.

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 Incorporated
      b. NIBCO, Incorporated; Chemtrol Division.

E. Flexible Transition Couplings for Underground Non-pressure 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. Company.
      b. Fernco, Incorporated.
      c. Mission Rubber Company.
      d. Plastic Oddities, Incorporated.

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 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 Company
      b. Central Plastics Company.
      c. Epco Sales, Incorporated
      d. Watts Industries, Incorporated; Water Products Division

D. 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, Incorporated

b. Calpico, Incorporated
c. Central Plastics Company.
d. Pipeline Seal and Insulator, Incorporated
2. Separate companion flanges and steel bolts and nuts shall have 150- or 300-psig minimum working pressure where required to suit system pressures.

E. 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, Incorporated
b. Lochinvar Corporation.

F. 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 Corporation.
b. Precision Plumbing Products, Incorporated
c. Sioux Chief Manufacturing Company, Incorporated
d. Victaulic Company of America.

2.6 CONCRETE BASES

A. Refer to Division 03 Section "Cast-in-Place Concrete” or Miscellaneous Cast-in-Place Concrete."

2.7 GROUT

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

1. Characteristics: Post-hardening, volume-adjusting, non-staining, 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 01 Section "Cutting and Patching" and Division 02 Section "Selective Structure Demolition" for general demolition requirements and procedures. Coordinate demolition with other disciplines, including architecture, electrical, structural and controls.

B. Where system shutdowns are required, schedule demolition work with building management.

C. 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: Abandoned piping is to be removed in its entirety. Do not abandon piping in place.
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.

D. 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 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. Verify final equipment locations for roughing-in.

M. Refer to equipment specifications in other Sections of these Specifications for roughing-in requirements.

3.3 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. 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.

I. Flanged Joints: Select appropriate asbestos-free, nonmetallic gasket material in size, type, and thickness suitable for domestic water service. Join flanges with gasket and bolts according to ASME B31.9.

J. 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. ABS Piping: Join according to ASTM D 2235 and ASTM D 2661 Appendixes.
3. CPVC Piping: Join according to ASTM D 2846/D 2846M Appendix.

4. 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.
5. PVC Non-pressure Piping: Join according to ASTM D 2855.
6. PVC to ABS Non-pressure Transition Fittings: Join according to ASTM D 3138 Appendix.

K. Plastic Pressure Piping Gasketed Joints: Join according to ASTM D 3139.

L. Plastic Non-pressure Piping Gasketed Joints: Join according to ASTM D 3212.

M. PE Piping Heat-Fusion Joints: Clean and dry joining surfaces by wiping with clean cloth or paper towels. Join according to ASTM D 2657.
   1. Plain-End Pipe and Fittings: Use butt fusion.
   2. Plain-End Pipe and Socket Fittings: Use socket fusion.

N. Steel-Piping Grooved Joints: Roll groove end of pipe. Assemble coupling with housing, gasket, lubricant, and bolts. Join steel pipe and grooved-end fittings according to AWWA C606 for steel-pipe grooved joints.

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

3.4 PIPING CONNECTIONS

A. Make connections according to the following, unless otherwise indicated:
   1. Install unions, in steel 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 flanges to connect piping materials of dissimilar metals.
   4. Wet Piping Systems: Install dielectric nipple fittings to connect piping materials of dissimilar metals.

3.5 EQUIPMENT INSTALLATION - COMMON REQUIREMENTS

A. Install plumbing equipment according to the equipment manufacturer’s installation instructions and as indicated on the drawings. Resolve conflicting instructions, with the architect before mounting equipment.

B. Install equipment to allow maximum possible headroom unless specific mounting heights are not indicated.

C. Install equipment level and plumb, parallel and perpendicular to other building systems and components in exposed interior spaces, unless otherwise indicated.

D. 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.

E. Install equipment to allow right of way for piping installed at required slope.

F. Refer to equipment shop drawings for rough-in locations; do not scale drawings.

3.6 PAINTING

A. Painting of plumbing systems, equipment, and components is specified in Division 09 Sections "Interior Painting" and "Exterior Painting."

B. Damage and Touchup: Repair marred and damaged factory-painted finishes with materials and procedures to match original factory finish.

3.7 ERECTION OF METAL SUPPORTS AND ANCHORAGES

A. Refer to Division 05 Section "Metal Fabrications" for structural steel.

B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor plumbing materials and equipment.

C. Field Welding: Comply with AWS D1.1.

3.8 ERECTION OF WOOD SUPPORTS AND ANCHORAGES

A. Cut, fit, and place wood grounds, nailers, blocking, and anchorages to support, and anchor plumbing materials and equipment.

B. Select fastener sizes that will not penetrate members if opposite side will be exposed to view or will receive finish materials. Tighten connections between members. Install fasteners without splitting wood members.

C. Attach to substrates as required to support applied loads.

3.9 GROUTING

A. Mix and install grout for plumbing equipment base bearing surfaces, pump and other equipment base plates, and anchors.

B. Clean surfaces that will come into contact with grout.

C. Provide forms as required for placement of grout.

D. Avoid air entrapment during placement of grout.

E. Place grout, completely filling equipment bases.

F. Place grout on concrete bases and provide smooth bearing surface for equipment.

G. Place grout around anchors.

H. Cure placed grout.

3.10 SEALANTS

A. Comply with joint-sealant materials and applications specified in Section 078400 “Firestopping,” Section 078443 “Fire-resistant Joint Sealants,” Section 079000 “Joint Protection,” and Section 092900 “Gypsum Board: Acoustical sealants.”

END OF SECTION

SECTION 220516
EXPANSION FITTINGS AND LOOPS FOR PLUMBING PIPING

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Flexible-hose packless expansion joints.
   2. Metal-bellows packless expansion joints.
   3. Grooved-joint expansion joints.
   4. Pipe loops and swing connections.
   5. Alignment guides and anchors.

1.2 PERFORMANCE REQUIREMENTS

A. Compatibility: Products shall be suitable for piping service fluids, materials, working pressures, and temperatures.

B. Capability: Products to absorb 200 percent of maximum axial movement between anchors.

1.3 ACTION SUBMITTALS

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

1.4 INFORMATIONAL SUBMITTALS

A. Welding certificates.

B. Product Certificates: For each type of expansion joint, from manufacturer.

1.5 CLOSEOUT SUBMITTALS

A. Maintenance Data: For expansion joints to include in maintenance manuals.

1.6 QUALITY ASSURANCE

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

PART 2 PRODUCTS

2.1 PACKLESS EXPANSION JOINTS

A. Flexible-Hose Packless Expansion Joints:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Flex Pression Ltd.
      b. Flex-Hose Co., Inc.
      c. Flexicraft Industries.
      d. Mason Industries, Inc.
      e. Metraflex Company (The).
      f. Unisource Manufacturing, Inc.
   2. Description: Manufactured assembly with inlet and outlet elbow fittings and two flexible-metal-hose legs joined by long-radius, 180-degree return bend or center section of flexible hose.
   3. Flexible Hose: Corrugated-metal inner hoses and braided outer sheaths.
   4. Expansion Joints for Copper Tubing NPS 3 and Smaller: Copper-alloy fittings with solder-joint or mechanical end connections.
   5. Expansion Joints for Steel Piping NPS 2-1/2 to NPS 6: Stainless-steel fittings with flanged end connections.

B. Metal-Bellows Packless Expansion Joints:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    a. Adsco Manufacturing LLC.
    b. American BOA, Inc.
    c. Badger Industries, Inc.
    d. Expansion Joint Systems, Inc.
    e. Flex Pression Ltd.
    f. Flex-Hose Co., Inc.
    g. Flex-Weld, Inc.
    h. Flexicraft Industries.
    i. Flo Fab inc.
    j. Hyspan Precision Products, Inc.
    k. Mason Industries, Inc.
    l. Metraflex Company (The).
    m. Proco Products, Inc.
    n. Senior Flexonics Pathway.
    o. Tozen Corporation.
    p. U.S. Bellows, Inc.
    q. Unaflex.
    r. Unisource Manufacturing, Inc.
    s. Universal Metal Hose.
    t. WahlcoMetroflex.
2. Standards: ASTM F 1120 and EJMA's "Standards of the Expansion Joint Manufacturers Association, Incorporated"
3. Type: Circular, corrugated bellows with external tie rods.
4. Minimum Pressure Rating: 150 psig unless otherwise indicated.
5. Configuration: Single joint class(es) unless otherwise indicated.
6. Expansion Joints for Copper Tubing: Single-ply phosphor-bronze bellows, copper pipe ends, and brass shrouds.
    a. End Connections for Copper Tubing NPS 2 and Smaller: Solder joint.

2.2 GROOVED-JOINT EXPANSION JOINTS

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

1. Anvil International, Incorporated
2. Shurjoint Piping Products.
3. Victaulic Company.

B. Description: Factory-assembled expansion joint made of several grooved-end pipe nipples, couplings, and grooved joints.

C. Standard: AWWA C606, for grooved joints.

D. Nipples: Galvanized, ASTM A 53/A 53M, Schedule 40, Type E or S, steel pipe with grooved ends.

E. Couplings: Five, flexible type for steel-pipe dimensions. Include ferrous housing sections, Buna-N gasket suitable for diluted acid, alkaline fluids, and cold and hot water and bolts and nuts.

2.3 ALIGNMENT GUIDES AND ANCHORS

A. Alignment Guides:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    a. Adsco Manufacturing LLC.
    b. Advanced Thermal Systems, Inc.
    c. Flex-Hose Co., Inc.
    d. Flex-Weld, Inc.
    e. Flexicraft Industries.
    f. Hyspan Precision Products, Inc.
    g. Mason Industries, Inc.
    h. Metraflex Company (The).

i. Senior Flexonics Pathway.
j. U.S. Bellows, Inc.
k. Unisource Manufacturing, Inc.

2. Description: Steel, factory-fabricated alignment guide, with bolted two-section outer cylinder and base for attaching to structure; with two-section guiding spider for bolting to pipe.

B. Anchor Materials:

1. Steel Shapes and Plates: ASTM A 36/A 36M.
2. Bolts and Nuts: ASME B18.10 or ASTM A 183, steel hex head.
3. Washers: ASTM F 844, steel, plain, flat washers.
4. Mechanical Fasteners: Insert-wedge-type stud with expansion plug anchor for use in hardened Portland cement concrete, with tension and shear capacities appropriate for application.
   a. Stud: Threaded, zinc-coated carbon steel.
   b. Expansion Plug: Zinc-coated steel.
   c. Washer and Nut: Zinc-coated steel.
5. Chemical Fasteners: Insert-type-stud, bonding-system anchor for use with hardened Portland cement concrete, with tension and shear capacities appropriate for application.
   a. Bonding Material: ASTM C 881/C 881M, Type IV, Grade 3, two-component epoxy resin suitable for surface temperature of hardened concrete where fastener is to be installed.
   b. Stud: ASTM A 307, zinc-coated carbon steel with continuous thread on stud unless otherwise indicated.
   c. Washer and Nut: Zinc-coated steel.

PART 3 EXECUTION

3.1 EXPANSION-JOINT INSTALLATION

A. Install expansion joints of sizes matching sizes of piping in which they are installed.

B. Install metal-bellows expansion joints according to EJMA's "Standards of the Expansion Joint Manufacturers Association, Incorporated"

C. Install grooved-joint expansion joints to grooved-end steel piping.

3.2 PIPE LOOP AND SWING CONNECTION INSTALLATION

A. Install pipe loops cold-sprung in tension or compression as required to partly absorb tension or compression produced during anticipated change in temperature.

B. Connect risers and branch connections to mains with at least three pipe fittings including tee in main.

3.3 ALIGNMENT-GUIDE AND ANCHOR INSTALLATION

A. Install alignment guides to guide expansion and to avoid end-loading and torsional stress.

B. Install two guides on each side of pipe expansion fittings and loops. Install guides nearest to expansion joint not more than four pipe diameters from expansion joint.

C. Attach guides to pipe and secure guides to building structure.

D. Install anchors at locations to prevent stresses from exceeding those permitted by ASME B31.9 and to prevent transfer of loading and stresses to connected equipment.

E. Anchor Attachments:

1. Anchor Attachment to Black-Steel Pipe: Attach by welding. Comply with ASME B31.9 and ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."
2. Anchor Attachment to Galvanized-Steel Pipe: Attach with pipe hangers. Use MSS SP-69, Type 42, riser clamp welded to anchor.
3. Anchor Attachment to Copper Tubing: Attach with pipe hangers. Use MSS SP-69, Type 24, U-bolts bolted to anchor.

F. Fabricate and install steel anchors by welding steel shapes, plates, and bars. Comply with ASME B31.9 and AWS D1.1/D1.1M.

1. Anchor Attachment to Steel Structural Members: Attach by welding.
2. Anchor Attachment to Concrete Structural Members: Attach by fasteners. Follow fastener manufacturer's written instructions.

G. Use grout to form flat bearing surfaces for guides and anchors attached to concrete.

END OF SECTION

SECTION 220517
SLEEVES AND SLEEVE SEALS FOR PLUMBING PIPING

PART 1 GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

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

1.3 ACTION SUBMITTALS

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

PART 2 PRODUCTS

2.1 SLEEVES

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

B. Galvanized-Steel-Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, zinc coated, with plain ends.

2.2 GROUT

A. Standard: ASTM C 1107/C 1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.

B. Characteristics: Nonshrink; recommended for interior and exterior applications.

C. Design Mix: 5000-psi, 28-day compressive strength.

D. Packaging: Premixed and factory packaged.

PART 3 EXECUTION

3.1 SLEEVE INSTALLATION

A. Install sleeves for piping passing through penetrations in floors, partitions, roofs, and walls.

B. Install sleeves for pipes passing through interior partitions.
   1. Cut sleeves to length for mounting flush with both surfaces.
   2. Install sleeves that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation.
   3. Seal annular space between sleeve and piping or piping insulation; use joint sealants appropriate for size, depth, and location of joint. Comply with requirements for sealants specified in Section 079200 "Joint Sealants."

C. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Comply with requirements for firestopping specified in Section 078413 "Penetration Firestopping."

D. Acoustical Interior Wall Penetrations: Maintain indicated STC rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with acoustical sealant materials.

3.2 SLEEVE AND SLEEVE-SEAL SCHEDULE

1. Interior Partitions:
   a. Piping Smaller Than NPS 6: Galvanized-steel-pipe sleeves.
   b. Piping NPS 6 and Larger: Galvanized-steel-pipe sleeves

END OF SECTION

SECTION 220523
GENERAL-DUTY VALVES 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. This Section includes the following general-duty valves:
1. Copper-alloy ball valves.
2. Ferrous-alloy butterfly valves.
3. Bronze check valves.
4. Gray-iron swing check valves.
5. Spring-loaded, lift-disc check valves.
6. Bronze globe valves.
7. Cast-iron globe valves.
8. Chainwheel actuators.

B. Related Sections include the following:
1. Division 21 fire-suppression piping and fire pump Sections for fire-protection valves.
2. Division 22 Section "Identification for Plumbing Piping and Equipment" for valve tags and charts.
3. 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. 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 for Ferrous Valves: ASME B16.10 and ASME B16.34 for dimension and design criteria.

B. NSF Compliance: NSF/ANSI 61 and/or NSF/ANSI 372 for valve materials for potable water service. Valves for domestic water must be third party certified.

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 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 VALVES, GENERAL

A. Refer to Part 3 "Valve Applications" Article for applications of valves.

B. Bronze Valves: NPS 3 and smaller with threaded ends, unless otherwise indicated.

C. Ferrous Valves: NPS 4 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.

J. Solder Joint: With sockets according to ASME B16.18.
   1. Caution: Use solder with melting point below 840 deg F for angle, check, gate, and globe valves. Do not use solder joint ball valves.

K. Threaded: With threads according to ASME B1.20.1.

L. Valve Bypass and Drain Connections: MSS SP-45.

2.3 COPPER-ALLOY BALL VALVES

A. Manufacturers:
   1. Two-Piece, Copper-Alloy Ball Valves:
      a. Conbraco Industries, Incorporated; Apollo Division
      b. Crane Company; Crane Valve Group.
      c. Grinnell Corporation.
      d. Hammond Valve.
      e. Jamesbury, Incorporated
      f. Jomar International, LTD.
      g. Legend Valve & Fitting, Incorporated

h. Milwaukee Valve Company.
i. Nexus Valve Specialties.
j. NIBCO Incorporated
k. Watts Industries, Incorporated; Water Products Division

B. Copper-Alloy Ball Valves, General: MSS SP-110.

C. Two-Piece, Copper-Alloy Ball Valves: Threaded Bronze body with standard-port, chrome-plated bronze ball; PTFE or TFE seats; and 600-psig minimum CWP rating and blowout-proof stem. Example: Conbraco #70-100-03

2.4 FERROUS-ALLOY BUTTERFLY VALVES

A. Manufacturers:

1. Single-Flange, Ferrous-Alloy Butterfly Valves:
   a. American Valve, Incorporated
   b. Bray International, Incorporated
   c. Cooper Cameron Corporation; Cooper Cameron Valves Division
   d. Crane Company; Crane Valve Group.
   e. Dover Corporation; Dover Resources Company; Norriseal Division
   f. General Signal; DeZurik Unit.
   g. Grinnell Corporation.
   h. Hammond Valve.
   i. Kitz Corporation of America.
   j. Legend Valve & Fitting, Incorporated
   k. Metraflex Company
   l. Milwaukee Valve Company.
   m. Mueller Steam Specialty.
   n. NIBCO INC.
   o. Process Development & Control.
   p. Red-White Valve Corporation
   q. Techno Corporation
   r. Tyco International, Ltd.; Tyco Valves & Controls.
   s. Watts Industries, Incorporated; Water Products Division
2. Flanged, Ferrous-Alloy Butterfly Valves:
   a. Bray International, Incorporated
   b. Cooper Cameron Corporation; Cooper Cameron Valves Division
   c. Grinnell Corporation.
   d. Mueller Steam Specialty.
   e. Tyco International, Ltd.; Tyco Valves & Controls.
3. Grooved-End, Ductile-Iron Butterfly Valves:
   a. Grinnell Corporation.
   b. Hammond Valve.
   c. McWane, Incorporated; Kennedy Valve Division
   d. Milwaukee Valve Company.
   e. Mueller Steam Specialty.
   f. NIBCO INC.
   g. Victaulic Company of America.

B. Single-Flange, 200-psig CWP Rating, Ferrous-Alloy Butterfly Valve MSS-SP25: Lug type with one-piece stainless steel stem, EPDM liner, and aluminum bronze disc. Example: NIBCO #LD 2000

C. Grooved-end, 300-psig CWP Rating, Ferrous-Alloy Butterfly Valve MSS-SP67: two-piece stainless steel stem, coated ductile iron disc, with EPDM seal. Example: Victaulic V-300 Series

2.5 BRONZE CHECK VALVES

A. Manufacturers:

1. Bronze, Horizontal Lift Check Valves with Nonmetallic Disc:
   a. Cincinnati Valve Company
   b. Crane Company; Crane Valve Group.
   c. NIBCO Incorporated.

d. Walworth Company
2. Bronze, Vertical Lift Check Valves with Nonmetallic Disc:
   a. Grinnell Corporation.
   b. Kitz Corporation of America.
   c. Milwaukee Valve Company.
   d. NIBCO Incorporated.
3. Bronze, Swing Check Valves with Metal Disc:
   a. American Valve, Incorporated
   b. Cincinnati Valve Company
   c. Crane Company; Crane Valve Group.
   d. Grinnell Corporation.
   e. Hammond Valve.
   f. Kitz Corporation of America.
   g. Legend Valve & Fitting, Incorporated
   h. Milwaukee Valve Company.
   i. NIBCO Incorporated.
   j. Powell, Wm. Company
   k. Red-White Valve Corporation
   l. Walworth Company
   m. Watts Industries, Incorporated; Water Products Division

B. Bronze Check Valves, General: MSS SP-80.

C. Type 2, Class 125, Bronze, Horizontal Lift Check Valves: Bronze body with nonmetallic disc and bronze seat. Example: NIBCO #T-480 or #S-480

D. Type 2, Class 125, Bronze, Vertical Lift Check Valves: Bronze body with nonmetallic disc and bronze seat. Example: NIBCO #T-480 or #S-480

E. Type 3, Class 125, Bronze, Swing Check Valves: Bronze body with bronze disc and seat. Example: NIBCO #T-413 or #S-413

F. Type 3, Class 150, Bronze, Swing Check Valves: Bronze body with bronze disc and seat. NIBCO #T-433 or #S-433

2.6 GRAY-IRON SWING CHECK VALVES

A. Manufacturers:
1. Gray-Iron Swing Check Valves with Metal Seats:
   a. Cincinnati Valve Company
   b. Crane Company; Crane Valve Group.
   c. Flomatic Valves.
   d. Grinnell Corporation.
   e. Hammond Valve.
   f. Kitz Corporation of America.
   g. Legend Valve & Fitting, Incorporated
   h. Milwaukee Valve Company.
   i. Mueller Company
   j. NIBCO Incorporated
   k. Powell, Wm. Company
   l. Red-White Valve Corporation
   m. Walworth Company
   n. Watts Industries, Incorporated; Water Products Division
2. Gray-Iron Swing Check Valves with Composition to Metal Seats:
   a. Crane Company; Crane Valve Group.
   b. Mueller Company
   c. Watts Industries, Incorporated; Water Products Division
3. Grooved-End, Ductile-Iron Swing Check Valves:
   a. Grinnell Corporation.
   b. Mueller Company
   c. Victaulic Company of America.

B. Gray-Iron Swing Check Valves, General: MSS SP-71.

C. Class 125, gray-iron, swing check valves with metal seats. Example: NIBCO #F-918-B or #T-918-B

D. 300-psig CWP Rating, Grooved-End, Swing Check Valves: Ductile-iron body with grooved or shouldered ends. Example Victaulic V-716 Series.

2.7 CAST-IRON GLOBE VALVES

A. Manufacturers:

1. Type I, Cast-Iron Globe Valves with Metal Seats:
    a. Cincinnati Valve Company
    b. Crane Company; Crane Valve Group.
    c. Grinnell Corporation.
    d. Hammond Valve.
    e. Kitz Corporation of America.
    f. Milwaukee Valve Company.
    g. NIBCO INC.
    h. Powell, Wm. Company
    i. Red-White Valve Corporation
    j. Walworth Company

B. Cast-Iron Globe Valves, General: MSS SP-85.

C. Type I, Class 125, Cast-Iron Globe Valves: Gray-iron body with bronze seats. Example: NIBCO #F-718-B

D. Type I, Class 250, Cast-Iron Globe Valves: Gray-iron body with bronze seats. Example: NIBCO #F-768-B

2.8 CHAINWHEEL ACTUATORS

A. Manufacturers:

1. Babbitt Steam Specialty Company
2. Roto Hammer Industries, Incorporated

B. Description: Valve actuation assembly with sprocket rim, brackets, and chain.

1. Sprocket Rim with Chain Guides: Ductile iron, of type and size required for valve
2. Brackets: Type, number, size, and fasteners required to mount actuator on valve.
3. Chain: Hot-dip, galvanized steel of size required to fit sprocket rim.

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:
   a. NPS 3 and smaller: Ball valves.
   b. NPS 4 and larger: Butterfly valves.
2. Throttling Service:
   a. NPS 3 and smaller: Ball valves.
   b. NPS 4 and Larger: Butterfly or globe valves.
3. Pump Discharge: Spring-loaded, lift-disc check valves.

B. If valves with specified CWP ratings are not available, the same types of valves with higher CWP ratings may be substituted.

C. Domestic Water Piping: Use the following types of valves:

1. Ball Valves, NPS 3 and Smaller: Two-piece, 600-psig CWP rating, copper alloy.
2. Butterfly Valves, NPS 4 and Larger: Flanged, 300-psig CWP rating, ferrous alloy, with EPDM liner.
3. Grooved-End, Ductile-Iron Butterfly Valves, NPS 4 and Larger: 300-psig CWP rating.
4. Lift Check Valves, NPS 2 and Smaller: Type 2, Class 150, horizontal or vertical, bronze.
5. Swing Check Valves, NPS 2-1/2 and Larger: Type II, Class 125, gray iron.
6. Grooved-End, Ductile-Iron, Swing Check Valves, NPS 2-1/2 and Larger: 300-psig CWP rating.
7. Spring-Loaded, Lift-Disc Check Valves, NPS 2-1/2 and Larger: Type [I] [I or II] [II] [III], Class 125, cast iron.
8. Globe Valves, 4 and Larger: Type I, Class 125, bronze-mounted cast iron.

D. Sanitary Waste and Storm Drainage Piping: Use the following types of valves:

1. Ball Valves, NPS 3 and Smaller: Two-piece, 600-psig CWP rating, copper alloy.
2. Swing Check Valves, NPS 3 and Smaller: Type [3] [4], Class [125] [150], bronze.
3. Swing Check Valves, NPS 4 and Larger: Type [I] [or] [II], Class 125, gray iron.

E. Select valves, except wafer and flangeless types, with the following end connections:

1. For Copper Tubing, NPS 3 and Smaller: Threaded ends.
2. For Steel Piping, NPS 4: Flanged or threaded ends.
3. For Steel Piping, NPS 5 and Larger: Flanged ends.
4. For Grooved-End, Steel Piping, NPS 4 and larger: Valve ends may be grooved.

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 chainwheel operators on valves NPS 4 and larger and more than 96 inches above floor. Extend chains to 60 inches above finished floor elevation.

G. Install check valves for proper direction of flow and as follows:

1. Swing Check Valves: In horizontal position with hinge pin level.
2. Lift Check Valves: With stem upright and plumb.

3.4 JOINT CONSTRUCTION

A. Refer to Division 22 Section "Common Work Results for Plumbing" 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

SECTION 220529
HANGERS AND SUPPORTS FOR PLUMBING PIPING AND EQUIPMENT

PART 1 GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

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

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

1.3 DEFINITIONS

A. MSS: Manufacturers Standardization Society of The Valve and Fittings Industry Inc.

1.4 PERFORMANCE REQUIREMENTS

A. Delegated Design: Design trapeze pipe hangers and equipment supports, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

1.5 ACTION SUBMITTALS

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

B. Shop Drawings: Show fabrication and installation details and include calculations for the following; include Product Data for components:
   1. Trapeze pipe hangers.
   2. Metal framing systems.
   3. Fiberglass strut systems.
   4. Pipe stands.
   5. Equipment supports.

1.6 INFORMATIONAL SUBMITTALS

A. Welding certificates.

1.7 QUALITY ASSURANCE

A. Structural Steel Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

B. Pipe Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code.

PART 2 PRODUCTS

2.1 METAL PIPE HANGERS AND SUPPORTS

A. Carbon-Steel Pipe Hangers and Supports:
   1. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
   2. Galvanized Metallic Coatings: Pre-galvanized or hot dipped.
   3. Nonmetallic Coatings: Plastic coating, jacket, or liner.
   4. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.
   5. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel

B. Copper Pipe Hangers:
   1. Description: MSS SP-58, Types 1 through 58, copper-coated-steel, factory-fabricated components.
   2. Hanger Rods: Continuous-thread rod, nuts, and washer made of copper-coated steel

2.2 TRAPEZE PIPE HANGERS

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

2.3 FIBERGLASS PIPE HANGERS

A. Clevis-Type, Fiberglass Pipe Hangers:
   1. Description: Similar to MSS SP-58, Type 1, steel pipe hanger except hanger is made of fiberglass or fiberglass-reinforced resin.
   2. Hanger Rods: Continuous-thread rod, washer, and nuts made of stainless steel

B. Strap-Type, Fiberglass Pipe Hangers:
   1. Description: Similar to MSS SP-58, Type 9 or Type 10, steel pipe hanger except hanger is made of fiberglass-reinforced resin.
   2. Hanger Rod and Fittings: Continuous-thread rod, washer, and nuts made of stainless steel

2.4 METAL FRAMING SYSTEMS

A. MFMA Manufacturer Metal Framing Systems:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Allied Tube & Conduit.
      b. Cooper B-Line, Inc.
      c. Flex-Strut Inc.
      d. GS Metals Corp.
      e. Thomas & Betts Corporation.
      f. Unistrut Corporation; Tyco International, Ltd.
      g. Wesanco, Inc.
   2. Description: Shop- or field-fabricated pipe-support assembly for supporting multiple parallel pipes.
   3. Standard: MFMA-4.
   4. Channels: Continuous slotted steel channel with in turned lips.
   5. Channel Nuts: Formed or stamped steel nuts or other devices designed to fit into channel slot and, when tightened, prevent slipping along channel.
   6. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel
   7. Metallic Coating: Hot-dipped galvanized

2.5 FASTENER SYSTEMS

A. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened Portland cement concrete with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

2.6 PIPE POSITIONING SYSTEMS

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

2.7 EQUIPMENT SUPPORTS

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

2.8 MISCELLANEOUS MATERIALS

A. Structural Steel: ASTM A 36/A 36M, carbon-steel plates, shapes, and bars; black and galvanized.

B. Grout: ASTM C 1107, factory-mixed and -packaged, dry, hydraulic-cement, non-shrink and non-metallic grout; suitable for interior and exterior applications.

1. Properties: Non-staining, noncorrosive, and nongaseous.
2. Design Mix: 5000-psi, 28-day compressive strength.

PART 3 EXECUTION

3.1 HANGER AND SUPPORT INSTALLATION

A. Metal Pipe-Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Install hangers, supports, clamps, and attachments as required to properly support piping from the building structure.

B. Metal Trapeze Pipe-Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Arrange for grouping of parallel runs of horizontal piping, and support together on field-fabricated trapeze pipe hangers.

1. Pipes of Various Sizes: Support together and space trapezes for smallest pipe size or install intermediate supports for smaller diameter pipes as specified for individual pipe hangers.
2. Field fabricate from ASTM A 36/A 36M, carbon-steel shapes selected for loads being supported. Weld steel according to AWS D1.1/D1.1M.

C. Metal Framing System Installation: Arrange for grouping of parallel runs of piping, and support together on field-assembled metal framing systems.

D. Fastener System Installation:

1. Install powder-actuated fasteners for use in lightweight concrete or concrete slabs less than 4 inches thick in concrete after concrete is placed and completely cured. Use operators that are licensed by powder-actuated tool manufacturer. Install fasteners according to powder-actuated tool manufacturer's operating manual.
2. Install mechanical-expansion anchors in concrete after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.

E. Pipe Positioning-System Installation: Install support devices to make rigid supply and waste piping connections to each plumbing fixture.

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

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

H. Install hangers and supports to allow controlled thermal and seismic movement of piping systems, to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units.

I. Install lateral bracing with pipe hangers and supports to prevent swaying.

J. Install building attachments within concrete slabs or attach to structural steel. Install additional attachments at concentrated loads, including valves, flanges, and strainers, NPS 2-1/2 and larger and at changes in direction of piping. Install concrete inserts before concrete is placed; fasten inserts to forms and install reinforcing bars through openings at top of inserts.

K. Load Distribution: Install hangers and supports so that piping live and dead loads and stresses from movement will not be transmitted to connected equipment.

L. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and to not exceed maximum pipe deflections allowed by ASME B31.9 for building services piping.

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

3.2 EQUIPMENT SUPPORTS

A. Fabricate structural-steel stands to suspend equipment from structure overhead or to support equipment above floor.

B. Grouting: Place grout under supports for equipment and make bearing surface smooth.

C. Provide lateral bracing, to prevent swaying, for equipment supports.

3.3 METAL FABRICATIONS

A. Cut, drill, and fit miscellaneous metal fabrications for trapeze pipe hangers and equipment supports.

B. Fit exposed connections together to form hairline joints. Field weld connections that cannot be shop welded because of shipping size limitations.

C. Field Welding: Comply with AWS D1.1/D1.1M procedures for shielded, metal arc welding; appearance and quality of welds; and methods used in correcting welding work; and with the following:
   1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
   2. Obtain fusion without undercut or overlap.
   3. Remove welding flux immediately.
   4. Finish welds at exposed connections so no roughness shows after finishing and so contours of welded surfaces match adjacent contours.

3.4 ADJUSTING

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

B. Trim excess length of continuous-thread hanger and support rods to 1-1/2 inches.

3.5 PAINTING

A. Touchup: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.

   1. Apply paint by brush or spray to provide a minimum dry film thickness of 2.0 mils.

B. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

3.6 HANGER AND SUPPORT SCHEDULE

A. Specific hanger and support requirements are in Sections specifying piping systems and equipment.

B. Comply with MSS SP-69 for pipe-hanger selections and applications that are not specified in piping system Sections.

C. Use hangers and supports with galvanized metallic coatings for piping and equipment that will not have field-applied finish.

D. Use nonmetallic coatings on attachments for electrolytic protection where attachments are in direct contact with copper tubing.

E. Use carbon-steel pipe hangers and supports and metal framing systems and attachments for general service applications.

F. Use fiberglass pipe hangers and fiberglass strut systems attachments for hostile environment applications.

G. Use copper-plated pipe hangers and copper attachments for copper piping and tubing.

H. Use padded hangers for piping that is subject to scratching.

I. Use thermal-hanger shield inserts for insulated piping and tubing.

J. Horizontal-Piping Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

   1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of non-insulated or insulated, stationary pipes NPS 1/2 to NPS 30.
   2. Adjustable, Steel Band Hangers (MSS Type 7): For suspension of non-insulated, stationary pipes NPS 1/2 to NPS 8.
   3. Extension Hinged or Two-Bolt Split Pipe Clamps (MSS Type 12): For suspension of non-insulated, stationary pipes NPS 3/8 to NPS 3.
   4. U-Bolts (MSS Type 24): For support of heavy pipes NPS 1/2 to NPS 30.
   5. Clips (MSS Type 26): For support of insulated pipes not subject to expansion or contraction.
   6. Pipe Saddle Supports (MSS Type 36): For support of pipes NPS 4 to NPS 36, with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate.
   7. Pipe Stanchion Saddles (MSS Type 37): For support of pipes NPS 4 to NPS 36, with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate, and with U-bolt to retain pipe.
   8. Adjustable Roller Hangers (MSS Type 43): For suspension of pipes NPS 2-1/2 to NPS 24, from single rod if horizontal movement caused by expansion and contraction might occur.
   9. 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.

K. Vertical-Piping Clamps: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

   1. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers NPS 3/4 to NPS 24.
   2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers NPS 3/4 to NPS 24 if longer ends are required for riser clamps.

L. Hanger-Rod Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Steel Turnbuckles (MSS Type 13): For adjustment up to 6 inches 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.

M. Building Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Steel or Malleable Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.
2. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joist construction, to attach to top flange of structural shape.
3. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.
4. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.
5. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.
6. C-Clamps (MSS Type 23): For structural shapes.
7. Top-Beam Clamps (MSS Type 25): For top of beams if hanger rod is required tangent to flange edge.
8. Side-Beam Clamps (MSS Type 27): For bottom of steel I-beams.
9. Steel-Beam Clamps with Eye Nuts (MSS Type 28): For attaching to bottom of steel I-beams for heavy loads.
10. Linked-Steel Clamps with Eye Nuts (MSS Type 29): For attaching to bottom of steel I-beams for heavy loads, with link extensions.
11. Malleable-Beam Clamps with Extension Pieces (MSS Type 30): For attaching to structural steel.
12. Welded-Steel Brackets: For support of pipes from below or for suspending from above by using clip and rod. Use one of the following for indicated loads:
    a. Light (MSS Type 31): 750 lb.
    b. Medium (MSS Type 32): 1500 lb.
    c. Heavy (MSS Type 33): 3000 lb.
13. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.
14. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.
15. Horizontal Travelers (MSS Type 58): For supporting piping systems subject to linear horizontal movement where headroom is limited.

N. Saddles and Shields: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Steel-Pipe-Covering Protection Saddles (MSS Type 39): To fill interior voids with insulation that matches adjoining insulation.
2. Protection Shields (MSS Type 40): Of length recommended in writing by manufacturer to prevent crushing insulation.
3. Thermal-Hanger Shield Inserts: For supporting insulated pipe.

O. Comply with MSS SP-69 for trapeze pipe-hanger selections and applications that are not specified in piping system Sections.

P. Comply with MFMA-103 for metal framing system selections and applications that are not specified in piping system Sections.

Q. Use powder-actuated fasteners instead of building attachments where required in concrete construction.

R. Use pipe positioning systems in pipe spaces behind plumbing fixtures to support supply and waste piping for plumbing fixtures.

END OF SECTION

SECTION 220553
IDENTIFICATION FOR PLUMBING PIPING AND EQUIPMENT

PART 1 GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

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

1.3 SUBMITTALS

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

B. Samples: For color, letter style, and graphic representation required for each identification material and device.

C. Equipment Label Schedule: Include a listing of all equipment to be labeled with the proposed content for each label.

D. Valve numbering scheme.

E. Valve Schedules: For each piping system to include in maintenance manuals.

1.4 COORDINATION

A. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.

B. Coordinate installation of identifying devices with locations of access panels and doors.

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

PART 2 PRODUCTS

2.1 EQUIPMENT LABELS

A. Stencils: Prepared with letter sizes according to ASME A13.1 for piping; and minimum letter height of 3/4 inch for equipment.
   1. Stencil Material: Fiberboard or metal.
   2. Stencil Paint: Exterior, gloss acrylic enamel black unless otherwise indicated. Paint may be in pressurized spray-can form.
   3. Identification Paint: Exterior, acrylic enamel in colors according to ASME A13.1 unless otherwise indicated.

B. Label Content: Include equipment's Drawing designation or unique equipment number, Drawing numbers where equipment is indicated (plans, details, and schedules), plus the Specification Section number and title where equipment is specified.

C. Equipment Label Schedule: For each item of equipment to be labeled, on 8-1/2-by-11-inch bond paper. Tabulate equipment identification number and identify Drawing numbers where equipment is indicated (plans, details, and schedules), plus the Specification Section number and title where equipment is specified. Equipment schedule shall be included in operation and maintenance data.

2.2 WARNING SIGNS AND LABELS

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

B. Letter Color: Black.

C. Background Color: Yellow.

D. Maximum Temperature: Able to withstand temperatures up to 160 deg F.

E. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.

F. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.

G. Fasteners: Stainless-steel rivets or self-tapping screws.

H. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

I. Label Content: Include caution and warning information, plus emergency notification instructions.

2.3 STENCILS

A. Stencils: Prepared with letter sizes according to ASME A13.1 for piping; and minimum letter height of 3/4 inch for access panel and door labels, equipment labels, and similar operational instructions.
   1. Stencil Material: Fiberboard or metal.
   2. Stencil Paint: Exterior, gloss acrylic enamel black unless otherwise indicated. Paint may be in pressurized spray-can form.
   3. 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.
   1. Tag Material: Brass, 0.032-inch minimum thickness, and having predrilled or stamped holes for attachment hardware.
   2. Fasteners: Brass wire-link or beaded chain; or S-hook.

B. Valve Schedules: For each piping system, on 8-1/2-by-11-inch bond paper. Tabulate valve number, piping system, system abbreviation (as shown on valve tag), location of valve (room or space), normal-operating position (open, closed, or modulating), and variations for identification. Mark valves for emergency shutoff and similar special uses.
   1. Valve-tag schedule shall be included in operation and maintenance data.

2.5 WARNING TAGS

A. Warning Tags: Preprinted or partially preprinted, accident-prevention tags, of plasticized card stock with matte finish suitable for writing.
   1. Size: Approximately 4 by 7 inches.
   2. Fasteners: Brass grommet and wire.
   3. Nomenclature: Large-size primary caption such as "DANGER," "CAUTION," or "DO NOT OPERATE."
   4. Color: Yellow background with black lettering.

PART 3 EXECUTION

3.1 PREPARATION

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

3.2 EQUIPMENT LABEL INSTALLATION

A. Install or permanently fasten labels on each major item of mechanical equipment.

B. Locate equipment labels where accessible and visible.

3.3 PIPE LABEL INSTALLATION

A. Piping Color-Coding: Painting of piping is specified in Division 09 Section.

B. Stenciled Pipe Label Option: Stenciled labels may be provided instead of manufactured pipe labels, at Installer's option. Install stenciled pipe, complying with ASME A13.1, on each piping system.

1. Identification Paint: Use for contrasting background.
2. Stencil Paint: Use for pipe marking.

C. Locate pipe labels where piping is exposed or above accessible ceilings in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior exposed locations as follows:

1. Near each valve and control device.
2. Near each branch connection, excluding short takeoffs for fixtures and terminal units. Where flow pattern is not obvious, mark each pipe at branch.
3. Near penetrations through walls, floors, ceilings, and inaccessible enclosures.
4. At access doors, manholes, and similar access points that permit view of concealed piping.
5. Near major equipment items and other points of origination and termination.
6. Spaced at maximum intervals of 50 feet along each run. Reduce intervals to 25 feet in areas of congested piping and equipment.
7. On piping above removable acoustical ceilings. Omit intermediately spaced labels.

D. Pipe Label Color Schedule:

1. Low-Pressure, Compressed-Air Piping:
   a. Background Color: Blue.
   b. Letter Color: White.
2. Medium-Pressure, Compressed-Air Piping:
   a. Background Color: Blue.
   b. Letter Color: White.
3. Domestic Water Piping:
   a. Background Color: Green.
   b. Letter Color: White.
4. Sanitary Waste and Storm Drainage Piping:
   a. Background Color: Green.
   b. Letter Color: White.

3.4 VALVE-TAG INSTALLATION

A. Install tags on valves and control devices in piping systems, except check valves; valves within factory-fabricated equipment units; shutoff valves; faucets; convenience and lawn-watering hose connections; and similar roughing-in connections of end-use fixtures and units. List tagged valves in a valve schedule.

B. Valve-Tag Application Schedule: Tag valves according to size, shape, and color scheme and with captions similar to those indicated in the following subparagraphs:

1. Valve-Tag Size and Shape:
   a. Cold Water: 1-1/2 inches round.
   b. Hot Water: 1-1/2 inches round.
   c. Low-Pressure Compressed Air: 1-1/2 inches round.
   d. High-Pressure Compressed Air: 1-1/2 inches round.
2. Valve-Tag Color:
   a. Cold Water: Natural.
   b. Hot Water: Natural.
3. Letter Color:
   a. Cold Water: White.
   b. Hot Water: White.

3.5 WARNING-TAG INSTALLATION

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

END OF SECTION

SECTION 220716
PLUMBING 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. Section includes insulating the following plumbing equipment:

1. Domestic water storage tanks.

B. Related Sections:

1. Section 220719 "Plumbing Piping Insulation."

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include thermal conductivity, water-vapor permeance thickness, and jackets (both factory and field applied, if any).

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified Installer.

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

C. Field quality-control reports.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or another craft training program certified by the Department of Labor, Bureau of Apprenticeship and Training.

B. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products according to ASTM E 84 by a testing agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing agency.

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

1.6 DELIVERY, STORAGE, AND HANDLING

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

1.7 COORDINATION

A. Coordinate sizes and locations of supports, hangers, and insulation shields specified in Section 220529 "Hangers and Supports for Plumbing Piping and Equipment."

B. Coordinate clearance requirements with equipment Installer for equipment insulation application.

C. Coordinate installation and testing of heat tracing.

1.8 SCHEDULING

A. Schedule insulation application after pressure testing systems and, where required, after installing and testing heat tracing. Insulation application may begin on segments that have satisfactory test results.

B. Complete installation and concealment of plastic materials as rapidly as possible in each area of construction.

PART 2 PRODUCTS

2.1 INSULATION MATERIALS

A. Products shall not contain asbestos, lead, mercury, or mercury compounds.

B. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C 871.

C. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C 795.

D. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.

E. Mineral-Fiber, Pipe and Tank Insulation: Mineral or glass fibers bonded with a thermosetting resin. Semirigid board material with factory-applied ASJ complying with ASTM C 1393, Type II or Type IIIA Category 2, or with properties similar to ASTM C 612, Type IB. Nominal density is 2.5 lb/cu. ft. or more. Thermal conductivity (k-value) at 100 deg F is 0.29 Btu x in. /h x sq. ft. x deg F or less. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
   1. Products: Subject to compliance with requirements, provide one of the following:
      a. CertainTeed Corp.; CrimpWrap.
      b. Johns Manville; MicroFlex.
      c. Knauf Insulation; Pipe and Tank Insulation.
      d. Manson Insulation Inc.; AK Flex.
      e. Owens Corning; Fiberglas Pipe and Tank Insulation.

2.2 ADHESIVES

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

B. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.
   1. Products: Subject to compliance with requirements, provide one of the following:
      a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-127.
      b. Eagle Bridges - Marathon Industries; 225.
      c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 85-60/85-70.
      d. Mon-Eco Industries, Inc.; 22-25.

C. ASJ Adhesive, and FSK and PVDC Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.
   1. Products: Subject to compliance with requirements, provide one of the following:
      a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-82.
      b. Eagle Bridges - Marathon Industries; 225.
      c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 85-50.
      d. Mon-Eco Industries, Inc.; 22-25.

D. PVC Jacket Adhesive: Compatible with PVC jacket.
   1. Products: Subject to compliance with requirements, provide one of the following:
      a. Dow Corning Corporation; 739, Dow Silicone.
      b. Johns Manville; Zeston Perma-Weld, CEEL-TITE Solvent Welding Adhesive.

c. P.I.C. Plastics, Inc.; Welding Adhesive.
d. Speedline Corporation; Polyco VP Adhesive.

2.3 MASTICS

A. Materials shall be compatible with insulation materials, jackets, and substrates; comply with MIL-PRF-19565C, Type II.

B. Vapor-Barrier Mastic: Water based; suitable for indoor use on below ambient services.
   1. Products: Subject to compliance with requirements, provide one of the following:
      a. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 30-80/30-90.
      b. Vimasco Corporation; 749.
   2. Water-Vapor Permeance: ASTM E 96/E 96M, Procedure B, 0.013 perm at 43-mil dry film thickness.
   3. Service Temperature Range: Minus 20 to plus 180 deg F.
   4. Solids Content: ASTM D 1644, 58 percent by volume and 70 percent by weight.
   5. Color: White.

C. Vapor-Barrier Mastic: Solvent based; suitable for indoor use on below ambient services.
   1. Products: Subject to compliance with requirements, provide one of the following:
      a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-30.
      b. Eagle Bridges - Marathon Industries; 501.
      c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 30-35.
      d. Mon-Eco Industries, Inc.; 55-10.
   2. Water-Vapor Permeance: ASTM F 1249, 0.05 perm at 35-mil dry film thickness.
   3. Service Temperature Range: 0 to 180 deg F.
   4. Solids Content: ASTM D 1644, 44 percent by volume and 62 percent by weight.
   5. Color: White.

D. Vapor-Barrier Mastic: Solvent based; suitable for outdoor use on below ambient services.
   1. Products: Subject to compliance with requirements, provide one of the following:
      a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; Encacel.
      b. Eagle Bridges - Marathon Industries; 570.
      c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 60-95/60-96.
   2. Water-Vapor Permeance: ASTM F 1249, 0.05 perm at 30-mil dry film thickness.
   3. Service Temperature Range: Minus 50 to plus 220 deg F.
   4. Solids Content: ASTM D 1644, 33 percent by volume and 46 percent by weight.
   5. Color: White.

E. Breather Mastic: Water based; suitable for indoor and outdoor use on above ambient services.
   1. Products: Subject to compliance with requirements, provide one of the following:
      a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-10.
      b. Eagle Bridges - Marathon Industries; 550.
      c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 46-50.
      d. Mon-Eco Industries, Inc.; 55-50.
      e. Vimasco Corporation; WC-1/WC-5.
   2. Water-Vapor Permeance: ASTM F 1249, 1.8 perms at 0.0625-inch dry film thickness.
   3. Service Temperature Range: Minus 20 to plus 180 deg F.
   4. Solids Content: 60 percent by volume and 66 percent by weight.
   5. Color: White.

2.4 LAGGING ADHESIVES

A. Description: Comply with MIL-A-3316C, Class I, Grade A, and shall be compatible with insulation materials, jackets, and substrates.

1. Products: Subject to compliance with requirements, provide one of the following:
   a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-50 AHV2.
   b. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 30-36.
   c. Vimasco Corporation; 713 and 714.
2. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over insulation.
3. Service Temperature Range: 0 to plus 180 deg F.
4. Color: White.

2.5 SEALANTS

A. Joint Sealants:
1. Products: Subject to compliance with requirements, provide one of the following:
   a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-76.
   b. Eagle Bridges - Marathon Industries; 405.
   c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 30-45.
   d. Mon-Eco Industries, Inc.; 44-05.
   e. Pittsburgh Corning Corporation; Pittseal 444.
2. Materials shall be compatible with insulation materials, jackets, and substrates.
3. Permanently flexible, elastomeric sealant.
4. Service Temperature Range: Minus 100 to plus 300 deg F.
5. Color: White or gray.

B. FSK and Metal Jacket Flashing Sealants:
1. Products: Subject to compliance with requirements, provide one of the following:
   a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-76.
   b. Eagle Bridges - Marathon Industries; 405.
   c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 95-44.
   d. Mon-Eco Industries, Inc.; 44-05.
2. Materials shall be compatible with insulation materials, jackets, and substrates.
3. Fire- and water-resistant, flexible, elastomeric sealant.
4. Service Temperature Range: Minus 40 to plus 250 deg F.
5. Color: Aluminum.

C. ASJ Flashing Sealants, and Vinyl, PVDC, and PVC Jacket Flashing Sealants:
1. Products: Subject to compliance with requirements, provide one of the following:
   a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-76.
2. Materials shall be compatible with insulation materials, jackets, and substrates.
3. Fire- and water-resistant, flexible, elastomeric sealant.
4. Service Temperature Range: Minus 40 to plus 250 deg F.
5. Color: White.

2.6 FACTORY-APPLIED JACKETS

A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:
1. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C 1136, Type I.
2. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C 1136, Type I.
3. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C 1136, Type II.

4. PVDC Jacket for Indoor Applications: 4-mil- thick, white PVDC biaxially oriented barrier film with a permeance at 0.02 perm when tested according to ASTM E 96/E 96M and with a flame-spread index of 5 and a smoke-developed index of 20 when tested according to ASTM E 84.
5. Products: Subject to compliance with requirements, provide one of the following:
    1) Dow Chemical Company (The); Saran 540 Vapor Retarder Film and Saran 560 Vapor Retarder Film.
6. PVDC Jacket for Outdoor Applications: 6-mil- thick, white PVDC biaxially oriented barrier film with a permeance at 0.01 perm when tested according to ASTM E 96/E 96M and with a flame-spread index of 5 and a smoke-developed index of 25 when tested according to ASTM E 84.
7. Products: Subject to compliance with requirements, provide one of the following:
    1) Dow Chemical Company (The); Saran 540 Vapor Retarder Film and Saran 560 Vapor Retarder Film.
8. PVDC-SSL Jacket: PVDC jacket with a self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip.
9. Products: Subject to compliance with requirements, provide one of the following:
    1) Dow Chemical Company (The); Saran 540 Vapor Retarder Film and Saran 560 Vapor Retarder Film.

2.7 FIELD-APPLIED JACKETS

A. Field-applied jackets shall comply with ASTM C 921, Type I, unless otherwise indicated.

B. PVC Jacket: High-impact-resistant, UV-resistant PVC complying with ASTM D 1784, Class 16354-C; thickness as scheduled; roll stock ready for shop or field cutting and forming. Thickness is indicated in field-applied jacket schedules.

1. Products: Subject to compliance with requirements, provide one of the following:
    a. Johns Manville; Zeston.
    b. P.I.C. Plastics, Inc.; FG Series.
    c. Proto Corporation; LoSmoke.
    d. Speedline Corporation; SmokeSafe.
2. Adhesive: As recommended by jacket material manufacturer.
3. Color: [White] [Color-code jackets based on system. Color as selected by Architect].
4. Factory-fabricated tank heads and tank side panels.

2.8 TAPES

A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C 1136.

1. Products: Subject to compliance with requirements, provide one of the following:
    a. ABI, Ideal Tape Division; 428 AWF ASJ.
    b. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0836.
    c. Compac Corporation; 104 and 105.
    d. Venture Tape; 1540 CW Plus, 1542 CW Plus, and 1542 CW Plus/SQ.
2. Width: 3 inches.
3. Thickness: 11.5 mils.
4. Adhesion: 90 ounces force/inch in width.
5. Elongation: 2 percent.
6. Tensile Strength: 40 lbf/inch in width.
7. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.

B. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C 1136.

1. Products: Subject to compliance with requirements, provide one of the following:
    a. ABI, Ideal Tape Division; 491 AWF FSK.
    b. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0827.
    c. Compac Corporation; 110 and 111.
    d. Venture Tape; 1525 CW NT, 1528 CW, and 1528 CW/SQ.
2. Width: 3 inches.
3. Thickness: 6.5 mils.
4. Adhesion: 90 ounces force/inch in width.
5. Elongation: 2 percent.

6. Tensile Strength: 40 lbf/inch in width.
7. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.

C. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive.
    1. Products: Subject to compliance with requirements, provide one of the following:
        a. ABI, Ideal Tape Division; 488 AWF.
        b. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0800.
        c. Compac Corporation; 120.
        d. Venture Tape; 3520 CW.
    2. Width: 2 inches.
    3. Thickness: 3.7 mils.
    4. Adhesion: 100 ounces force/inch in width.
    5. Elongation: 5 percent.
    6. Tensile Strength: 34 lbf/inch in width.

2.9 SECUREMENTS

A. Bands:
    1. Products: Subject to compliance with requirements, provide one of the following:
        a. ITW Insulation Systems; Gerrard Strapping and Seals.
        b. RPR Products, Inc.; Insul-Mate Strapping, Seals, and Springs.
    2. Stainless Steel: ASTM A 167 or ASTM A 240/A 240M, Type 304 or Type 316; 0.015 inch thick, 1/2 inch or 3/4 inch wide with wing seal or closed seal.
    3. Aluminum: ASTM B 209, Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch thick, 1/2 inch or 3/4 inch wide with wing seal or closed seal.
    4. Springs: Twin spring set constructed of stainless steel with ends flat and slotted to accept metal bands. Spring size determined by manufacturer for application.

B. Insulation Pins and Hangers:
    1. Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.135-inch- diameter shank, length to suit depth of insulation indicated.
    2. Products: Subject to compliance with requirements, provide one of the following:
        1) AGM Industries, Inc.; CWP-1.
        2) GEMCO; CD.
        3) Midwest Fasteners, Inc.; CD.
        4) Nelson Stud Welding; TPA, TPC, and TPS.
    3. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.135-inch- diameter shank, length to suit depth of insulation indicated with integral 1-1/2-inch galvanized carbon-steel washer.
    4. Products: Subject to compliance with requirements, provide one of the following:
        1) AGM Industries, Inc.; CHP-1.
        2) GEMCO; Cupped Head Weld Pin.
        3) Midwest Fasteners, Inc.; Cupped Head.
        4) Nelson Stud Welding; CHP.
    5. Metal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place.
    6. Products: Subject to compliance with requirements, provide one of the following:
        1) AGM Industries, Inc.; Tactoo Perforated Base Insul-Hangers.
        2) GEMCO; Perforated Base.
        3) Midwest Fasteners, Inc.; Spindle.
        b. Baseplate: Perforated, galvanized carbon-steel sheet, 0.030 inch thick by 2 inches square.
        c. Spindle: Copper- or zinc-coated, low-carbon steel or Aluminum or Stainless steel, fully annealed, 0.106-inch- diameter shank, length to suit depth of insulation indicated.
        d. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.
    7. Nonmetal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate fastened to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place.
    8. Products: Subject to compliance with requirements, provide one of the following:

1) GEMCO; Nylon Hangers.
2) Midwest Fasteners, Inc.; Nylon Insulation Hangers.

b. Baseplate: Perforated, nylon sheet, 0.030 inch thick by 1-1/2 inches in diameter.
c. Spindle: Nylon, 0.106-inch- diameter shank, length to suit depth of insulation indicated, up to 2-1/2 inches.
d. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.

9. Self-Sticking-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place.
10. Products: Subject to compliance with requirements, provide one of the following:
    1) AGM Industries, Inc.; Tactoo Self-Adhering Insul-Hangers.
    2) GEMCO; Peel & Press.
    3) Midwest Fasteners, Inc.; Self Stick.

    b. Baseplate: Galvanized carbon-steel sheet, 0.030 inch thick by 2 inches square.
    c. Spindle: Copper- or zinc-coated, low-carbon steel or Aluminum or Stainless steel fully annealed, 0.106-inch- diameter shank, length to suit depth of insulation indicated.
    d. Adhesive-backed base with a peel-off protective cover.
11. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch- thick, galvanized-steel or aluminum or stainless-steel sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.
12. Products: Subject to compliance with requirements, provide one of the following:
    1) AGM Industries, Inc.; RC 150.
    2) GEMCO; R-150.
    3) Midwest Fasteners, Inc.; WA-150.
    4) Nelson Stud Welding; Speed Clips.

    b. Protect ends with capped self-locking washers incorporating a spring steel insert to ensure permanent retention of cap in exposed locations.
13. Nonmetal Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch- thick nylon sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.
14. Products: Subject to compliance with requirements, provide one of the following:
    1) GEMCO.
    2) Midwest Fasteners, Inc.

C. Staples: Outward-clinching insulation staples, nominal 3/4-inch- wide, stainless steel or Monel.

D. Wire: 0.062-inch soft-annealed, stainless steel

1. Products: Subject to compliance with requirements, provide one of the following:
   a. C & F Wire.

2.10 CORNER ANGLES

A. PVC Corner Angles: 30 mils thick, minimum 1 by 1 inch, PVC according to ASTM D 1784, Class 16354-C. White or color-coded to match adjacent surface.

B. Aluminum Corner Angles: 0.040 inch thick, minimum 1 by 1 inch, aluminum according to ASTM B 209, Alloy 3003, 3005, 3105, or 5005; Temper H-14.

C. Stainless-Steel Corner Angles: 0.024 inch thick, minimum 1 by 1 inch, stainless steel according to ASTM A 167 or ASTM A 240/A 240M, Type 304 or Type 316.

PART 3 EXECUTION

3.1 EXAMINATION

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

1. Verify that systems and equipment to be insulated have been tested and are free of defects.
2. Verify that surfaces to be insulated are clean and dry.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.

B. Surface Preparation: Clean and prepare surfaces to be insulated. Before insulating, apply a corrosion coating to insulated surfaces as follows:

1. Stainless Steel: Coat 300 series stainless steel with epoxy primer 5 mils thick and an epoxy finish 5 mils thick if operating in a temperature range between 140 and 300 deg F. Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.
2. Carbon Steel: Coat carbon steel operating at a service temperature between 32 and 300 deg F with an epoxy coating. Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.

C. Coordinate insulation installation with the trade installing heat tracing. Comply with requirements for heat tracing that apply to insulation.

3.3 GENERAL INSTALLATION REQUIREMENTS

A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of equipment.

B. Install insulation materials, forms, vapor barriers or retarders, jackets, and thicknesses required for each item as specified in insulation system schedules.

C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.

D. Install insulation with longitudinal seams at top and bottom of horizontal runs.

E. Install multiple layers of insulation with longitudinal and end seams staggered.

F. Keep insulation materials dry during application and finishing.

G. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.

H. Install insulation with least number of joints practical.

I. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.

1. Install insulation continuously through hangers and around anchor attachments.
2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.
3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.
4. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.

J. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.

K. Install insulation with factory-applied jackets as follows:

1. Draw jacket tight and smooth.
2. Cover circumferential joints with 3-inch- wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches o.c.
3. Overlap jacket longitudinal seams at least 1-1/2 inches. Install insulation with longitudinal seams at bottom of pipe. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 2 inches o.c.
    a. For below ambient services, apply vapor-barrier mastic over staples.

4. Cover joints and seams with tape, according to insulation material manufacturer's written instructions, to maintain vapor seal.
5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints.

L. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.

M. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.

N. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.

O. For above ambient services, do not install insulation to the following:

1. Vibration-control devices.
2. Testing agency labels and stamps.
3. Nameplates and data plates.
4. Manholes.
5. Handholes.
6. Cleanouts.

3.4 INSTALLATION OF EQUIPMENT, TANK, AND VESSEL INSULATION

A. Mineral-Fiber, Pipe, and Tank Insulation Installation for Tanks and Vessels: Secure insulation with adhesive and anchor pins and speed washers.

1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 50 percent coverage of tank and vessel surfaces.
2. Groove and score insulation materials to fit as closely as possible to equipment, including contours. Bevel insulation edges for cylindrical surfaces for tight joints. Stagger end joints.
3. Protect exposed corners with secured corner angles.
4. Install adhesively attached or self-sticking insulation hangers and speed washers on sides of tanks and vessels as follows:
    a. Do not weld anchor pins to ASME-labeled pressure vessels.
    b. Select insulation hangers and adhesive that is compatible with service temperature and with substrate.
    c. On tanks and vessels, maximum anchor-pin spacing is 3 inches from insulation end joints, and 16 inches o.c. in both directions.
    d. Do not over-compress insulation during installation.
    e. Cut and miter insulation segments to fit curved sides and domed heads of tanks and vessels.
    f. Impale insulation over anchor pins and attach speed washers.
    g. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.
5. Secure each layer of insulation with stainless-steel or aluminum bands. Select band material compatible with insulation materials.
6. Where insulation hangers on equipment and vessels are not permitted or practical and where insulation support rings are not provided, install a girdle network for securing insulation. Stretch prestressed aircraft cable around the diameter of vessel and make taut with clamps, turnbuckles, or breather springs. Place one circumferential girdle around equipment approximately 6 inches from each end. Install wire or cable between two circumferential girdles 12 inches o.c. Install a wire ring around each end and around outer periphery of center openings, and stretch prestressed aircraft cable radially from the wire ring to nearest circumferential girdle. Install additional circumferential girdles along the body of equipment or tank at a minimum spacing of 48 inches o.c. Use this network for securing insulation with tie wire or bands.
7. Stagger joints between insulation layers at least 3 inches.
8. Install insulation in removable segments on equipment access doors, manholes, handholes, and other elements that require frequent removal for service and inspection.
9. Bevel and seal insulation ends around manholes, handholes, ASME stamps, and nameplates.
10. For equipment with surface temperatures below ambient, apply mastic to open ends, joints, seams, breaks, and punctures in insulation.

3.5 FIELD-APPLIED JACKET INSTALLATION

A. Where PVC jackets are indicated, install with 1-inch overlap at longitudinal seams and end joints; for horizontal applications, install with longitudinal seams along top and bottom of tanks and vessels. Seal with manufacturer's recommended adhesive.

1. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge.

3.6 EQUIPMENT INSULATION SCHEDULE

A. Insulation materials and thicknesses are identified below. If more than one material is listed for a type of equipment, selection from materials listed is Contractor's option.

B. Insulate indoor and outdoor equipment that is not factory insulated.

C. Domestic hot-water storage tank insulation shall be the following, of thickness to provide an R-value of 12.5:

1. Mineral-fiber pipe and tank.

D. Domestic water storage tank insulation shall be the following:

1. Mineral-Fiber Pipe and Tank: 1 inch thick.

E. Domestic water filter-housing insulation shall be the following:

1. Mineral-Fiber Pipe and Tank: 2 inches thick.

3.7 INDOOR, FIELD-APPLIED JACKET SCHEDULE

A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.

B. If more than one material is listed, selection from materials listed is Contractor's option.

C. Equipment, Concealed:

1. None.

D. Equipment, Exposed, up to 48 Inches in Diameter or with Flat Surfaces up to 72 Inches:

1. PVC 30 mils thick.

E. Equipment, Exposed, Larger Than 48 Inches in Diameter or with Flat Surfaces Larger Than 72 Inches:

1. PVC 30 mils thick.

END OF SECTION

SECTION 220719
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. Section includes insulating the following plumbing piping services:
   1. Domestic cold-water piping.
   2. Domestic hot-water piping.
   3. Domestic recirculating hot-water piping.
   4. Roof drains and rainwater leaders.
   5. Supplies and drains for handicap-accessible lavatories and sinks.

B. Related Sections:
   1. Section 220716 "Plumbing Equipment Insulation."

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include thermal conductivity, water-vapor permeance thickness, and jackets (both factory- and field-applied, if any).

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified Installer.

1.5 QUALITY ASSURANCE

A. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products according to ASTM E 84 by a testing agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing agency.
   1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.
   2. Insulation Installed Outdoors: Flame-spread index of 75 or less, and smoke-developed index of 150 or less.
   3. Supply and Drain Protective Shielding Guards: ICC A117.1.

1.6 DELIVERY, STORAGE, AND HANDLING

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

1.7 COORDINATION

A. Coordinate sizes and locations of supports, hangers, and insulation shields specified in Section 220529 "Hangers and Supports for Plumbing Piping and Equipment."

B. Coordinate clearance requirements with piping Installer for piping insulation application. Before preparing piping Shop Drawings establish and maintain clearance requirements for installation of insulation and field-applied jackets and finishes and for space required for maintenance.

C. Coordinate installation and testing of heat tracing.

1.8 SCHEDULING

A. Schedule insulation application after pressure testing systems and, where required, after installing and testing heat tracing. Insulation application may begin on segments that have satisfactory test results.

B. Complete installation and concealment of plastic materials as rapidly as possible in each area of construction.

PART 2 PRODUCTS

2.1 INSULATION MATERIALS

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

B. Products shall not contain asbestos, lead, mercury, or mercury compounds.

C. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C 871.

D. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C 795.

E. Mineral-Fiber, Preformed Pipe Insulation:
   1. Products: Subject to compliance with requirements, provide one of the following:
      a. Fibrex Insulations Inc.; Coreplus 1200.
      b. Johns Manville; Micro-Lok.
      c. Knauf Insulation; 1000-Degree Pipe Insulation.
      d. Manson Insulation Inc.; Alley-K.
      e. Owens Corning; Fiberglas Pipe Insulation.
   2. Type I, 850 Deg F Materials: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 547, Type I, Grade A, with factory-applied ASJ-SSL. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

2.2 INSULATING CEMENTS

A. Mineral-Fiber Insulating Cement: Comply with ASTM C 195.
   1. Products: Subject to compliance with requirements, provide one of the following:
      a. Ramco Insulation, Inc.; Super-Stik.

B. Expanded or Exfoliated Vermiculite Insulating Cement: Comply with ASTM C 196.
   1. Products: Subject to compliance with requirements, provide one of the following:
      a. Ramco Insulation, Inc.; Thermokote V.

C. Mineral-Fiber, Hydraulic-Setting Insulating and Finishing Cement: Comply with ASTM C 449.
   1. Products: Subject to compliance with requirements, provide one of the following:
      a. Ramco Insulation, Inc.; Ramcote 1200 and Quik-Cote.

2.3 ADHESIVES

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

B. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.
   1. Products: Subject to compliance with requirements, provide one of the following:
      a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-127.
      b. Eagle Bridges - Marathon Industries; 225.
      c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 85-60/85-70.
      d. Mon-Eco Industries, Inc.; 22-25.

C. ASJ Adhesive, and FSK Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.

1. Products: Subject to compliance with requirements, provide one of the following:
   a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-82.
   b. Eagle Bridges - Marathon Industries; 225.
   c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 85-20.
   d. Mon-Eco Industries, Inc.; 22-25.

D. PVC Jacket Adhesive: Compatible with PVC jacket.

1. Products: Subject to compliance with requirements, provide one of the following:
   a. Dow Corning Corporation; 739, Dow Silicone.
   b. Johns Manville; Zeston Perma-Weld, CEEL-TITE Solvent Welding Adhesive.
   c. P.I.C. Plastics, Inc.; Welding Adhesive.
   d. Speedline Corporation; Polyco VP Adhesive.

2.4 MASTICS

A. Materials shall be compatible with insulation materials, jackets, and substrates; comply with MIL-PRF-19565C, Type II.

1. For indoor applications, use mastics that have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

B. Vapor-Barrier Mastic: Water based; suitable for indoor use on below-ambient services.

1. Products: Subject to compliance with requirements, provide one of the following:
   a. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 30-80/30-90.
   b. Vimasco Corporation; 749.
2. Water-Vapor Permeance: ASTM E 96/E 96M, Procedure B, 0.013 perm at 43-mil dry film thickness.
3. Service Temperature Range: Minus 20 to plus 180 deg F.
4. Solids Content: ASTM D 1644, 58 percent by volume and 70 percent by weight.
5. Color: White.

2.5 SEALANTS

A. Joint Sealants:

1. Products: Subject to compliance with requirements, provide one of the following:
   a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-76.
   b. Eagle Bridges - Marathon Industries; 405.
   c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 30-45.
   d. Mon-Eco Industries, Inc.; 44-05.
   e. Pittsburgh Corning Corporation; Pittseal 444.
2. Materials shall be compatible with insulation materials, jackets, and substrates.
3. Permanently flexible, elastomeric sealant.
4. Service Temperature Range: Minus 100 to plus 300 deg F.
5. Color: White or gray.

2.6 FACTORY-APPLIED JACKETS

A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:

1. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C 1136, Type I.

2.7 PROTECTIVE SHIELDING GUARDS

A. Protective Shielding Pipe Covers>:

1. Products: Subject to compliance with requirements, provide one of the following:
   a. Engineered Brass Company.
   b. Insul-Tect Products Co.; a subsidiary of MVG Molded Products.
   c. McGuire Manufacturing.
   d. Plumberex.
   e. Truebro; a brand of IPS Corporation.
   f. Zurn Industries, LLC; Tubular Brass Plumbing Products Operation.
2. Description: Manufactured plastic wraps for covering plumbing fixture hot- and cold-water supplies and trap and drain piping. Comply with Americans with Disabilities Act (ADA) requirements.

B. Protective Shielding Piping Enclosures:

1. Products: Subject to compliance with requirements, provide one of the following:
   a. Truebro; a brand of IPS Corporation.
   b. Zurn Industries, LLC; Tubular Brass Plumbing Products Operation.
2. Description: Manufactured plastic enclosure for covering plumbing fixture hot- and cold-water supplies and trap and drain piping. Comply with ADA requirements.

PART 3 EXECUTION

3.1 EXAMINATION

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

1. Verify that systems to be insulated have been tested and are free of defects.
2. Verify that surfaces to be insulated are clean and dry.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.

B. Coordinate insulation installation with the trade installing heat tracing. Comply with requirements for heat tracing that apply to insulation.

3.3 GENERAL INSTALLATION REQUIREMENTS

A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of piping including fittings, valves, and specialties.

B. Install insulation materials, forms, vapor barriers or retarders, jackets, and thicknesses required for each item of pipe system as specified in insulation system schedules.

C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.

D. Install insulation with longitudinal seams at top and bottom of horizontal runs.

E. Install multiple layers of insulation with longitudinal and end seams staggered.

F. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.

G. Keep insulation materials dry during application and finishing.

H. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.

I. Install insulation with least number of joints practical.

J. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.

1. Install insulation continuously through hangers and around anchor attachments.

2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.
3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.
4. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.

K. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.

L. Install insulation with factory-applied jackets as follows:

1. Draw jacket tight and smooth.
2. Cover circumferential joints with 3-inch- wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches o.c.
3. Overlap jacket longitudinal seams at least 1-1/2 inches. Install insulation with longitudinal seams at bottom of pipe. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 2 inches o.c.
   a. For below-ambient services, apply vapor-barrier mastic over staples.
4. Cover joints and seams with tape, according to insulation material manufacturer's written instructions, to maintain vapor seal.
5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to pipe flanges and fittings.

M. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.

N. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.

O. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.

P. For above-ambient services, do not install insulation to the following:

1. Vibration-control devices.
2. Testing agency labels and stamps.
3. Nameplates and data plates.
4. Cleanouts.

3.4 PENETRATIONS

A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.

1. Seal penetrations with flashing sealant.
2. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
3. Extend jacket of outdoor insulation outside roof flashing at least 2 inches below top of roof flashing.
4. Seal jacket to roof flashing with flashing sealant.

B. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.

1. Seal penetrations with flashing sealant.
2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches.
4. Seal jacket to wall flashing with flashing sealant.

C. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.

D. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Install insulation continuously through penetrations of fire-rated walls and partitions.

1. Comply with requirements in Section 078413 "Penetration Firestopping" for firestopping and fire-resistive joint sealers.

E. Insulation Installation at Floor Penetrations:

1. Pipe: Install insulation continuously through floor penetrations.
2. Seal penetrations through fire-rated assemblies. Comply with requirements in Section 078413 "Penetration Firestopping."

3.5 GENERAL PIPE INSULATION INSTALLATION

A. Requirements in this article generally apply to all insulation materials except where more specific requirements are specified in various pipe insulation material installation articles.

B. Insulation Installation on Fittings, Valves, Strainers, Flanges, and Unions:

1. Install insulation over fittings, valves, strainers, flanges, unions, and other specialties with continuous thermal and vapor-retarder integrity unless otherwise indicated.
2. Insulate pipe elbows using preformed fitting insulation or mitered fittings made from same material and density as adjacent pipe insulation. Each piece shall be butted tightly against adjoining piece and bonded with adhesive. Fill joints, seams, voids, and irregular surfaces with insulating cement finished to a smooth, hard, and uniform contour that is uniform with adjoining pipe insulation.
3. Insulate tee fittings with preformed fitting insulation or sectional pipe insulation of same material and thickness as used for adjacent pipe. Cut sectional pipe insulation to fit. Butt each section closely to the next and hold in place with tie wire. Bond pieces with adhesive.
4. Insulate valves using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. For valves, insulate up to and including the bonnets, valve stuffing-box studs, bolts, and nuts. Fill joints, seams, and irregular surfaces with insulating cement.
5. Insulate strainers using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Fill joints, seams, and irregular surfaces with insulating cement. Insulate strainers so strainer basket flange or plug can be easily removed and replaced without damaging the insulation and jacket. Provide a removable reusable insulation cover. For below-ambient services, provide a design that maintains vapor barrier.
6. Insulate flanges and unions using a section of oversized preformed pipe insulation. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker.
7. Cover segmented insulated surfaces with a layer of finishing cement and coat with a mastic. Install vapor-barrier mastic for below-ambient services and a breather mastic for above-ambient services. Reinforce the mastic with fabric-reinforcing mesh. Trowel the mastic to a smooth and well-shaped contour.
8. For services not specified to receive a field-applied jacket except for flexible elastomeric and polyolefin, install fitted PVC cover over elbows, tees, strainers, valves, flanges, and unions. Terminate ends with PVC end caps. Tape PVC covers to adjoining insulation facing using PVC tape.
9. Stencil or label the outside insulation jacket of each union with the word "union." Match size and color of pipe labels.

C. Insulate instrument connections for thermometers, pressure gages, pressure temperature taps, test connections, flow meters, sensors, switches, and transmitters on insulated pipes. Shape insulation at these connections by tapering it to and around the connection with insulating cement and finish with finishing cement, mastic, and flashing sealant.

D. Install removable insulation covers at locations indicated. Installation shall conform to the following:

1. Make removable flange and union insulation from sectional pipe insulation of same thickness as that on adjoining pipe. Install same insulation jacket as adjoining pipe insulation.
2. Construct removable valve insulation covers in same manner as for flanges, except divide the two-part section on the vertical center line of valve body.

3.6 INSTALLATION OF MINERAL-FIBER INSULATION

A. Insulation Installation on Straight Pipes and Tubes:

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

B. Insulation Installation on Pipe Flanges:

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

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install preformed sections of same material as straight segments of pipe insulation when available.
2. When preformed insulation elbows and fittings are not available, install mitered sections of pipe insulation, to a thickness equal to adjoining pipe insulation. Secure insulation materials with wire or bands.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed sections of same material as straight segments of pipe insulation when available.
2. When preformed sections are not available, install mitered sections of pipe insulation to valve body.
3. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
4. Install insulation to flanges as specified for flange insulation application.

3.7 FIELD-APPLIED JACKET INSTALLATION

A. Where PVC jackets are indicated, install with 1-inch overlap at longitudinal seams and end joints. Seal with manufacturer's recommended adhesive.

1. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge.

3.8 PIPING INSULATION SCHEDULE, GENERAL

A. Acceptable preformed pipe and tubular insulation materials and thicknesses are identified for each piping system and pipe size range. If more than one material is listed for a piping system, selection from materials listed is Contractor's option.

B. Items Not Insulated: Unless otherwise indicated, do not install insulation on the following:

1. Drainage piping located in crawl spaces.
2. Underground piping.
3. Chrome-plated pipes and fittings unless there is a potential for personnel injury.

3.9 INDOOR PIPING INSULATION SCHEDULE

A. Domestic Cold Water:

1. NPS 2 and Smaller: Insulation shall be the following:
   a. Mineral-Fiber Pipe Insulation, Type I: 1/2 inch thick.
2. NPS 2-1/2 and Larger: Insulation shall be the following:
   a. Mineral-Fiber Pipe Insulation, Type I: 1 inch thick.

B. Domestic Hot and Recirculated Hot Water:

1. NPS 1-1/4 and Smaller: Insulation shall be the following:
   a. Mineral-Fiber Pipe Insulation, Type I: 1/2 inch thick.
2. NPS 1-1/2 and Larger: Insulation shall be the following:
   a. Mineral-Fiber Pipe Insulation, Type I: 1 inch thick.

C. Storm-water and Overflow:

1. Insulate down comers from roof drain bodies, horizontal piping to the connection at main vertical piping, and 5 feet down the vertical piping from the connection. Insulate down comers from overflow roof drain bodies and piping within 5 feet of the overflow roof drains.
2. Insulate all exposed overflow storm water piping.
3. All Pipe Sizes: Insulation shall be the following:
   a. Mineral-Fiber Pipe Insulation, Type I: 1 inch thick.

D. Roof Drain and Overflow Drain Bodies:

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

E. Condensate and Equipment Drain Water below 60 Degrees F:

1. Extend insulation to the connection to main sanitary or storm water piping, and all piping within 10 feet of the drain (including sanitary or storm water main piping).
2. All Pipe Sizes: Insulation shall be the following:
   a. Mineral-Fiber Pipe Insulation, Type I: 1/2 inch thick.

F. Floor Drains, Traps, and Sanitary Drain Piping within 10 Feet of Drain Receiving Condensate and Equipment Drain Water below 60 Degrees F:

1. All Pipe Sizes: Insulation shall be the following:
   a. Mineral-Fiber Pipe Insulation, Type I: 1/2 inch thick.

G. Sump pump discharge: Insulate drain tile, elevator pit, and other clear water waste discharge piping from the pump to the point of connection to another drainage system, or until the pipe discharges to grade.

1. All Pipe Sizes: Insulation shall be the following:
   a. Mineral-Fiber Pipe Insulation, Type I: 1/2 inch thick.

3.10 INDOOR, FIELD-APPLIED JACKET SCHEDULE

A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.

B. If more than one material is listed, selection from materials listed is Contractor's option.

C. Piping, Exposed:

1. Piping located within 8 feet of the floor; less than 200 degrees F: PVC: 30 mils thick.

END OF SECTION

SECTION 221116
DOMESTIC WATER PIPING

PART 1 GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

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

1.3 ACTION SUBMITTALS

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

1.4 INFORMATIONAL SUBMITTALS

A. System purging and disinfecting activities report.

B. Field quality-control reports.

PART 2 PRODUCTS

2.1 PIPING MATERIALS

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

B. Potable-water piping and components shall comply with NSF 14 and NSF 61. Plastic piping components shall be marked with "NSF-pw."

2.2 COPPER TUBE AND FITTINGS

A. Hard Copper Tube: ASTM B 88, Type L water tube, drawn temper.

B. Soft Copper Tube: ASTM B 88, Type K water tube, annealed temper.

C. Cast-Copper, Solder-Joint Fittings: ASME B16.18, pressure fittings.

D. Wrought-Copper, Solder-Joint Fittings: ASME B16.22, wrought-copper pressure fittings.

E. Bronze Flanges: ASME B16.24, Class 150, with solder-joint ends.

F. Copper Push-on-Joint Fittings:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Victaulic Company.
   2. Description:
      a. Cast-copper fitting complying with ASME B16.18 or wrought-copper fitting complying with ASME B 16.22.
      b. Stainless-steel teeth and EPDM-rubber, O-ring seal in each end instead of solder-joint ends.

G. Copper-Tube, Extruded-Tee Connections:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. T-Drill Industries Inc.
   2. Description: Tee formed in copper tube according to ASTM F 2014.

H. Prohibited: ProPress

2.3 STAINLESS-STEEL PIPING

A. Potable-water piping and components shall comply with NSF 61.

B. Stainless-Steel Pipe: ASTM A 312/A 312M, Schedule 10.

C. Stainless-Steel Pipe Fittings: ASTM A 815/A 815M.

D. Appurtenances for Grooved-End, Stainless-Steel Pipe:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    a. Anvil International.
    b. Grinnell Mechanical Products; Tyco Fire Products LP.
    c. Shurjoint Piping Products.
    d. Victaulic Company.
2. Fittings for Grooved-End, Stainless-Steel Pipe: Stainless-steel casting with dimensions matching stainless-steel pipe.
3. Mechanical Couplings for Grooved-End, Stainless-Steel Pipe:
    a. AWWA C606 for stainless-steel-pipe dimensions.
    b. Stainless-steel housing sections.
    c. Stainless-steel bolts and nuts.
    d. EPDM-rubber gaskets suitable for hot and cold water.
    e. Minimum Pressure Rating:
        1) NPS 8 and Smaller: 600 psig.

2.4 PIPING JOINING MATERIALS

A. Pipe-Flange Gasket Materials:

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

B. Metal, Pipe-Flange Bolts and Nuts: ASME B18.2.1, carbon steel unless otherwise indicated.

C. Solder Filler Metals: ASTM B 32, lead-free alloys.

D. Flux: ASTM B 813, water flushable.

E. Brazing Filler Metals: AWS A5.8/A5.8M, BCuP Series, copper-phosphorus alloys for general-duty brazing unless otherwise indicated.

2.5 ENCASEMENT FOR PIPING

A. Standard: ASTM A 674 or AWWA C105/A21.5.

B. Form: Sheet or tube.

C. Color: Black or natural.

2.6 TRANSITION FITTINGS

A. General Requirements:

1. Same size as pipes to be joined.
2. Pressure rating at least equal to pipes to be joined.
3. End connections compatible with pipes to be joined.

B. Fitting-Type Transition Couplings: Manufactured piping coupling or specified piping system fitting.

C. Sleeve-Type Transition Coupling: AWWA C219.

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

f. Smith-Blair, Inc.; a Sensus company.
g. Viking Johnson.

2.7 DIELECTRIC FITTINGS

A. General Requirements: Assembly of copper alloy and ferrous materials with separating nonconductive insulating material. Include end connections compatible with pipes to be joined.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Capitol Manufacturing Company; member of the Phoenix Forge Group.
      b. Central Plastics Company.
      c. Matco-Norca.
      d. Watts; a division of Watts Water Technologies, Inc.
      e. Wilkins; a Zurn company.
   2. Standard: ASSE 1079.
   3. Factory-fabricated, bolted, companion-flange assembly.
   4. Pressure Rating: 125 psig minimum at 180 deg F
   5. End Connections: Solder-joint copper alloy and threaded ferrous; threaded solder-joint copper alloy and threaded ferrous.

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

C. Dielectric Nipples:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Elster Perfection Corporation.
      b. Grinnell Mechanical Products; Tyco Fire Products LP.
      c. Matco-Norca.
      d. Precision Plumbing Products, Inc.
      e. Victaulic Company.
   2. Standard: IAPMO PS 66.
   3. Electroplated steel nipple complying with ASTM F 1545.
   4. Pressure Rating and Temperature: 300 psig at 225 deg F
   5. End Connections: Male threaded or grooved.
   6. Lining: Inert and noncorrosive, propylene.

PART 3 EXECUTION

3.1 EARTHWORK

A. Comply with requirements in Division 31for excavating, trenching, and backfilling.

3.2 PIPING INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of domestic water piping. Indicated locations and arrangements are used to size pipe and calculate friction loss, expansion, and other design considerations. Install piping as indicated unless deviations to layout are approved on coordination drawings.

B. Install shutoff valve, hose-end drain valve, strainer, pressure gage, and test tee with valve inside the building at each domestic water-service entrance. Comply with requirements for pressure gages in Section 220519 "Meters and Gages for Plumbing Piping" and with requirements for drain valves and strainers in Section 221119 "Domestic Water Piping Specialties."

C. Install shutoff valve immediately upstream of each dielectric fitting.

D. Install water-pressure-reducing valves downstream from shutoff valves. Comply with requirements for pressure-reducing valves in Section 221119 "Domestic Water Piping Specialties."

E. Install domestic water piping level and plumb.

F. Rough-in domestic water piping for water-meter installation according to utility company's requirements.

G. Install piping concealed from view and protected from physical contact by building occupants unless otherwise indicated and except in equipment rooms and service areas.

H. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

I. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal, and coordinate with other services occupying that space.

J. Install piping to permit valve servicing.

K. Install nipples, unions, special fittings, and valves with pressure ratings the same as or higher than the system pressure rating used in applications below unless otherwise indicated.

L. Install piping free of sags and bends.

M. Install fittings for changes in direction and branch connections.

N. Install unions in copper tubing at final connection to each piece of equipment, machine, and specialty.

O. Install pressure gages on suction and discharge piping for each plumbing pump and packaged booster pump. Comply with requirements for pressure gages in Section 220519 "Meters and Gages for Plumbing Piping."

P. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 220517 "Sleeves and Sleeve Seals for Plumbing Piping."

Q. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 220517 "Sleeves and Sleeve Seals for Plumbing Piping."

R. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 220518 "Escutcheons for Plumbing Piping."

3.3 JOINT CONSTRUCTION

A. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.

B. Remove scale, slag, dirt, and debris from inside and outside of pipes, tubes, and fittings before assembly.

C. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:

1. Apply appropriate tape or thread compound to external pipe threads.
2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged.

D. Brazed Joints for Copper Tubing: Comply with CDA's "Copper Tube Handbook," "Brazed Joints" chapter.

E. Soldered Joints for Copper Tubing: Apply ASTM B 813, water-flushable flux to end of tube. Join copper tube and fittings according to ASTM B 828 or CDA's "Copper Tube Handbook."

F. Push-on Joints for Copper Tubing: Clean end of tube. Measure insertion depth with manufacturer's depth gage. Join copper tube and push-on-joint fittings by inserting tube to measured depth.

G. Extruded-Tee Connections: Form tee in copper tube according to ASTM F 2014. Use tool designed for copper tube; drill pilot hole, form collar for outlet, dimple tube to form seating stop, and braze branch tube into collar.

H. Flanged Joints: Select appropriate asbestos-free, nonmetallic gasket material in size, type, and thickness suitable for domestic water service. Join flanges with gasket and bolts according to ASME B31.9.

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

3.4 TRANSITION FITTING INSTALLATION

A. Install transition couplings at joints of dissimilar piping.

B. Transition Fittings in Aboveground Domestic Water Piping NPS 2 and Smaller: Plastic-to-metal transition fittings.

3.5 DIELECTRIC FITTING INSTALLATION

A. Install dielectric fittings in piping at connections of dissimilar metal piping and tubing.

B. Dielectric Fittings for NPS 3 and Smaller: Use dielectric couplings or nipples.

C. Dielectric Fittings for NPS 2-1/2 to NPS 4: Use dielectric flanges.

D. Dielectric Fittings for NPS 5 and Larger: Use dielectric flange kits.

3.6 HANGER AND SUPPORT INSTALLATION

A. Comply with requirements for pipe hanger, support products, and installation in Section 220529 "Hangers and Supports for Plumbing Piping and Equipment."
   1. Vertical Piping: MSS Type 8 or 42, clamps.
   2. Individual, Straight, Horizontal Piping Runs:
      a. 100 Feet and Less: MSS Type 1, adjustable, steel clevis hangers.
      b. Longer Than 100 Feet: MSS Type 43, adjustable roller hangers.
      c. Longer Than 100 Feet if Indicated: MSS Type 49, spring cushion rolls.
   3. Multiple, Straight, Horizontal Piping Runs 100 Feet or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
   4. Base of Vertical Piping: MSS Type 52, spring hangers.

B. Support vertical piping and tubing at base and at each floor.

C. Rod diameter may be reduced one size for double-rod hangers, to a minimum of 3/8 inch.

D. Install hangers for copper tubing with the following maximum horizontal spacing and minimum rod diameters:
   1. NPS 3/4 and Smaller: 60 inches with 3/8-inch rod.
   2. NPS 1 and NPS 1-1/4: 72 inches with 3/8-inch rod.
   3. NPS 1-1/2 and NPS 2: 96 inches with 3/8-inch rod.
   4. NPS 2-1/2: 108 inches with 1/2-inch rod.
   5. NPS 3 to NPS 5: 10 feet with 1/2-inch rod.

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

F. Install hangers for stainless-steel piping with the following maximum horizontal spacing and minimum rod diameters:
   1. NPS 3 and NPS 3-1/2: 12 feet with 1/2-inch rod.
   2. NPS 4 and NPS 5: 12 feet with 5/8-inch rod.
   3. NPS 6: 12 feet with 3/4-inch rod.
   4. NPS 8 to NPS 12: 12 feet with 7/8-inch rod.

G. Install supports for vertical stainless-steel piping every 15 feet.

3.7 CONNECTIONS

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

B. When installing piping adjacent to equipment and machines, allow space for service and maintenance.

C. Connect domestic water piping to exterior water-service piping. Use transition fitting to join dissimilar piping materials.

D. Connect domestic water piping to water-service piping with shutoff valve; extend and connect to the following:
   1. Domestic Water Booster Pumps: Cold-water suction and discharge piping.
   2. Water Heaters: Cold-water inlet and hot-water outlet piping in sizes indicated, but not smaller than sizes of water heater connections.
   3. Plumbing Fixtures: Cold- and hot-water-supply piping in sizes indicated, but not smaller than that required by plumbing code.
   4. Equipment: Cold- and hot-water-supply piping as indicated, but not smaller than equipment connections. Provide shutoff valve and union for each connection. Use flanges instead of unions for NPS 2-1/2 and larger.

3.8 IDENTIFICATION

A. Identify system components. Comply with requirements for identification materials and installation in Section 220553 "Identification for Plumbing Piping and Equipment."

B. Label pressure piping with system operating pressure.

3.9 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:
   1. Piping Inspections:
      a. Do not enclose, cover, or put piping into operation until it has been inspected and approved by authorities having jurisdiction.
      b. During installation, notify authorities having jurisdiction at least one day before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction:
         1) Roughing-in Inspection: Arrange for inspection of piping before concealing or closing in after roughing in and before setting fixtures.
         2) Final Inspection: Arrange for authorities having jurisdiction to observe tests specified in "Piping Tests" Subparagraph below and to ensure compliance with requirements.
      c. Re-inspection: If authorities having jurisdiction find that piping will not pass tests or inspections, make required corrections and arrange for re-inspection.
      d. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.
   2. Piping Tests:
      a. Fill domestic water piping. Check components to determine that they are not air bound and that piping is full of water.
      b. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired. If testing is performed in segments, submit a separate report for each test, complete with diagram of portion of piping tested.
      c. Leave new, altered, extended, or replaced domestic water piping uncovered and unconcealed until it has been tested and approved. Expose work that was covered or concealed before it was tested.
      d. Cap and subject piping to static water pressure of 50 psig above operating pressure, without exceeding pressure rating of piping system materials. Isolate test source and allow it to stand for four hours. Leaks and loss in test pressure constitute defects that must be repaired.
      e. Repair leaks and defects with new materials, and retest piping or portion thereof until satisfactory results are obtained.
      f. Prepare reports for tests and for corrective action required.

B. Domestic water piping will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports.

3.10 ADJUSTING

A. Perform the following adjustments before operation:
   1. Close drain valves, hydrants, and hose bibbs.
   2. Open shutoff valves to fully open position.
   3. Open throttling valves to proper setting.
   4. Adjust balancing valves in hot-water-circulation return piping to provide adequate flow.
      a. Manually adjust ball-type balancing valves in hot-water-circulation return piping to provide hot-water flow in each branch.
      b. Adjust calibrated balancing valves to flows indicated.
   5. Remove plugs used during testing of piping and for temporary sealing of piping during installation.
   6. Remove and clean strainer screens. Close drain valves and replace drain plugs.
   7. Remove filter cartridges from housings and verify that cartridges are as specified for application where used and are clean and ready for use.
   8. Check plumbing specialties and verify proper settings, adjustments, and operation.

3.11 CLEANING

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

B. Clean non-potable domestic water piping as follows:
   1. Purge new piping and parts of existing piping that have been altered, extended, or repaired before using.
   2. Use purging procedures prescribed by authorities having jurisdiction or; if methods are not prescribed, follow procedures described below:
      a. Flush piping system with clean, potable water until dirty water does not appear at outlets.
      b. Submit water samples in sterile bottles to authorities having jurisdiction. Repeat procedures if biological examination shows contamination.

C. Prepare and submit reports of purging and disinfecting activities. Include copies of water-sample approvals from authorities having jurisdiction.

D. Clean interior of domestic water piping system. Remove dirt and debris as work progresses.

3.12 PIPING SCHEDULE

A. Transition and special fittings with pressure ratings at least equal to piping rating may be used in applications below unless otherwise indicated.

B. Flanges and unions may be used for aboveground piping joints NPS 4 and larger, unless otherwise indicated.

C. Fitting Option: Extruded-tee connections and brazed joints may be used on aboveground copper tubing.

D. Under-building-slab, domestic water, building-service piping, NPS 3 and smaller shall be the following:

1. Soft copper tube, ASTM B 88, Type K; wrought-copper, solder-joint fittings; and brazed joints.

E. Under-building-slab, domestic water, building-service piping, NPS 4 and larger, shall be one of the following:

1. Mechanical-joint, ductile-iron pipe; standard pattern mechanical-joint fittings; and mechanical joints.
2. Push-on-joint, ductile-iron pipe; standard pattern push-on-joint fittings; and gasketed joints.
3. Plain-end, ductile-iron pipe; grooved-joint, ductile-iron-pipe appurtenances; and grooved joints.
4. PVC, Schedule 80 pipe; PVC, Schedule 80 socket fittings; and solvent-cemented joints.

F. Aboveground domestic water piping, NPS 3 and smaller, shall be one of the following:

1. Hard copper tube, ASTM B 88, Type L; cast-or wrought-copper solder-joint fittings; and soldered joints.

G. Aboveground domestic water piping, NPS 4 and larger, shall be the following:

1. Stainless-steel Schedule 10 pipe, grooved-joint fittings, and grooved joints.

3.13 VALVE SCHEDULE

A. Drawings indicate valve types to be used. Where specific valve types are not indicated, the following requirements apply:

1. Shutoff Duty: Use ball valves for piping NPS 3 and smaller. Use butterfly, with flanged ends for piping NPS 4 and larger.
2. Throttling Duty: Use ball valves for piping NPS 3 and smaller. Use butterfly valves with flanged ends for piping NPS 4 and larger.
3. Hot-Water Circulation Piping, Balancing Duty: Calibrated, Memory-stop balancing valves.
4. Drain Duty: Hose-end ball valves.

B. Use check valves to maintain correct direction of domestic water flow to and from equipment.

C. Iron grooved-end valves may be used with grooved-end piping.

END OF SECTION

SECTION 221119
DOMESTIC WATER PIPING 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. Section Includes:

1. Vacuum breakers.
2. Backflow preventers.
3. Water pressure-reducing valves.
4. Balancing valves.
5. Temperature-actuated, water mixing valves.
6. Strainers.
7. Outlet boxes.
8. Hose stations.
9. Hose bibbs.
10. Drain valves.
11. Water-hammer arresters.
12. Air vents.
13. Trap-seal primer valves.
14. Trap-seal primer systems.
15. Flexible connectors.

B. Related Requirements:

1. Section 220519 "Meters and Gages for Plumbing Piping" for thermometers, pressure gages, and flow meters in domestic water piping.
2. Section 221116 "Domestic Water Piping" for water meters.
3. Section 223200 "Domestic Water Filtration Equipment" for water filters in domestic water piping.
4. Section 224300 "Medical Plumbing Fixtures" for thermostatic mixing valves for sitz baths, thermostatic mixing-valve assemblies for hydrotherapy equipment, and outlet boxes for dialysis equipment.
5. Section 224500 "Emergency Plumbing Fixtures" for water tempering equipment.
6. Section 224713 "Drinking Fountains" for water filters for water coolers.
7. Section 224716 "Pressure Water Coolers" for water filters for water coolers.
8. Section 224723 "Remote Water Coolers" for water filters for water coolers.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For domestic water piping specialties.

1. Include diagrams for power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

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

PART 2 PRODUCTS

2.1 GENERAL REQUIREMENTS FOR PIPING SPECIALTIES

A. Potable-water piping and components shall comply with NSF 61.

2.2 PERFORMANCE REQUIREMENTS

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

2.3 VACUUM BREAKERS

A. Pipe-Applied, Atmospheric-Type Vacuum Breakers:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Ames Fire & Waterworks; a division of Watts Water Technologies, Inc.
      b. Cash Acme; a division of Reliance Worldwide Corporation.
      c. Conbraco Industries, Inc.
      d. FEBCO; a division of Watts Water Technologies, Inc.
      e. Rain Bird Corporation.
      f. Toro Company (The); Irrigation Div.
      g. Watts; a division of Watts Water Technologies, Inc.; Watts Regulator Company.
      h. Zurn Industries, LLC; Plumbing Products Group; Wilkins Water Control Products.
   2. Standard: ASSE 1001.
   3. Size: NPS 1/4 to NPS 3, as required to match connected piping.
   4. Body: Bronze.
   5. Inlet and Outlet Connections: Threaded.
   6. Finish: Rough bronze or Chrome plated.

B. Hose-Connection Vacuum Breakers:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Arrowhead Brass Products.
      b. Cash Acme; a division of Reliance Worldwide Corporation.
      c. Conbraco Industries, Inc.
      d. Legend Valve.
      e. MIFAB, Inc.
      f. Prier Products, Inc.
      g. Watts; a division of Watts Water Technologies, Inc.; Watts Regulator Company.
      h. Woodford Manufacturing Company; a division of WCM Industries, Inc.
      i. Zurn Industries, LLC; Plumbing Products Group; Light Commercial Products.
      j. Zurn Industries, LLC; Plumbing Products Group; Wilkins Water Control Products.
   2. Standard: ASSE 1011.
   3. Body: Bronze, non-removable, with manual drain.
   4. Outlet Connection: Garden-hose threaded complying with ASME B1.20.7.
   5. Finish: Chrome or nickel plated or Rough bronze

C. Pressure Vacuum Breakers:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Ames Fire & Waterworks; a division of Watts Water Technologies, Inc.
      b. Conbraco Industries, Inc.
      c. FEBCO; a division of Watts Water Technologies, Inc.
      d. Flomatic Corporation.
      e. Toro Company (The); Irrigation Div.
      f. Watts; a division of Watts Water Technologies, Inc.; Watts Regulator Company.
      g. Zurn Industries, LLC; Plumbing Products Group; Wilkins Water Control Products.
   2. Standard: ASSE 1020.
   3. Operation: Continuous-pressure applications.
   4. Pressure Loss: 5 psig maximum, through middle third of flow range.
   5. Size: Refer to drawings.

6. Design Flow Rate: Refer to drawings.
7. Selected Unit Flow Range Limits: Refer to drawings.
8. Pressure Loss at Design Flow Rate: Refer to drawings.
9. Accessories:
   a. Valves: Ball type, on inlet and outlet.

2.4 BACKFLOW PREVENTERS

A. Intermediate Atmospheric-Vent Backflow Preventers:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Cash Acme; a division of Reliance Worldwide Corporation.
      b. Conbraco Industries, Inc.
      c. FEBCO; a division of Watts Water Technologies, Inc.
      d. Honeywell International Inc.
      e. Legend Valve.
      f. Watts; a division of Watts Water Technologies, Inc.; Watts Regulator Company.
      g. Zurn Industries, LLC; Plumbing Products Group; Wilkins Water Control Products.
   2. Standard: ASSE 1012.
   3. Operation: Continuous-pressure applications.
   4. Size: NPS 3/4.
   5. Body: Bronze.
   6. End Connections: Union, solder joint.
   7. Finish: Chrome plated.

B. Reduced-Pressure-Principle Backflow Preventers:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Ames Fire & Waterworks; a division of Watts Water Technologies, Inc.
      b. Conbraco Industries, Inc.
      c. FEBCO; a division of Watts Water Technologies, Inc.
      d. Flomatic Corporation.
      e. Watts; a division of Watts Water Technologies, Inc.; Watts Regulator Company.
      f. Zurn Industries, LLC; Plumbing Products Group; Wilkins Water Control Products.
   2. Standard: ASSE 1013.
   3. Operation: Continuous-pressure applications.
   4. Pressure Loss: 12 psig maximum, through middle third of flow range.
   5. Size: Refer to drawings.
   6. Design Flow Rate: Refer to drawings.
   7. Selected Unit Flow Range Limits: Refer to drawings.
   8. Pressure Loss at Design Flow Rate: 5 psig for sizes NPS 2 and smaller; 8 psig for NPS 2-1/2 and larger.
   9. Body: Bronze for NPS 2 and smaller; stainless steel for NPS 2-1/2 and larger.
   10. End Connections: Threaded for NPS 2 and smaller; flanged for NPS 2-1/2 and larger.
   11. Configuration: Designed for horizontal, straight-through flow.
   12. Accessories:
       a. Valves NPS 2 and Smaller: Ball type with threaded ends on inlet and outlet.
       b. Valves NPS 2-1/2 and Larger: Outside-screw and yoke-gate type with flanged ends on inlet and outlet.
       c. Air-Gap Fitting: ASME A112.1.2, matching backflow-preventer connection.

C. Double-Check, Backflow-Prevention Assemblies:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Ames Fire & Waterworks; a division of Watts Water Technologies, Inc.
      b. Conbraco Industries, Inc.
      c. FEBCO; a division of Watts Water Technologies, Inc.
      d. Flomatic Corporation.
      e. Watts; a division of Watts Water Technologies, Inc.; Watts Regulator Company.
      f. Zurn Industries, LLC; Plumbing Products Group; Wilkins Water Control Products.
   2. Standard: ASSE 1015.

3. Operation: Continuous-pressure applications unless otherwise indicated.
4. Pressure Loss: 5 psig maximum, through middle third of flow range.
5. Size: Refer to drawings.
6. Design Flow Rate: Refer to drawings.
7. Selected Unit Flow Range Limits: Refer to drawings.
8. Pressure Loss at Design Flow Rate: 5 psig for sizes NPS 2 and smaller; 8 psig for NPS 2-1/2 and larger.
9. Body: Bronze for NPS 2 and smaller; stainless steel for NPS 2-1/2 and larger.
10. End Connections: Threaded for NPS 2 and smaller; flanged for NPS 2-1/2 and larger.
11. Configuration: Designed for horizontal, straight-through flow.
12. Accessories:
    a. Valves NPS 2 and Smaller: Ball type with threaded ends on inlet and outlet.
    b. Valves NPS 2-1/2 and Larger: Outside-screw and yoke-gate type with flanged ends on inlet and outlet.

D. Beverage-Dispensing-Equipment Backflow Preventers:

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

E. Carbonated-Beverage-Dispenser, Dual-Check-Valve Backflow Preventers:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    a. Cash Acme; a division of Reliance Worldwide Corporation.
    b. Lancer Corporation.
    c. Watts; a division of Watts Water Technologies, Inc.; Watts Regulator Company.
2. Standard: ASSE 1032.
3. Operation: Continuous-pressure applications.
4. Size: NPS 1/4 or NPS 3/8.
5. Body: Stainless steel.
6. End Connections: Threaded.

F. Backflow-Preventer Test Kits:

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

2.5 WATER PRESSURE-REDUCING VALVES

A. Water Regulators:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    a. Cash Acme; a division of Reliance Worldwide Corporation.
    b. Conbraco Industries, Inc.
    c. Honeywell International Inc.
    d. Watts; a division of Watts Water Technologies, Inc.; Watts Regulator Company.
    e. Zurn Industries, LLC; Plumbing Products Group; Wilkins Water Control Products.
2. Standard: ASSE 1003.

3. Pressure Rating: Initial working pressure of 150 psig.
4. Size: Refer to drawings.
5. Design Flow Rate: Refer to drawings.
6. Design Inlet Pressure: Refer to drawings.
7. Design Outlet Pressure Setting: Refer to drawings.
8. Body: Bronze with chrome-plated finish for NPS 2 and smaller; cast iron with interior lining that complies with AWWA C550 or that is FDA approved for NPS 2-1/2 and NPS 3.
9. Valves for Booster Heater Water Supply: Include integral bypass.
10. End Connections: Threaded for NPS 2 and smaller; flanged for NPS 2-1/2 and NPS 3.

B. Water-Control Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. CLA-VAL.
   b. Flomatic Corporation.
   c. OCV Control Valves.
   d. Watts; a division of Watts Water Technologies, Inc.; Control Valves (Watts ACV).
   e. Zurn Industries, LLC; Plumbing Products Group; Wilkins Water Control Products.
2. Description: Pilot-operated, diaphragm-type, single-seated, main water-control valve.
3. Pressure Rating: Initial working pressure of 150 psig minimum with AWWA C550 or FDA-approved, interior epoxy coating. Include small pilot-control valve, restrictor device, specialty fittings, and sensor piping.
4. Main Valve Body: Cast- or ductile-iron body with AWWA C550 or FDA-approved, interior epoxy coating; or stainless-steel body.
   a. Size: Refer to drawings.
   b. Pattern: **Angle** or **Globe** valve design.
   c. Trim: Stainless steel.
5. Design Flow: Refer to drawings.
6. Design Inlet Pressure: Refer to drawings.
7. Design Outlet Pressure Setting: Refer to drawings.
8. End Connections: Threaded for NPS 2 and smaller; flanged for NPS 2-1/2 and larger.

2.6 BALANCING VALVES

A. Copper-Alloy Calibrated Balancing Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Armstrong International, Inc.
   b. Flo Fab Inc.
   c. ITT Corporation; Bell & Gossett Div.
   d. NIBCO Inc.
   e. TAC.
   f. TACO Incorporated.
   g. Watts; a division of Watts Water Technologies, Inc.; Watts Regulator Company.
2. Type: Ball valve with two readout ports and memory-setting indicator.
3. Body: bronze.
4. Size: Same as connected piping, but not larger than NPS 2.
5. Accessories: Meter hoses, fittings, valves, differential pressure meter, and carrying case.

B. Cast-Iron Calibrated Balancing Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Armstrong International, Inc.
   b. Flo Fab Inc.
   c. ITT Corporation; Bell & Gossett Div.
   d. NIBCO Inc.
   e. TAC.
   f. Watts; a division of Watts Water Technologies, Inc.; Watts Regulator Company.
2. Type: Adjustable with Y-pattern globe valve, two readout ports, and memory-setting indicator.
3. Size: Same as connected piping, but not smaller than NPS 2-1/2.

C. Accessories: Meter hoses, fittings, valves, differential pressure meter, and carrying case.

D. Memory-Stop Balancing Valves:

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

2.7 TEMPERATURE-ACTUATED, WATER MIXING VALVES

A. Water-Temperature Limiting Devices:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    a. Armstrong International, Inc.
    b. Cash Acme; a division of Reliance Worldwide Corporation.
    c. Conbraco Industries, Inc.
    d. Honeywell International Inc.
    e. Lawler Manufacturing Company, Inc.
    f. Legend Valve.
    g. Leonard Valve Company.
    h. Powers; a division of Watts Water Technologies, Inc.
    i. Symmons Industries, Inc.
    j. Watts; a division of Watts Water Technologies, Inc.; Watts Regulator Company.
    k. Zurn Industries, LLC; Plumbing Products Group; Wilkins Water Control Products.
2. Standard: ASSE 1017.
3. Pressure Rating: 125 psig.
4. Type: Thermostatically controlled, water mixing valve.
5. Material: Bronze body with corrosion-resistant interior components.
6. Connections: Threaded union inlets and outlet.
7. Accessories: Check stops on hot- and cold-water supplies, and adjustable, temperature-control handle.
8. Tempered-Water Setting: Refer to drawings.
9. Tempered-Water Design Flow Rate: Refer to drawings.
10. Valve Finish: Chrome plated.

B. Primary, Thermostatic, Water Mixing Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    a. Armstrong International, Inc.
    b. Lawler Manufacturing Company, Inc.
    c. Leonard Valve Company.
    d. Powers; a division of Watts Water Technologies, Inc.
    e. Symmons Industries, Inc.
2. Standard: ASSE 1017.
3. Pressure Rating: 125 psig minimum unless otherwise indicated.
4. Type: Exposed-mounted, thermostatically controlled, water mixing valve.

5. Material: Bronze body with corrosion-resistant interior components.
6. Connections: Threaded union inlets and outlet.
7. Accessories: Manual temperature control, check stops on hot- and cold-water supplies, and adjustable, temperature-control handle.
8. Tempered-Water Setting: Refer to drawings.
9. Tempered-Water Design Flow Rate: Refer to drawings.
10. Selected Valve Flow Rate at 45-psig Pressure Drop: Refer to drawings.
11. Pressure Drop at Design Flow Rate: Refer to drawings.
12. Valve Finish: Rough bronze.
13. Piping Finish: Copper.

2.8 STRAINERS FOR DOMESTIC WATER PIPING

A. Y-Pattern Strainers:
   1. Pressure Rating: 125 psig minimum unless otherwise indicated.
   2. Body: Bronze for NPS 2 and smaller; cast iron [with interior lining that complies with AWWA C550 or that is FDA approved, epoxy coated and] for NPS 2-1/2 and larger.
   3. End Connections: Threaded for NPS 2 and smaller; flanged for NPS 2-1/2 and larger.
   4. Screen: Stainless steel with round perforations unless otherwise indicated.
   5. Perforation Size:
      a. Strainers NPS 2 and Smaller: 0.033 inch
      b. Strainers NPS 2-1/2 to NPS 4: 0.062 inch
      c. Strainers NPS 5 and Larger: 0.125 inch
   6. Drain: Factory-installed, hose-end drain valve.

2.9 OUTLET BOXES

A. Clothes Washer Outlet Boxes <Insert drawing designation if any>:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Acorn Engineering Company.
      b. Guy Gray Manufacturing Co., Inc.
      c. IPS Corporation.
      d. LSP Products Group, Inc.
      e. Oatey.
      f. Plastic Oddities.
      g. Symmons Industries, Inc.
      h. Watts; a division of Watts Water Technologies, Inc.; Watts Regulator Company.
      i. Whitehall Manufacturing; a div. of Acorn Engineering Company.
      j. Zurn Industries, LLC; Plumbing Products Group; Light Commercial Products.
   2. Mounting: Recessed.
   3. Material and Finish: Enameled-steel, epoxy-painted-steel, or plastic box and faceplate.
   4. Faucet: Combination valved fitting or separate hot- and cold-water valved fittings complying with ASME A112.18.1. Include garden-hose thread complying with ASME B1.20.7 on outlets.
   5. Supply Shutoff Fittings: NPS 1/2 gate, globe, or ball valves and NPS 1/2 copper, water tubing.
   6. Drain: NPS 2 standpipe and P-trap for direct waste connection to drainage piping.
   7. Inlet Hoses: Two 60-inch- long, rubber household clothes washer inlet hoses with female, garden-hose-thread couplings. Include rubber washers.
   8. Drain Hose: One 48-inch- long, rubber household clothes washer drain hose with hooked end.

B. Icemaker Outlet Boxes:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Acorn Engineering Company.
      b. IPS Corporation.
      c. LSP Products Group, Inc.
      d. Oatey.
      e. Plastic Oddities.
   2. Mounting: Recessed.
   3. Material and Finish: Enameled-steel, epoxy-painted-steel, or plastic box and faceplate.

4. Faucet: Valved fitting complying with ASME A112.18.1. Include NPS 1/2 or smaller copper tube outlet.
5. Supply Shutoff Fitting: NPS 1/2 gate, globe, or ball valve and NPS 1/2 copper, water tubing.

2.10 HOSE STATIONS

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
2. ARCHON Industries, Inc.
3. Armstrong International, Inc.
4. Cooney Brothers, Inc.
5. DynaFluid Ltd.
6. Leonard Valve Company.
7. Strahman Valves, Inc.
8. T & S Brass.

B. Single-Temperature-Water Hose Stations:

1. Standard: ASME A112.18.1.
2. Cabinet: Stainless-steel enclosure with exposed valve handle, hose connection, and hose rack. Include thermometer in front.
3. Hose-Rack Material: Stainless steel.
4. Body Material: Bronze with stainless-steel wetted parts.
5. Body Finish: Rough bronze, chrome plated.
6. Mounting: Wall, with reinforcement
7. Supply Fittings: NPS 3/4 gate, globe, or ball valve and check valve and NPS 3/4 copper, water tubing. Omit check valve if check stop is included with fitting.
8. Hose: Manufacturer's standard, for service fluid, temperature, and pressure; 50 feet long.
9. Nozzle: With hand-squeeze, on-off control.
10. Vacuum Breaker:
    a. Integral or factory-installed, non-removable, manual-drain-type, hose-connection vacuum breaker complying with ASSE 1011 or backflow preventer complying with ASSE 1052.
    b. Garden-hose thread complying with ASME B1.20.7 on outlet.

2.11 HOSE BIBBS

A. Hose Bibbs:

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

2.12 DRAIN VALVES

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

1. Standard: MSS SP-110 for standard-port, two-piece ball valves.
2. Pressure Rating: 400-psig minimum CWP.
3. Size: NPS 3/4.
4. Body: Copper alloy.
5. Ball: Chrome-plated brass.

6. Seats and Seals: Replaceable.
7. Handle: Vinyl-covered steel.
8. Inlet: Threaded or solder joint.
9. Outlet: Threaded, short nipple with garden-hose thread complying with ASME B1.20.7 and cap with brass chain.

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

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

C. Stop-and-Waste Drain Valves:

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

2.13 WATER-HAMMER ARRESTERS

A. Water-Hammer Arresters:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. AMTROL, Inc.
   b. Josam Company.
   c. MIFAB, Inc.
   d. Precision Plumbing Products, Inc.
   e. Sioux Chief Manufacturing Company, Inc.
   f. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
   g. Tyler Pipe; Wade Div.
   h. Watts Drainage Products.
   i. Zurn Industries, LLC; Plumbing Products Group; Specification Drainage Products.
2. Standard: ASSE 1010 or PDI-WH 201.
3. Type: Copper tube with piston.
4. Size: ASSE 1010, Sizes AA and A through F, or PDI-WH 201, Sizes A through F.

2.14 TRAP-SEAL PRIMER DEVICE

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

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. MIFAB, Inc.
   b. Precision Plumbing Products, Inc.
   c. Sioux Chief Manufacturing Company, Inc.
   d. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
   e. Watts; a division of Watts Water Technologies, Inc.; Watts Regulator Company.
2. Standard: ASSE 1018.
3. Pressure Rating: 125 psig minimum.
4. Body: Bronze.
5. Inlet and Outlet Connections: NPS 1/2 threaded, union, or solder joint.
6. Gravity Drain Outlet Connection: NPS 1/2 threaded or solder joint.
7. Finish: Chrome plated, or rough bronze for units used with pipe or tube that is not chrome finished.

B. Drainage-Type, Trap-Seal Primer Device:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.

2. Standard: ASSE 1044, lavatory P-trap with NPS 3/8 minimum, trap makeup connection.
3. Size: NPS 1-1/4 minimum.
4. Material: Chrome-plated, cast brass.

2.15 FLEXIBLE CONNECTORS

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
2. Flex-Hose Co., Inc.
3. Flexicraft Industries.
4. Flex Pression, Ltd.
5. Flex-Weld Incorporated.
6. Hyspan Precision Products, Inc.
7. Mercer Gasket & Shim, Inc.
8. Metraflex, Inc.
9. Proco Products, Inc.
10. TOZEN Corporation.
11. Unaflex.Universal Metal Hose; a Hyspan company.

B. Bronze-Hose Flexible Connectors: Corrugated-bronze tubing with bronze wire-braid covering and ends brazed to inner tubing.

1. Working-Pressure Rating: Minimum 200 psig.
2. End Connections NPS 2 and Smaller: Threaded copper pipe or plain-end copper tube.
3. End Connections NPS 2-1/2 and Larger: Flanged copper alloy.

C. Stainless-Steel-Hose Flexible Connectors: Corrugated-stainless-steel tubing with stainless-steel wire-braid covering and ends welded to inner tubing.

1. Working-Pressure Rating: Minimum 200 psig.
2. End Connections NPS 2 and Smaller: Threaded steel-pipe nipple.
3. End Connections NPS 2-1/2 and Larger: Flanged steel nipple.

PART 3 EXECUTION

3.1 INSTALLATION

A. Install backflow preventers in each water supply to mechanical equipment and systems and to other equipment and water systems that may be sources of contamination. Comply with authorities having jurisdiction.

1. Locate backflow preventers in same room as connected equipment or system.
2. Install drain for backflow preventers with atmospheric-vent drain connection with air-gap fitting, fixed air-gap fitting, or equivalent positive pipe separation of at least two pipe diameters in drain piping and pipe-to-floor drain. Locate air-gap device attached to or under backflow preventer. Simple air breaks are unacceptable for this application.
3. Do not install bypass piping around backflow preventers.

B. Install water regulators with inlet and outlet shutoff valves and bypass with memory-stop balancing valve. Install pressure gages on inlet and outlet.

C. Install water-control valves with inlet and outlet shutoff valves and bypass with globe valve. Install pressure gages on inlet and outlet.

D. Install balancing valves in locations where they can easily be adjusted.

E. Install temperature-actuated, water mixing valves with check stops or shutoff valves on inlets and with shutoff valve on outlet.

1. Install cabinet-type units recessed in or surface mounted on wall as specified.

F. Install Y-pattern strainers for water on supply side of each control valve, water pressure-reducing valve, solenoid valve and pump.

G. Install outlet boxes recessed in wall or surface mounted on wall. Install 2-by-4-inch fire-retardant-treated-wood blocking, wall reinforcement between studs. Comply with requirements for fire-retardant-treated-wood blocking in Section 061000 "Rough Carpentry."

H. Install hose stations with check stops or shutoff valves on inlets and with thermometer on outlet.

1. Install cabinet-type units recessed in or surface mounted on wall as specified. Install 2-by-4-inch fire-retardant-treated-wood blocking, wall reinforcement between studs. Comply with requirements for fire-retardant-treated-wood blocking in Section 061000 "Rough Carpentry."

I. Install ground hydrants with 1 cu. yd. of crushed gravel around drain hole. Set ground hydrants with box flush with grade.

J. Install draining-type post hydrants with 1 cu. yd. of crushed gravel around drain hole. Set post hydrants in concrete paving or in 1 cu. ft. of concrete block at grade.

K. Set non-freeze, non-draining-type post hydrants in concrete or pavement.

L. Set freeze-resistant yard hydrants with riser pipe in concrete or pavement. Do not encase canister in concrete.

M. Install water-hammer arresters in water piping according to PDI-WH 201.

N. Install air vents at high points of water piping. Install drain piping and discharge onto floor drain.

O. Install supply-type, trap-seal primer valves with outlet piping pitched down toward drain trap a minimum of 1 percent, and connect to floor-drain body, trap, or inlet fitting. Adjust valve for proper flow.

P. Install drainage-type, trap-seal primer valves as lavatory trap with outlet piping pitched down toward drain trap a minimum of 1 percent, and connect to floor-drain body, trap, or inlet fitting.

Q. Install trap-seal primer systems with outlet piping pitched down toward drain trap a minimum of 1 percent, and connect to floor-drain body, trap, or inlet fitting. Adjust system for proper flow.

3.2 CONNECTIONS

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

B. Fire-retardant-treated-wood blocking is specified in Section 260519 "Low-Voltage Electrical Power Conductors and Cables" for electrical connections.

3.3 LABELING AND IDENTIFYING

A. Equipment Nameplates and Signs: Install engraved plastic-laminate equipment nameplate or sign on or near each of the following:

1. Pressure vacuum breakers.
2. Intermediate atmospheric-vent backflow preventers.
3. Reduced-pressure-principle backflow preventers.
4. Double-check, backflow-prevention assemblies.
5. Carbonated-beverage-machine backflow preventers.
6. Dual-check-valve backflow preventers.
7. Reduced-pressure-detector, fire-protection, backflow-preventer assemblies.
8. Double-check, detector-assembly backflow preventers.
9. Water pressure-reducing valves.
10. Calibrated balancing valves.
11. Primary, thermostatic, water mixing valves.
12. Manifold, thermostatic, water mixing-valve assemblies.
13. Photographic-process, thermostatic, water mixing-valve assemblies.
14. Primary water tempering valves.
15. Outlet boxes.
16. Hose stations.
17. Supply-type, trap-seal primer valves.
18. Trap-seal primer systems.

B. Distinguish among multiple units, inform operator of operational requirements, indicate safety and emergency precautions, and warn of hazards and improper operations, in addition to identifying unit. Nameplates and signs are specified in Section 220553 "Identification for Plumbing Piping and Equipment."

3.4 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Test each pressure vacuum breaker, reduced-pressure-principle backflow preventer, double-check, backflow-prevention assembly and double-check, detector-assembly backflow preventer according to authorities having jurisdiction and the device's reference standard.

B. Domestic water piping specialties will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

3.5 ADJUSTING

A. Set field-adjustable pressure set points of water pressure-reducing valves.

B. Set field-adjustable flow set points of balancing valves.

C. Set field-adjustable temperature set points of temperature-actuated, water mixing valves.

END OF SECTION

SECTION 221316
SANITARY WASTE AND VENT PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
   1. Pipe, tube, and fittings.
   2. Specialty pipe fittings.
   3. Encasement for underground metal piping.

1.3 DEFINITIONS

A. EPDM: Ethylene-propylene-diene terpolymer rubber.

1.4 PERFORMANCE REQUIREMENTS

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

1.5 ACTION SUBMITTALS

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

1.6 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.7 QUALITY ASSURANCE

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

B. Comply with NSF/ANSI 14, "Plastics Piping Systems Components and Related Materials," for plastic piping components. Include marking with "NSF-DWV" for plastic drain, waste, and vent piping and "NSF-sewer" for plastic sewer piping.

PART 2 - PRODUCTS

2.1 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 PIPING MATERIALS

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

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

A. Pipe and Fittings: ASTM A 74, Service class.
   1. Manufacturers:

a. AB&I Foundry
b. Charlotte Pipe and Foundry
c. Tyler Pipe; Soil Pipe Division

B. Gaskets: ASTM C 564, rubber.

2.4 HUBLESS, CAST-IRON SOIL PIPE AND FITTINGS

A. Pipe and Fittings: ASTM A 888 or CISPI 301.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. AB&I Foundry
   b. Charlotte Pipe and Foundry
   c. Tyler Pipe; Soil Pipe Division

B. Standard Hubless-Piping Couplings:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. ANACO-Husky.
   b. Dallas Specialty & Manufacturing Company
   c. Fernco Incorporated
   d. Ideal
   e. Matco-Norca, Incorporated
   f. MIFAB, Incorporated
   g. Mission Rubber Company; a division of MCP Industries, Incorporated
   h. Stant.
   i. Tyler Pipe.
2. Standards: ASTM C 1277; CISPI Designation 310-09, NSF Certified.
3. Description: 301 stainless-steel corrugated shield with stainless-steel bands and tightening devices; and ASTM C 564, Neoprene sleeve with integral, center pipe stop.
4. Bands:
   a. NPS 4 inches and less: 2 bands, 60 inch pounds torque.
   b. NPS 5 to NPS 10: 4 bands, 60 inch pounds torque.
   c. NPS 12 and larger: 6 bands, 80 inch pounds torque.

2.5 PVC PIPE AND FITTINGS

A. Solid-Wall PVC Pipe: ASTM D 2665, drain, waste, and vent.

B. Cellular-Core PVC Pipe: ASTM F 891, Schedule 40.

C. PVC Socket Fittings: ASTM D 2665, made to ASTM D 3311, drain, waste, and vent patterns and to fit Schedule 40 pipe.

D. Adhesive Primer: ASTM F 656.

E. Solvent Cement: ASTM D 2564.

2.6 SPECIALTY PIPE FITTINGS

A. Transition Couplings:

1. General Requirements: Fitting or device for joining piping with small differences in OD's or of different materials. Include end connections same size as and compatible with pipes to be joined.
2. Fitting-Type Transition Couplings: Manufactured piping coupling or specified piping system fitting.
3. Unshielded, Non-pressure Transition Couplings:
   a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      1) Dallas Specialty & Manufacturing Company
      2) Fernco Incorporated
      3) Mission Rubber Company; a division of MCP Industries, Incorporated
      4) Plastic Oddities; a division of Diverse Corporate Technologies, Incorporated
   b. Standard: ASTM C 1173, NSF Certified.

c. Description: Elastomeric, sleeve-type, reducing or transition pattern. Include shear ring and corrosion-resistant-metal tension band and tightening mechanism on each end.
d. Sleeve Materials:
1) For Cast-Iron Soil Pipes: ASTM C 564, rubber.
2) For Plastic Pipes: ASTM F 477, elastomeric seal or ASTM D 5926, PVC.
3) For Dissimilar Pipes: ASTM D 5926, PVC or other material compatible with pipe materials being joined.

4. Shielded, Non-pressure Transition Couplings:
a. Manufacturers: Subject to compliance with requirements, [provide products by one of the following:
1) Cascade Waterworks Manufacturing Company
2) Mission Rubber Company; a division of MCP Industries, Incorporated
b. Standard: ASTM C 1460, NSF Certified.
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.

2.7 ENCASEMENT FOR UNDERGROUND METAL PIPING

A. Standard: ASTM A 674 or AWWA C105/A 21.5.

B. Material: Linear low-density polyethylene film of 0.008-inch.

C. Form: Sheet.

D. Color: Black.

PART 3 - EXECUTION

3.1 EARTH MOVING

A. Comply with requirements for excavating, trenching, and backfilling specified in Division 31 Section "Earth Moving."

3.2 PIPING INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on coordination drawings.

B. Sanitary sewer piping more than 5-feet outside the building is specified in Division 33 Section "Sanitary Sewerage."

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. Make changes in direction for soil and waste drainage and vent piping using appropriate branches, bends, and long-sweep bends. Sanitary tees and short-sweep 1/4 bends may be used on vertical stacks if change in direction of flow is from horizontal to vertical. Use long-turn, double Y-branch and 1/8-bend fittings if two fixtures are installed back to back or side by side with common drain pipe. Straight tees, elbows, and crosses may be used on vent lines. Do not change direction of flow more than 90 degrees. Use proper size of standard increasers and reducers if pipes of different sizes are connected. Reducing size of drainage piping in direction of flow is prohibited.

L. Install soil and waste drainage and vent piping at the following minimum slopes unless otherwise indicated:

1. Building Sanitary Drain: 2 percent downward in direction of flow for piping NPS 3 and smaller; 1 percent downward in direction of flow for piping NPS 4 and larger.
2. Horizontal Sanitary Drainage Piping: 2 percent downward in direction of flow.
3. Vent Piping: 1 percent down toward vertical fixture vent or toward vent stack.

M. Install cast-iron soil piping according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook," Chapter IV, "Installation of Cast Iron Soil Pipe and Fittings."

1. Install encasement on underground piping according to ASTM A 674 or AWWA C105/A 21.5.

N. Install steel piping according to applicable plumbing code.

O. Install underground PVC piping according to ASTM D 2321.

3.3 PLUMBING SPECIALTIES

A. Install backwater valves in sanitary waste gravity-flow piping. Comply with requirements for backwater valves specified in Division 22 Section "Sanitary Waste Piping Specialties."

B. Install cleanouts at grade and extend to where building sanitary drains connect to building sanitary sewers in sanitary drainage gravity-flow piping. Install cleanout fitting with closure plug inside the building in sanitary drainage force-main piping. Comply with requirements for cleanouts specified in Division 22 Section "Sanitary Waste Piping Specialties."

C. Install drains in sanitary drainage gravity-flow piping. Comply with requirements for drains specified in Division 22 Section "Sanitary Waste Piping Specialties."

D. Do not enclose, cover, or put piping into operation until it is inspected and approved by authorities having jurisdiction.

E. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Division 22 Section "Sleeves and Sleeve Seals for Plumbing Piping."

F. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Division 22 Section "Sleeves and Sleeve Seals for Plumbing Piping."

G. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Division 22 Section "Escutcheons for Plumbing Piping."

3.4 JOINT CONSTRUCTION

A. Join hub-and-spigot, cast-iron soil piping with gasket joints according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for compression joints.

B. Join hubless, cast-iron soil piping according to CISPI 310 and CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for hubless-piping coupling joints.

C. Plastic, Non-pressure-Piping, Solvent-Cement Joints: Clean and dry joining surfaces. Join pipe and fittings according to the following:

1. Comply with ASTM F 402 for safe-handling practice of cleaners, primers, and solvent cements.
2. PVC Piping: Join according to ASTM D 2855 and ASTM D 2665 Appendixes.

3.5 SPECIALTY PIPE FITTING INSTALLATION

A. Transition Couplings:

1. Install transition couplings at joints of piping with small differences in OD's.
2. In Drainage Piping: Shielded, non-pressure transition couplings.

3. In Aboveground Force Main Piping: Fitting-type transition couplings.
4. In Underground Force Main Piping:
   a. NPS 1-1/2 and Smaller: Fitting-type transition couplings.
   b. NPS 2 and Larger: Pressure transition couplings.

3.6 VALVE INSTALLATION

A. General valve installation requirements are specified in Division 22 Section "General-Duty Valves for Plumbing Piping."

B. Backwater Valves: Install backwater valves in piping subject to backflow.
   1. Horizontal Piping: Horizontal backwater valves. [Use normally closed type unless otherwise indicated.]
   2. Floor Drains: Drain outlet backwater valves unless drain has integral backwater valve.
   3. Install backwater valves in accessible locations.
   4. Comply with requirements for backwater valve specified in Division 22 Section "Sanitary Waste Piping Specialties."

3.7 HANGER AND SUPPORT INSTALLATION

A. Comply with requirements for pipe hanger and support devices and installation specified in Division 22 Section "Hangers and Supports for Plumbing Piping and Equipment."
   1. Install carbon-steel pipe hangers for horizontal piping in noncorrosive environments.
   2. Install 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. Install individual, straight, horizontal piping runs:
      a. 100 Feet and Less: MSS Type 1, adjustable, steel clevis hangers.
      b. Longer than 100 Feet: MSS Type 43, adjustable roller hangers.
      c. Longer than 100 Feet if Indicated: MSS Type 49, spring cushion rolls.
   7. Multiple, Straight, Horizontal Piping Runs 100 Feet or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
   8. Base of Vertical Piping: MSS Type 52, spring hangers.

B. Support horizontal piping and tubing within 18 inches of each fitting and coupling.

C. Support vertical piping and tubing at base and at each floor.

D. Rod diameter may be reduced one size for double-rod hangers, with 3/8-inch minimum rods.

E. Install hangers for cast-iron soil piping with the following maximum horizontal spacing and minimum rod diameters:
   1. NPS 1-1/2 and NPS 2: 60 inches with 3/8-inch rod.
   2. NPS 3: 60 inches with 1/2-inch rod.
   3. NPS 4 and NPS 5: 60 inches with 5/8-inch rod.
   4. NPS 6 and NPS 8: 60 inches with 3/4-inch rod.
   5. NPS 10 and NPS 12: 60 inches with 7/8-inch rod.
   6. Spacing for 10-foot lengths may be increased to 10 feet. Spacing for fittings is limited to 60 inches.

F. Install supports for vertical cast-iron soil piping every 15 feet.

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

H. Bracing: Horizontal cast-iron pipe and fittings NPS 5 and larger shall be braced to prevent horizontal movement. Bracing shall be located at each branch connection and each change of direction.

3.8 CONNECTIONS

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

B. Connect soil and waste piping to exterior sanitary sewerage piping. Use transition fitting to join dissimilar piping materials.

C. Connect drainage and vent piping to the following:

1. Plumbing Fixtures: Connect drainage piping in sizes indicated, but not smaller than required by plumbing code.
2. Plumbing Fixtures and Equipment: Connect atmospheric vent piping in sizes indicated, but not smaller than required by authorities having jurisdiction.
3. Plumbing Specialties: Connect drainage and vent piping in sizes indicated, but not smaller than required by plumbing code.
4. Install test tees (wall cleanouts) in conductors near floor and floor cleanouts with cover flush with floor.
5. Install horizontal backwater valves with cleanout cover flush with floor.
6. Comply with requirements for backwater valves, cleanouts, and drains specified in Division 22 Section "Sanitary Waste Piping Specialties."
7. 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.

D. Where installing piping adjacent to equipment, allow space for service and maintenance of equipment.

3.9 IDENTIFICATION

A. Identify exposed sanitary waste and vent piping. Comply with requirements for identification specified in Division 22 Section "Identification for Plumbing Piping and Equipment."

3.10 FIELD QUALITY CONTROL

A. During installation, notify authorities having jurisdiction at least 24 hours before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction.

1. Roughing-in Inspection: Arrange for inspection of piping before concealing or closing-in after roughing-in and before setting fixtures.
2. Final Inspection: Arrange for final inspection by authorities having jurisdiction to observe tests specified below and to ensure compliance with requirements.

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

C. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.

D. Test sanitary drainage and vent piping according to procedures of authorities having jurisdiction or, in absence of published procedures, as follows:

1. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.
2. Leave uncovered and unconcealed new, altered, extended, or replaced drainage and vent piping until it has been tested and approved. Expose work that was covered or concealed before it was tested.
3. Roughing-in Plumbing Test Procedure: Test drainage and vent piping except outside leaders on completion of roughing-in. Close openings in piping system and fill with water to point of overflow, but not less than 10-foot head of water. From 15 minutes before inspection starts to completion of inspection, water level must not drop. Inspect joints for leaks.
4. Finished Plumbing Test Procedure: After plumbing fixtures have been set and traps filled with water, test connections and prove they are gastight and watertight. Plug vent-stack openings on roof and building drains where they leave building. Introduce air into piping system equal to pressure of 1-inch wg. Use U-tube or manometer inserted in trap of water closet to measure this pressure. Air pressure must remain constant without introducing additional air throughout period of inspection. Inspect plumbing fixture connections for gas and water leaks.
5. Repair leaks and defects with new materials and retest piping, or portion thereof, until satisfactory results are obtained.
6. Prepare reports for tests and required corrective action.

3.11 CLEANING AND PROTECTION

A. Clean interior of piping. Remove dirt and debris as work progresses.

B. Protect drains during remainder of construction period to avoid clogging with dirt and debris and to prevent damage from traffic and construction work.

C. Place plugs in ends of uncompleted piping at end of day and when work stops.

3.12 PIPING SCHEDULE

A. Aboveground, soil and waste piping NPS 1.5 and smaller shall be the following:
   1. Hubless, cast-iron soil pipe and fittings; standard hubless-piping couplings; and coupled joints.

B. Aboveground, soil and waste piping NPS 2 to NPS 10 shall be the following:
   1. Hubless, cast-iron soil pipe and fittings; standard hubless-piping couplings; and coupled joints.

C. Aboveground, vent piping NPS 1.5 and smaller shall be the following:
   1. Hubless, cast-iron soil pipe and fittings; standard hubless-piping couplings; and coupled joints.

D. Aboveground, vent piping NPS 2 to NPS 10 shall be the following:
   1. Hubless, cast-iron soil pipe and fittings; standard hubless-piping couplings; and coupled joints.

E. Underground, soil, waste, and vent piping NPS 12 and smaller shall be the following:
   1. Solid wall PVC pipe, PVC socket fittings, and solvent-cemented joints.
   2. Dissimilar Pipe-Material Couplings: Shielded, non-pressure transition couplings.

END OF SECTION

SECTION 221319
SANITARY WASTE PIPING 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. Section Includes:
   1. Backwater valves.
   2. Cleanouts.
   3. Floor drains.
   4. Roof flashing assemblies.
   5. Through-penetration fire stops assemblies.
   6. Miscellaneous sanitary drainage piping specialties.
   7. Flashing materials.

B. Related Requirements:
   1. Division 22 Section "Storm Drainage Piping Specialties" for storm drainage piping inside the building, drainage piping specialties, and drains.
   2. Division 22 Section "Plumbing Fixtures" for hair interceptors.
   3. Division 22 Section "Healthcare Plumbing Fixtures" for plaster sink interceptors.
   4. Division 33 Section "Storm Utility Drainage Piping" for storm draining piping and piping specialties outside the building.

1.3 DEFINITIONS

A. ABS: Acrylonitrile-butadiene-styrene plastic.

B. FRP: Fiberglass-reinforced plastic.

C. HDPE: High-density polyethylene plastic.

D. PE: Polyethylene plastic.

E. PP: Polypropylene plastic.

F. PVC: Polyvinyl chloride plastic.

1.4 INFORMATIONAL SUBMITTALS

A. Field quality-control test reports.

1.5 CLOSEOUT SUBMITTALS

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

1.6 QUALITY ASSURANCE

A. Drainage piping specialties shall bear label, stamp, or other markings of specified testing agency.

B. Comply with NSF 14, "Plastics Piping Components and Related Materials," for plastic sanitary piping specialty components.

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 size and location of roof penetrations.

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. Cultures: Provide 1-gallon bottles of bacteria culture recommended by manufacturer of FOG disposal systems equal to 200 percent of amount installed, but no fewer than 2 1-gallon bottles.

PART 2 PRODUCTS

2.1 BACKWATER VALVES

A. Horizontal, Cast-Iron Backwater Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Josam Company; Josam Div.
   b. Smith, Jay R. Mfr. Co.; Division of Smith Industries, Inc.
   c. Tyler Pipe; Wade Div.
   d. Watts Drainage Products Inc.
   e. Zurn Plumbing Products Group; Specification Drainage Operation.
2. Standard: ASME A112.14.1.
3. Size: Same as connected piping.
4. Body: Cast iron.
5. Cover: Cast iron with bolted access check valve.
6. End Connections: Hub and spigot or hubless.
7. Type Check Valve: Removable, bronze, swing check, factory assembled or field modified to hang open for airflow unless subject to backflow condition.
8. Extension: ASTM A 74, Service class; full-size, cast-iron, soil-pipe extension to field-installed cleanout at floor; replaces backwater valve cover.

B. Drain-Outlet Backwater Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Josam Company; Josam Div.
   b. Smith, Jay R. Mfr. Co.; Division of Smith Industries, Inc.
   c. Watts Drainage Products Inc.
   d. Zurn Plumbing Products Group; Specification Drainage Operation.
2. Size: Same as floor drain outlet.
3. Body: Cast iron or bronze made for vertical installation in bottom outlet of floor drain.
4. Check Valve: Removable ball float.
5. Inlet: Threaded.
6. Outlet: Threaded or spigot.

C. Horizontal, Plastic Backwater Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Canplas LLC.
   b. IPS Corporation.
   c. NDS Inc.
   d. Oatey.
   e. Plastic Oddities; a division of Diverse Corporate Technologies.
   f. Sioux Chief Manufacturing Company, Inc.
   g. Zurn Plumbing Products Group; Light Commercial Operation.
2. Size: Same as connected piping.
3. Body: ABS or PVC to match adjoining pipe material.
4. Cover: Same material as body with threaded access to check valve.
5. Check Valve: Removable swing check.
6. End Connections: Socket type.

2.2 CLEANOUTS

A. Exposed Metal Cleanouts:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    a. Josam Company; Josam Div.
    b. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
    c. Tyler Pipe; Wade Div.
    d. Watts Drainage Products Inc.
    e. Zurn Plumbing Products Group; Specification Drainage Operation.
    f. Josam Company; Blucher-Josam Div.
2. Standard: ASME A112.36.2M for cast iron or ASME A112.3.1 for stainless steel for cleanout test tee.
3. Refer to cleanout schedule on drawings.

B. Metal Floor Cleanouts:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    a. Josam Company; Josam Div.
    b. Oatey.
    c. Sioux Chief Manufacturing Company, Inc.
    d. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
    e. Tyler Pipe; Wade Div.
    f. Watts Drainage Products Inc.
    g. Zurn Plumbing Products Group; Light Commercial Operation.
    h. Zurn Plumbing Products Group; Specification Drainage Operation.
    i. Kusel Equipment Co.
2. Standard: ASME A112.36.2M
3. Refer to cleanout schedule on drawings.

C. Cast-Iron Wall Cleanouts:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    a. Josam Company; Josam Div.
    b. MIFAB, Inc.
    c. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
    d. Tyler Pipe; Wade Div.
    e. Watts Drainage Products Inc.
    f. Zurn Plumbing Products Group; Specification Drainage Operation.
2. Standard: ASME A112.36.2M. Include wall access.
3. Wall Access: Round, nickel-bronze, copper-alloy, or stainless-steel wall-installation frame and cover.
4. Refer to cleanout schedule on drawings.

D. Plastic Floor Cleanouts:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    a. Canplas LLC.
    b. IPS Corporation.
    c. NDS Inc.
    d. Plastic Oddities; a division of Diverse Corporate Technologies.
    e. Sioux Chief Manufacturing Company, Inc.
    f. Zurn Plumbing Products Group; Light Commercial Operation.
2. Size: Same as connected branch.
3. Body: PVC.
4. Refer to cleanout schedule on drawings.

2.3 FLOOR DRAINS

A. Cast-Iron Floor Drains:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    a. Commercial Enameling Co.
    b. Josam Company; Josam Div.

c. MIFAB, Inc.
d. Prier Products, Inc.
e. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
f. Tyler Pipe; Wade Div.
g. Watts Drainage Products Inc.
h. Zurn Plumbing Products Group; Light Commercial Operation.
i. Zurn Plumbing Products Group; Specification Drainage Operation.
2. Standard: ASME A112.6.3 with backwater valve.
3. Refer to floor drain schedule on drawings:

B. Stainless-Steel Floor Drains:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Josam Company; Blucher-Josam Div.
   b. Josam Company; Josam Div.
   c. Kusel Equipment Co.
   d. Scherping Systems, Inc.
   e. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
   f. Tyler Pipe; Wade Div.
   g. Watts Drainage Products Inc.
   h. Zurn Plumbing Products Group; Specification Drainage Operation.
2. Standard: ASME A112.3.1 or ASME A112.6.3.
3. Refer to floor drain schedule on drawings:

C. Plastic Floor Drains:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Canplas LLC.
   b. IPS Corporation.
   c. Josam Company; Josam Div.
   d. Oatey.
   e. Plastic Oddities; a division of Diverse Corporate Technologies.
   f. Sioux Chief Manufacturing Company, Inc.
   g. Zurn Plumbing Products Group; Light Commercial Operation.
2. Standard: ASME A112.6.3.
3. Refer to floor drain schedule on drawings:

2.4 TRENCH DRAINS

A. Trench Drains:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Josam Company; Josam Div.
   b. MIFAB, Inc.
   c. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
   d. Tyler Pipe; Wade Div.
   e. Watts Drainage Products Inc.
   f. Zurn Plumbing Products Group; Specification Drainage Operation.
2. Standard: ASME A112.6.3 for trench drains.
3. Refer to trench drain schedule on drawings:

2.5 ROOF FLASHING ASSEMBLIES

A. Roof Flashing Assemblies <Insert drawing designation if any>:

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

B. Description: Manufactured assembly made of 6.0-lb/sq. ft., 0.0938-inch- thick, lead flashing collar and skirt extending at least 6 inches from pipe, with galvanized-steel boot reinforcement and counter flashing fitting.

1. Extended Vent Cap: With field-installed, vandal-proof vent cap.

2.6 THROUGH-PENETRATION FIRESTOP ASSEMBLIES

A. Through-Penetration Fire stop Assemblies:

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

2.7 MISCELLANEOUS SANITARY DRAINAGE PIPING SPECIALTIES

A. Open Drains:

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

B. Deep-Seal Traps:

1. Description: Cast-iron or bronze casting, with inlet and outlet matching connected piping and cleanout trap-seal primer valve connection.
2. Size: Same as connected waste piping.
    a. NPS 2: 4-inch- minimum water seal.
    b. NPS 2-1/2 and Larger: 5-inch- minimum water seal.

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

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

D. Air-Gap Fittings:

1. Standard: ASME A112.1.2, for fitting designed to ensure fixed, positive air gap between installed inlet and outlet piping.
2. Body: Bronze or cast iron.
3. Inlet: Opening in top of body.
4. Outlet: Larger than inlet.
5. Size: Same as connected waste piping and with inlet large enough for associated indirect waste piping.

E. Stack Flashing Fittings:

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

F. Vent Caps:

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

G. Frost-Resistant Vent Terminals:

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

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

2.8 FLASHING MATERIALS

A. Lead Sheet: ASTM B 749, Type L51121, copper bearing, with the following minimum weights and thicknesses, unless otherwise indicated:
   1. General Use: 4.0-lb/sq. ft., 0.0625-inch thickness.
   2. Vent Pipe Flashing: 3.0-lb/sq. ft., 0.0469-inch thickness.
   3. Burning: 6-lb/sq. ft., 0.0938-inch thickness.

B. Copper Sheet: ASTM B 152/B 152M, of the following minimum weights and thicknesses, unless otherwise indicated:
   1. General Applications: 12 oz. /sq. ft.
   2. Vent Pipe Flashing: 8 oz. /sq. ft.

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

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

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

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

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

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

PART 3 EXECUTION

3.1 INSTALLATION

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

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

C. For floor cleanouts for piping below floors, install cleanout deck plates with top flush with finished floor.

D. For cleanouts located in concealed piping, install cleanout wall access covers, of types indicated, with frame and cover flush with finished wall.

E. Install floor drains at low points of surface areas to be drained. Set grates of drains flush with finished floor, unless otherwise indicated.
   1. Position floor drains for easy access and maintenance.
   2. Set floor drains below elevation of surrounding finished floor to allow floor drainage. Set with grates depressed according to the following drainage area radii:

a. Radius, 30 Inches or Less: Equivalent to 1 percent slope, but not less than 1/4-inch total depression.
b. Radius, 30 to 60 Inches: Equivalent to 1 percent slope.
c. Radius, 60 Inches or Larger: Equivalent to 1 percent slope, but not greater than 1-inch total depression.

3. Install floor-drain flashing collar or flange so no leakage occurs between drain and adjoining flooring. Maintain integrity of waterproof membranes where penetrated.
4. Install individual traps for floor drains connected to sanitary building drain, unless otherwise indicated.

F. Install roof flashing assemblies on sanitary stack vents and vent stacks that extend through roof.

G. Install flashing fittings on sanitary stack vents and vent stacks that extend through roof.

H. Install through-penetration fire stop assemblies in plastic conductors and stacks at floor penetrations.

I. Install deep-seal traps on floor drains and other waste outlets, if indicated.

J. Install floor-drain, trap-seal primer fittings on inlet to floor drains that require trap-seal primer connection.

1. Exception: Fitting may be omitted if trap has trap-seal primer connection.
2. Size: Same as floor drain inlet.

K. Install air-gap fittings on draining-type backflow preventers and on indirect-waste piping discharge into sanitary drainage system.

L. Install sleeve flashing device with each riser and stack passing through floors with waterproof membrane.

M. Install frost-resistant vent terminals on each vent pipe passing through roof. Maintain 1-inch clearance between vent pipe and roof substrate.

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

O. Install frost-proof vent caps on each vent pipe passing through roof. Maintain 1-inch clearance between vent pipe and roof substrate.

P. Install inflammable waste trap with cleanout immediately downstream from trap that do not have integral cleanout on outlet.

Q. Install wood-blocking reinforcement for wall-mounting-type specialties.

R. Install traps on plumbing specialty drain outlets. Omit traps on indirect wastes unless trap is indicated.

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. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

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

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 6.0-lb/sq. ft., 0.0938-inch thickness or thicker. Solder joints of lead sheets 4.0-lb/sq. ft., 0.0625-inch thickness or thinner.
2. Copper Sheets: Solder joints of copper sheets.

B. Install sheet flashing on pipes, sleeves, 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 counter-flashing or commercially made flashing fittings, according to Division 07 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 of the following:

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

3.5 PROTECTION

A. Protect drains during remainder of construction period to avoid clogging with dirt or debris and to prevent damage from traffic or construction work.

B. Place plugs in ends of uncompleted piping at end of each day or when work stops.

END OF SECTION

SECTION 221413
FACILITY 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 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
   1. Pipe, tube, and fittings.
   2. Specialty pipe fittings.
   3. Encasement for underground metal piping.

1.3 DEFINITIONS

A. Hub Drain: Open ended drainage pipe. The hub end of a hub and spigot cast iron, or PVC pipe; open pipe end of a cast iron no-hub system. Hub drain material shall be the same as the connecting drainage system.

1.4 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. Coordinate with project requirements.

1.5 ACTION SUBMITTALS

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

B. Shop Drawings: Required only for controlled-flow or siphonic roof drainage system. Include calculations, plans, and details.

1.6 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.7 QUALITY ASSURANCE

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

1.8 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 without Owner's written permission.

PART 2 PRODUCTS

2.1 PIPING MATERIALS

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

2.2 HUBLESS, CAST-IRON SOIL PIPE AND FITTINGS

A. Pipe and Fittings: ASTM A 888 or CISPI 301.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. AB&I Foundry
   b. Charlotte Pipe and Foundry
   c. Tyler Pipe; Soil Pipe Division

B. CISPI, Hubless-Piping Couplings:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. ANACO-Husky.
   b. Dallas Specialty & Mfg. Co.
   c. Fernco Inc.
   d. Ideal
   e. Matco-Norca, Inc.
   f. MIFAB, Inc.
   g. Mission Rubber Company; a division of MCP Industries, Inc.
   h. Stant.
2. Standards: ASTM C 1277 and CISPI 310.
3. Description: Stainless-steel corrugated shield with stainless-steel bands and tightening devices; and ASTM C 564, rubber sleeve with integral, center pipe stop.

C. Heavy-Duty, Hubless-Piping Couplings:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. ANACO-Husky.
   b. Clamp-All Corp.
   c. Dallas Specialty & Mfg. Co.
   d. Ideal
   e. MIFAB, Inc.
   f. Mission Rubber Company; a division of MCP Industries, Inc.
   g. Stant.
   h. Tyler Pipe.
2. Standards: ASTM C 1277 and ASTM C 1540.
3. Description: Stainless-steel shield with stainless-steel bands and tightening devices; and ASTM C 564, rubber sleeve with integral, center pipe stop.

D. Cast-Iron, Hubless-Piping Couplings:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. MG Piping Products Company.
2. Standard: ASTM C 1277.
3. Description: Two-piece ASTM A 48/A 48M, cast-iron housing; stainless-steel bolts and nuts; and ASTM C 564, rubber sleeve with integral, center pipe stop.

2.3 PVC PIPE AND FITTINGS

A. Solid-Wall PVC Pipe: ASTM D 2665, drain, waste, and vent.

B. Cellular-Core PVC Pipe: ASTM F 891, Schedule 40.

C. PVC Socket Fittings: ASTM D 2665, made to ASTM D 3311, drain, waste, and vent patterns and to fit Schedule 40 pipe.

D. Adhesive Primer: ASTM F 656.

1. Adhesive primer shall have a VOC content of 550 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

E. Solvent Cement: ASTM D 2564.

2.4 SPECIALTY PIPE FITTINGS

A. Transition Couplings:

1. General Requirements: Fitting or device for joining piping with small differences in OD's or of different materials. Include end connections same size as and compatible with pipes to be joined.
2. Fitting-Type Transition Couplings: Manufactured piping coupling or specified-piping-system fitting.
3. Unshielded, Non-pressure Transition Couplings:
4. 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.
5. Shielded, Non-pressure Transition Couplings:
6. 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.

PART 3 EXECUTION

3.1 EARTH MOVING

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

3.2 PIPING INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations from layout are approved on coordination drawings.

B. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.

C. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

D. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

E. Install piping to permit valve servicing.

F. Install piping at indicated slopes.

G. Install piping free of sags and bends.

H. Install fittings for changes in direction and branch connections.

I. Install piping to allow application of insulation.

J. Make changes in direction for storm drainage piping using appropriate branches, bends, and long-sweep bends. Do not change direction of flow more than 90 degrees. Use proper size of standard increasers and reducers if pipes of different sizes are connected. Reducing size of drainage piping in direction of flow is prohibited.

K. Lay buried building storm drainage piping beginning at low point of each system. Install true to grades and alignment indicated, with unbroken continuity of invert. Place hub ends of piping up-stream. Install required gaskets according to manufacturer's written instructions for use of lubri-cants, cements, and other installation requirements. Maintain swab in piping and pull past each joint as completed.

L. Install storm drainage piping at the following minimum slopes unless otherwise indicated by the lo-cal Authority Having Jurisdiction over the project:

1. Building Storm Drain: 1 percent downward in direction of flow for piping NPS 3 and smaller; 2 percent downward in direction of flow for piping NPS 4 and larger.
2. Horizontal Storm-Drainage Piping: 2 percent downward in direction of flow.

M. Install cast-iron soil piping according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook," Chap-ter IV, "Installation of Cast Iron Soil Pipe and Fittings."

N. Install steel piping according to applicable plumbing code.

O. Install underground PVC piping according to ASTM D 2321.

P. Plumbing Specialties:

1. Install backwater valves in storm drainage gravity-flow piping. Comply with requirements for backwater valves specified in Section 221423 "Storm Drainage Piping Specialties."
2. Install cleanouts at grade and extend to where building storm drains connect to building storm sewers in storm drainage gravity-flow piping. Install cleanout fitting with closure plug inside the building in storm drainage force-main piping. Comply with requirements for cleanouts specified in Section 221423 "Storm Drainage Piping Specialties."
3. Install drains in storm drainage gravity-flow piping. Comply with requirements for drains speci-fied in Section 221423 "Storm Drainage Piping Specialties."

Q. Do not enclose, cover, or put piping into operation until it is inspected and approved by authorities having jurisdiction.

R. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 220517 "Sleeves and Sleeve Seals for Plumbing Piping."

S. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 220517 "Sleeves and Sleeve Seals for Plumbing Piping."

T. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 220518 "Escutcheons for Plumbing Piping."

3.3 JOINT CONSTRUCTION

A. Hubless, Cast-Iron Soil Piping Coupled Joints: Join according to CISPI 310 and CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for hubless-piping coupling joints.

B. Plastic, Non-pressure-Piping, Solvent-Cemented Joints: Clean and dry joining surfaces. Join pipe and fittings according to the following:

1. Comply with ASTM F 402 for safe-handling practice of cleaners, primers, and solvent cements.
2. PVC Piping: Join according to ASTM D 2855 and ASTM D 2665 Appendixes.

3.4 SPECIALTY PIPE FITTING INSTALLATION

A. Transition Couplings:

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

3.5 VALVE INSTALLATION

A. General valve installation requirements are specified in Section 220523 "General-Duty Valves for Plumbing Piping."

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.

D. Backwater Valves: Install backwater valves in piping subject to backflow.

1. Horizontal Piping: Horizontal backwater valves. Use normally closed type unless otherwise indicated.
2. Install backwater valves in accessible locations.
3. Comply with requirements for backwater valves specified in Section 221423 "Storm Drainage Piping Specialties."

3.6 HANGER AND SUPPORT INSTALLATION

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

1. Install carbon-steel pipe hangers for horizontal piping in noncorrosive environments.
2. Install 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 1, adjustable, steel clevis hangers.
7. Multiple, Straight, Horizontal Piping Runs 100 Feet or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
8. Base of Vertical Piping: MSS Type 52, spring hangers.

B. Support horizontal piping and tubing within 18 inches of each fitting, valve, and coupling.

C. Support vertical piping and tubing at base and at each floor.

D. Rod diameter may be reduced one size for double-rod hangers, with 3/8-inch minimum rods.

E. Install hangers for cast-iron soil piping with the following maximum horizontal spacing and minimum rod diameters:

1. NPS 1-1/2 and NPS 2: 60 inches with 3/8-inch rod.
2. NPS 3: 60 inches with 1/2-inch rod.
3. NPS 4 and NPS 5: 60 inches with 5/8-inch rod.
4. NPS 6 and NPS 8: 60 inches with 3/4-inch rod.
5. NPS 10 and NPS 12: 60 inches with 7/8-inch rod.
6. Spacing for 10-foot pipe lengths may be increased to 10 feet. Spacing for fittings is limited to 60 inches.

F. Install supports for vertical cast-iron soil piping every 15 feet.

G. 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.
2. Install horizontal backwater valves [with cleanout cover flush with floor] [in pit with pit cover flush with floor] <Insert description>.
3. Comply with requirements for backwater valves, cleanouts and drains specified in Section 221423 "Storm Drainage Piping Specialties."

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 Section 220553 "Identification for Plumbing Piping and Equipment."

3.9 FIELD QUALITY CONTROL

A. During installation, notify authorities having jurisdiction at least 24 hours before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction.

1. Roughing-in Inspection: Arrange for inspection of piping before concealing or closing-in after roughing-in.
2. Final Inspection: Arrange for final inspection by authorities having jurisdiction to observe tests specified below and to ensure compliance with requirements.

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

C. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.

D. Test storm drainage piping according to procedures of authorities having jurisdiction or, in absence of published procedures, as follows:

1. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.
2. Leave uncovered and unconcealed new, altered, extended, or replaced storm drainage piping until it has been tested and approved. Expose work that was covered or concealed before it was tested.
3. Test Procedure: Test storm drainage piping, except outside leaders, on completion of roughing-in. Close openings in piping system and fill with water to point of overflow, but not less than 10-foot head of water. From 15 minutes before inspection starts until completion of inspection, water level must not drop. Inspect joints for leaks.
4. Repair leaks and defects with new materials and retest piping, or portion thereof, until satisfactory results are obtained.
5. Prepare reports for tests and required corrective action.

E. Test force-main piping according to procedures of authorities having jurisdiction or, in absence of published procedures, as follows:

1. Leave uncovered and unconcealed new, altered, extended, or replaced force-main piping until it has been tested and approved. Expose work that was covered or concealed before it was tested.
2. Cap and subject piping to static-water pressure of 50 psig above operating pressure, without exceeding pressure rating of piping system materials. Isolate test source and allow to stand for four hours. Leaks and loss in test pressure constitute defects that must be repaired.
3. Repair leaks and defects with new materials and retest piping, or portion thereof, until satisfactory results are obtained.
4. Prepare reports for tests and required corrective action.

3.10 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.

3.11 PIPING SCHEDULE

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. Hubless, cast-iron soil pipe and fittings; CISPI, heavy-duty, hubless-piping couplings; and coupled joints.

C. Aboveground, storm drainage piping NPS 8 and larger shall be any of the following:

1. Hubless, cast-iron soil pipe and fittings; CISPI, heavy-duty, hubless-piping couplings; and coupled joints.

D. Underground storm drainage piping NPS 6 and smaller shall be any of the following:

1. Hubless, cast-iron soil pipe and fittings; CISPI, heavy-duty, hubless-piping couplings; and coupled joints.
2. Solid-wall PVC pipe, PVC socket fittings, and solvent-cemented joints.
3. Dissimilar Pipe-Material Couplings: Shielded, non-pressure transition couplings.

E. Underground, storm drainage piping NPS 8 and larger shall be any of the following:

1. Hubless, cast-iron soil pipe and fittings; CISPI, heavy-duty, hubless-piping couplings; and coupled joints.
2. Solid-wall PVC pipe, PVC socket fittings, and solvent-cemented joints.
3. Cellular-core, sewer and drain series, PVC pipe; PVC socket fittings; and solvent-cemented joints.
4. Dissimilar Pipe-Material Couplings: Shielded, non-pressure transition couplings.

F. Aboveground storm drainage force mains NPS 1-1/2 and NPS 2 shall be any of the following:

1. Hard copper tube, copper pressure fittings, and soldered joints.
2. Galvanized-steel pipe, pressure fittings, and threaded joints.

G. Aboveground storm drainage force mains NPS 2-1/2 to NPS 6 shall be any of the following:

1. Galvanized-steel pipe, pressure fittings, and threaded joints.
2. Grooved-end, galvanized-steel pipe; grooved-joint, galvanized-steel-pipe appurtenances; and grooved joints.
3. Fitting-type transition couplings if dissimilar pipe materials.

H. Underground storm drainage force mains shall be any of the following:

1. Solid-wall PVC pressure pipe, PVC pressure fittings, and solvent-cemented joints.
2. Fitting-type transition coupling for piping smaller than NPS 1-1/2 and pressure transition coupling for NPS 1-1/2 and larger if dissimilar pipe materials.

END OF SECTION

SECTION 221423
STORM DRAINAGE PIPING SPECIALTIES

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. Roof drains.
   2. Miscellaneous storm drainage piping specialties.
   3. Cleanouts.
   4. Backwater valves.
   5. Trench drains.
   6. Through-penetration firestop assemblies.
   7. Flashing materials.

1.3 ACTION SUBMITTALS

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

1.4 QUALITY ASSURANCE

A. Drainage piping specialties shall bear label, stamp, or other markings of specified testing agency.

PART 2 PRODUCTS

2.1 METAL ROOF DRAINS

A. Cast-Iron, Large-Sump, General-Purpose Roof Drains:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following
      a. Josam Company.
      b. Smith, Jay R. Mfg. Co.
      c. Tyler Pipe.
      d. Watts Water Technologies, Inc.
      e. Zurn Plumbing Products Group; Specification Drainage Operation.
   2. Standard: ASME A112.6.4, for general-purpose roof drains.
   3. Combination Flashing Ring and Gravel Stop: Not required
   4. Extension Collars: Not required
   5. Expansion Joint: Not required
   6. Sump Receiver Plate: Not required
   7. Vandal-Proof Dome: Not required
   8. Refer to roof drain schedule for additional characteristics.

B. Cast-Iron, Medium-Sump, General-Purpose Roof Drains:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following
      a. Josam Company.
      b. Marathon Roofing Products.
      c. Portals Plus; Commercial Products Group of Hart & Cooley, Inc.
      d. Smith, Jay R. Mfg. Co.
      e. Tyler Pipe.
      f. Watts Water Technologies, Inc.
      g. Zurn Plumbing Products Group; Light Commercial Products Operation.
      h. Zurn Plumbing Products Group; Specification Drainage Operation.

2. Standard: ASME A112.6.4, for general-purpose roof drains.
3. Combination Flashing Ring and Gravel Stop: Not required
4. Extension Collars: Not required
5. Expansion Joint: Not required
6. Sump Receiver Plate: Not required
7. Refer to roof drain schedule for additional characteristics.

2.2 MISCELLANEOUS STORM DRAINAGE PIPING SPECIALTIES

A. Downspout Adaptors:

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

B. Downspout Boots:

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

C. Conductor Nozzles <Insert drawing designation if any>:

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

D. Expansion Joints:

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

2.3 CLEANOUTS

A. Floor Cleanouts:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following
   a. Josam Company.
   b. Oatey.
   c. Sioux Chief Manufacturing Company, Inc.
   d. Smith, Jay R. Mfg. Co.
   e. Tyler Pipe.
   f. Watts Water Technologies, Inc.
   g. Zurn Plumbing Products Group; Light Commercial Products Operation.
   h. Zurn Plumbing Products Group; Specification Drainage Operation.
2. Standard: ASME A112.36.2M, for adjustable housing cleanouts.
3. Size: Same as connected branch.
4. Type: Adjustable housing
5. Body or Ferrule Material: Cast iron
6. Clamping Device: Not required
7. Adjustable Housing Material: Cast iron or Plastic with threads or set-screws or other device.
8. Frame and Cover Shape: Round
9. Top-Loading Classification: Medium Duty.
10. Riser: ASTM A 74, Service class, cast-iron drainage pipe fitting and riser to cleanout.

B. Test Tees:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following
   a. Josam Company.
   b. Smith, Jay R. Mfg. Co.
   c. Tyler Pipe.
   d. Watts Water Technologies, Inc.
   e. Zurn Plumbing Products Group; Specification Drainage Operation.

2. Standard: ASME A112.36.2M and ASTM A 74, ASTM A 888, or CISPI 301, for cleanout test tees.
3. Size: Same as connected drainage piping.
4. Body Material: Hub-and-spigot, cast-iron soil-pipe T-branch or hubless, cast-iron soil-pipe test tee as required to match connected piping.
5. Closure Plug: Countersunk
6. Closure Plug Size: Same as or not more than one size smaller than cleanout size.

C. Wall Cleanouts:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following
   a. Josam Company.
   b. MIFAB, Inc.
   c. Smith, Jay R. Mfg. Co.
   d. Tyler Pipe.
   e. Watts Water Technologies, Inc.
   f. Zurn Plumbing Products Group; Specification Drainage Operation.
2. Standard: ASME A112.36.2M, for cleanouts. Include wall access.
3. Size: Same as connected drainage piping.
4. Body Material: Hubless, cast-iron soil-pipe test tee as required to match connected piping.
5. Closure: Countersunk Raised-head, brass plug.
6. Closure Plug Size: Same as or not more than one size smaller than cleanout size.
7. Wall Access: Round, flat, chrome-plated brass or stainless-steel cover plate with screw.
8. Wall Access (where installed in drywall): Round, nickel-bronze, copper-alloy, or stainless-steel wall-installation frame and cover.

2.4 BACKWATER VALVES

A. Cast-Iron, Horizontal Backwater Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following
   a. Josam Company.
   b. Smith, Jay R. Mfg. Co.
   c. Tyler Pipe.
   d. Watts Water Technologies, Inc.
   e. Zurn Plumbing Products Group; Specification Drainage Operation.
2. Standard: ASME A112.14.1, for backwater valves.
3. Size: Same as connected piping.
4. Body Material: Cast iron.
5. Cover: Cast iron with bolted or threaded access check valve.
6. End Connections: hubless.
7. Check Valve: Removable, bronze, swing check, factory assembled or field modified to hang open for airflow unless subject to backflow condition.
8. Extension: ASTM A 74, Service class; full-size, cast-iron soil-pipe extension to field-installed cleanout at floor; replaces backwater valve cover.

2.5 TRENCH DRAINS

A. Trench Drains:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following
   a. Josam Company.
   b. MIFAB, Inc.
   c. Smith, Jay R. Mfg. Co.
   d. Tyler Pipe.
   e. Watts Water Technologies, Inc.
   f. Zurn Plumbing Products Group; Specification Drainage Operation.
2. Standard: ASME A112.6.3, for trench drains.
3. Body Material: Cast iron.
4. Flange, Clamping Device, Outlet Location, Grate Finish, Frame and Grate Dimensions, Top-Loading Classification: See drawings and schedules.

2.6 THROUGH-PENETRATION FIRESTOP ASSEMBLIES

A. Through-Penetration Firestop Assemblies:

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

2.7 FLASHING MATERIALS

A. Copper Sheet: ASTM B 152/B 152M, 12 oz. /sq. ft.

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

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

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

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

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

PART 3 EXECUTION

3.1 INSTALLATION

A. Install roof drains at low points of roof areas according to roof membrane manufacturer's written installation instructions.

1. Install flashing collar or flange of roof drain to prevent leakage between drain and adjoining roofing. Maintain integrity of waterproof membranes where penetrated.
2. Install expansion joints, if indicated, in roof drain outlets.
3. Position roof drains for easy access and maintenance.

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

C. Install downspout boots at grade with top 18 inches above grade. Secure to building wall.

D. Install conductor nozzles at exposed bottom of conductors where they spill onto grade.

E. Install cleanouts in aboveground piping and building drain piping according to the following instructions unless otherwise indicated:

1. Use cleanouts the same size as drainage piping up to NPS 4. Use NPS 4 for larger drainage piping unless larger cleanout is indicated.
2. Locate cleanouts at each change in direction of piping greater than 45 degrees.
3. Locate cleanouts at minimum intervals of 50 feet for piping NPS 4 and smaller and 100 feet for larger piping.
4. Locate cleanouts at base of each vertical soil and waste stack.

F. For floor cleanouts for piping below floors, install cleanout deck plates with top flush with finished floor.

G. For cleanouts located in concealed piping, install cleanout wall access covers, of types indicated, with frame and cover flush with finished wall.

H. Install horizontal backwater valves in floor with cover flush with floor.

I. Install drain-outlet backwater valves in outlet of drains.

J. Install test tees in vertical conductors and near floor.

K. Install wall cleanouts in vertical conductors. Install access door in wall if indicated.

L. Install through-penetration firestop assemblies in plastic conductors at concrete floor penetrations.

M. Install sleeve flashing device with each conductor passing through floors with waterproof membrane.

3.2 CONNECTIONS

A. Comply with requirements for piping specified in Section 221413 "Facility Storm Drainage Piping." Drawings indicate general arrangement of piping, fittings, and specialties.

3.3 FLASHING INSTALLATION

A. Fabricate flashing from single piece of metal unless large pans, sumps, or other drainage shapes are required. Join flashing according to the following if required:

1. Lead Sheets: Burn joints of 6.0-lb/sq. ft. lead sheets, 0.0938-inch thickness or thicker. Solder joints of 4.0-lb/sq. ft. lead sheets, 0.0625-inch thickness or thinner.

B. Install sheet flashing on pipes, sleeves, and specialties passing through or embedded in floors and roofs with waterproof membrane.

1. Pipe Flashing: Sleeve type, matching the pipe size, with a minimum length of 10 inches and with skirt or flange extending at least 8 inches around pipe.
2. Sleeve Flashing: Flat sheet, with skirt or flange extending at least 8 inches around sleeve.
3. Embedded Specialty Flashing: Flat sheet, with skirt or flange extending at least 8 inches around specialty.

C. Set flashing on floors and roofs in solid coating of bituminous cement.

D. Secure flashing into sleeve and specialty clamping ring or device.

E. Fabricate and install flashing and pans, sumps, and other drainage shapes.

3.4 PROTECTION

A. Protect drains during remainder of construction period to avoid clogging with dirt or debris and to prevent damage from traffic or construction work.

B. Place plugs in ends of uncompleted piping at end of each day or when work stops.

END OF SECTION

SECTION 224000
PLUMBING FIXTURES AND WATER COOLERS

PART 1 GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes the following conventional plumbing fixtures and related components:

1. Faucets.
2. Flushometers.
3. Toilet seats.
4. Protective shielding guards.
5. Fixture supports.
6. Water closets.
7. Urinals.
8. Lavatories.
9. Commercial sinks.
10. Kitchen sinks.
11. Service sinks.
12. Service basins.
13. Electric water cooler with bottle filler.

B. Related Sections include the following:

1. Division 10 Section "Toilet, Bath, and Laundry Accessories."
2. Division 22 Section "Emergency Plumbing Fixtures."
3. Division 22 Section "Drinking Fountains and Water Coolers."

1.3 DEFINITIONS

A. ABS: Acrylonitrile-butadiene-styrene plastic.

B. Accessible Fixture: Plumbing fixture that can be approached, entered, and used by people with disabilities.

C. Cast Polymer: Cast-filled-polymer-plastic material. This material includes cultured-marble and solid-surface materials.

D. Cultured Marble: Cast-filled-polymer-plastic material with surface coating.

E. Fitting: Device that controls the flow of water into or out of the 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.

F. FRP: Fiberglass-reinforced plastic.

G. PMMA: Polymethyl methacrylate (acrylic) plastic.

H. PVC: Polyvinyl chloride plastic.

I. Solid Surface: Nonporous, homogeneous, cast-polymer-plastic material with heat-, impact-, scratch-, and stain-resistance qualities.

J. Water Cooler: Electrically powered fixture for generating and delivering cooled drinking water.

1.4 SUBMITTALS

A. Product Data: For each type of plumbing fixture indicated. Include selected fixture and trim, fittings, accessories, appliances, appurtenances, equipment, and supports. Indicate materials and finishes, dimensions, construction details, and flow-control rates.

B. Shop Drawings: Diagram power, signal, and control wiring.

C. Operation and Maintenance Data: For plumbing fixtures to include in emergency, operation, and maintenance manuals.

D. Warranty: Special warranty specified in this Section.

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. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

C. Regulatory Requirements: Comply with requirements in ICC A117.1, "Accessible and Usable Buildings and Facilities"; Public Law 90-480, "Architectural Barriers Act"; and Public Law 101-336, "Americans with Disabilities Act"; for plumbing fixtures for people with disabilities.

D. Regulatory Requirements: Comply with requirements in Public Law 102-486, "Energy Policy Act," about water flow and consumption rates for plumbing fixtures.

E. NSF Standard: Comply with NSF 61, "Drinking Water System Components--Health Effects," for fixture materials that will be in contact with potable water.

F. Select combinations of fixtures and trim, faucets, fittings, and other components that are compatible.

G. Comply with the following applicable standards and other requirements specified for plumbing fixtures:

1. Enameled, Cast-Iron Fixtures: ASME A112.19.1M.
2. Porcelain-Enameled, Formed-Steel Fixtures: ASME A112.19.4M.
3. Solid-Surface-Material Lavatories and Sinks: ANSI/ICPA SS-1.
4. Stainless-Steel Residential Sinks: ASME A112.19.3.
5. Vitreous-China Fixtures: ASME A112.19.2M.
6. Water-Closet, Flushometer Tank Trim: ASSE 1037.

H. Comply with the following applicable standards and other requirements specified for lavatory and sink faucets:

1. Faucets: ASME A112.18.1.
2. Hose-Connection Vacuum Breakers: ASSE 1011.
3. Hose-Coupling Threads: ASME B1.20.7.
4. Integral, Atmospheric Vacuum Breakers: ASSE 1001.
5. NSF Potable-Water Materials: NSF 61.
6. Pipe Threads: ASME B1.20.1.
7. Sensor-Actuated Faucets and Electrical Devices: UL 1951.
8. Supply Fittings: ASME A112.18.1.
9. Brass Waste Fittings: ASME A112.18.2.

I. Comply with the following applicable standards and other requirements specified for miscellaneous fittings:

1. Atmospheric Vacuum Breakers: ASSE 1001.
2. Brass and Copper Supplies: ASME A112.18.1.
3. Dishwasher Air-Gap Fittings: ASSE 1021.
4. Manual-Operation Flushometers: ASSE 1037.
5. Plastic Tubular Fittings: ASTM F 409.
6. Brass Waste Fittings: ASME A112.18.2.
7. Sensor-Operation Flushometers: ASSE 1037 and UL 1951.

J. Comply with the following applicable standards and other requirements specified for miscellaneous components:

1. Floor Drains: ASME A112.6.3.

2. Off-Floor Fixture Supports: ASME A112.6.1M.
3. Pipe Threads: ASME B1.20.1.
4. Supply and Drain Protective Shielding Guards: ICC A117.1.

1.6 WARRANTY

A. Special Warranties: Manufacturer's standard form in which manufacturer agrees to repair or replace components of whirlpools that fail in materials or workmanship within specified warranty period.
   1. Failures include, but are not limited to, the following:
      a. Structural failures of unit shell.
      b. Faulty operation of controls, blowers, pumps, heaters, and timers.
      c. Deterioration of metals, metal finishes, and other materials beyond normal use.
   2. Warranty Period for Commercial Applications: Three years from date of Substantial Completion.
   3. Warranty Period Applications of Pumps and Blowers: Five years from date of Substantial Completion.
   4. Warranty Period for Applications of Electronic Controls: Five years from date of Substantial Completion.

PART 2 PRODUCTS

2.1 EXISTING CONDITIONS

A. Where there are existing plumbing fixtures the new fixtures shall match the existing fixtures.

2.2 LAVATORY FAUCETS

A. Lavatory Faucets: Refer to plumbing fixture schedule
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Chicago Faucets.
      b. Elkay Manufacturing Company
      c. Grohe America, Incorporated
      d. Moen, Incorporated
      e. T & S Brass and Bronze Works, Incorporated
   2. Hennepin County standard for water use for lavatory faucets: 0.5 gallons per minute.

2.3 SINK FAUCETS

A. Sink Faucets: Refer to plumbing fixture schedule.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. American Standard Companies, Incorporated
      b. Chicago Faucets.
      c. Elkay Manufacturing Company
      d. Grohe America, Incorporated
      e. Moen, Incorporated
      f. Speakman
      g. T & S Brass and Bronze Works, Incorporated

2.4 FLUSHOMETERS

A. Flushometers: Refer to plumbing fixture schedule
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Sloan Valve Company.

2.5 TOILET SEATS

A. Toilet Seats: Refer to plumbing fixture schedule

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. American Standard Companies, Incorporated
   b. Bemis Manufacturing Company.
   c. PlumBest
   d. Church Seats.
   e. Eljer.
   f. Kohler Company
   g. Olsonite Corp.
   h. Sanderson Plumbing Products, Incorporated; Beneke Division
   i. Sperzel.

2.6 PROTECTIVE SHIELDING GUARDS

A. Protective Shielding Pipe Covers: Refer to plumbing fixture schedule.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Engineered Brass Company
      b. Insul-Tect Products Company; a Subsidiary of MVG Molded Products.
      c. McGuire Manufacturing Company, Incorporated
      d. Plumberex Specialty Products Incorporated
      e. TCI Products.
      f. TRUEBRO, Incorporated
   2. Description: Manufactured plastic wraps for covering plumbing fixture hot- and cold-water supplies and trap and drain piping. Comply with Americans with Disabilities Act (ADA) requirements.

2.7 FIXTURE SUPPORTS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Josam Company.
   2. Smith, Jay R. Mfg. Company
   3. Tyler Pipe; Wade Division

B. Water-Closet Supports: Refer to plumbing fixture schedule
   1. Description: Combination carrier designed for accessible and standard mounting height of wall-mounting, water-closet-type fixture. 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.

C. Urinal Supports: Refer to plumbing fixture schedule.
   1. Description: Type I, urinal carrier with fixture support plates and coupling with seal and fixture bolts and hardware matching fixture and type II, urinal carrier with hanger and bearing plates for wall-mounting, urinal-type fixture. Include steel uprights with feet.
   2. Accessible-Fixture Support: Include rectangular steel uprights.

D. Lavatory Supports: Refer to plumbing fixture schedule.
   1. Description: Type I, lavatory carrier with exposed arms and tie rods, type II, lavatory carrier with concealed arms and tie rod, and type III, lavatory carrier with hanger plate and tie rod for wall-mounting, lavatory-type fixture. Include steel uprights with feet.
   2. Accessible-Fixture Support: Include rectangular steel uprights.

E. Sink Supports: Refer to plumbing fixture schedule.
   1. Description: Type I, sink carrier with exposed arms and tie rods, type II, sink carrier with hanger plate, bearing studs, and tie rod, and type III, sink carrier with hanger plate and exposed arms for sink-type fixture. Include steel uprights with feet.

2.8 WATER CLOSETS

A. Water Closets: Refer to plumbing fixture schedule

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    a. American Standard Companies, Incorporated
    b. Crane Plumbing, L.L.C./Fiat Products.
    c. Eljer.
    d. Kohler Company
    e. Sloan Valve Company
2. Hennepin County standard for water use for water closets: 1.6 gallons per flush.

2.9 URINALS

A. Urinals: Refer to plumbing fixture schedule.
    1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
        a. American Standard Companies, Incorporated
        b. Crane Plumbing, L.L.C./Fiat Products.
        c. Eljer.
        d. Kohler Company
        e. Sloan Valve Company
    2. Hennepin County standard for water use for urinals: 0.5 gallons per flush.

2.10 LAVATORIES

A. Lavatories; Refer to plumbing fixture schedule.
    1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
        a. American Standard Companies, Incorporated
        b. Crane Plumbing, L.L.C./Fiat Products.
        c. Eljer.
        d. Kohler Company
        e. Sloan Valve Company

2.11 COMMERCIAL SINKS

A. Commercial Sinks: Refer to plumbing fixture schedule.
    1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
        a. Advance Tabco.
        b. Elkay Manufacturing Company
        c. Just Manufacturing Company.
        d. Metal Masters Foodservice Equipment Company, Incorporated

2.12 KITCHEN SINKS

A. Kitchen Sinks: Refer to plumbing fixture schedule.
    1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
        a. Elkay Manufacturing Company
        b. Franke Consumer Products, Incorporated, Kitchen Systems Division
        c. Just Manufacturing Company.
        d. Kohler Company
        e. Moen, Incorporated
        f. Revere Sink.
        g. Sterling Plumbing Group, Incorporated

2.13 SERVICE SINKS

A. Service Sinks: Refer to plumbing fixture schedule.
    1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
        a. American Standard Companies, Incorporated

b. Commercial Enameling Company.
c. Eljer.
d. Kohler Company

2.14 SERVICE BASINS

A. Service Basins: Refer to plumbing fixture schedule.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Acorn Engineering Company.
      b. Crane Plumbing, L.L.C./Fiat Products.
      c. Florestone Products Company, Incorporated
      d. Precast Terrazzo Enterprises, Incorporated
      e. Stern-Williams Company, Incorporated

2.15 ELECTRIC WATER COOLER WITH BOTTLE FILLER

A. Manufacturers:
   1. Elkay Manufacturing Company.

B. Description:
   1. Electric water cooler with bottle filling station. (Elkay Model EZH2O or approved equivalent.)
   2. Shall deliver 8 GPH of 50F of drinking water at 90 F ambient and 80F inlet water.
   3. Type 304 stainless steel.
   4. Front and side pushbar button.
   5. Bottle filling unit shall include electronic ssensor for touchless activation with an auomatic 20 second shut off timer.
   6. Filter with visual filter monitor.
   7. Mount unit at ADA accessible height.

PART 3 EXECUTION

3.1 COORDINATION

A. Coordinate plumbing fixture rough-in locations and plumbing fixture manufactures installation requirements.

3.2 EXAMINATION

A. Examine roughing-in of water supply and sanitary drainage and vent piping systems to verify actual locations of piping connections before plumbing fixture installation.

B. Examine cabinets, counters, floors, and walls for suitable conditions where fixtures will be installed before rough-in.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.3 INSTALLATION

A. Assemble plumbing fixtures, trim, fittings, and other components according to manufacturers' written instructions.

B. Install off-floor supports, affixed to building substrate, for wall-mounting fixtures.
   1. Use carrier supports with waste fitting and seal for back-outlet fixtures.
   2. Use carrier supports without waste fitting for fixtures with tubular waste piping.
   3. Use chair-type carrier supports with rectangular steel uprights for accessible fixtures.

C. Install back-outlet, wall-mounting fixtures onto waste fitting seals and attach to supports.

D. Install wall-mounting fixtures with tubular waste piping attached to supports.

E. Install counter-mounting fixtures in and attached to casework.

F. Install fixtures level and plumb according to roughing-in drawings.

G. Install water-supply piping with stop on each supply to each fixture to be connected to water distribution piping. Attach supplies to supports or substrate within pipe spaces behind fixtures. Install stops in locations where they can be easily reached for operation.
   1. Exception: Use ball valves if supply stops are not specified with fixture. Valves are specified in Division 22 Section "General-Duty Valves for Plumbing Piping."

H. Install trap and tubular waste piping on drain outlet of each fixture to be directly connected to sanitary drainage system.

I. Install tubular waste piping on drain outlet of each fixture to be indirectly connected to drainage system.

J. Install accessible urinals with rim height not more than 17-inches or less than 16.5-inches above the finished floor.

K. Install flush valves for accessible urinals with handle centered 44-inches above the finished floor.

L. Install toilet seats on water closets.

M. Install traps on fixture outlets.
   1. Exception: Omit trap on fixtures with integral traps.
   2. Exception: Omit trap on indirect wastes, unless otherwise indicated.

N. Install escutcheons at piping wall ceiling penetrations in exposed, finished locations and within cabinets and millwork. Use deep-pattern escutcheons if required to conceal protruding fittings. Escutcheons are specified in Division 22 Section "Common Work Results for Plumbing."

O. Seal joints between fixtures and walls, floors, and countertops using sanitary-type, one-part, mildew-resistant silicone sealant. Match sealant color to fixture color. Sealants are specified in Division 07 Section "Joint Sealants."

3.4 CONNECTIONS

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

B. Connect fixtures with water supplies, stops, and risers, and with traps, soil, waste, and vent piping. Use size fittings required to match fixtures.

C. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

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

3.5 FIELD QUALITY CONTROL

A. Verify that installed plumbing fixtures are categories and types specified for locations where installed.

B. Check that plumbing fixtures are complete with trim, faucets, fittings, and other specified components.

C. Inspect installed plumbing fixtures for damage. Replace damaged fixtures and components.

D. Test installed fixtures after water systems are pressurized for proper operation. Replace malfunctioning fixtures and components, then retest. Repeat procedure until units operate properly.

E. Install fresh batteries in sensor-operated mechanisms.

3.6 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.

C. Replace washers and seals of leaking and dripping faucets and stops.

D. Install fresh batteries in sensor-operated mechanisms.

3.7 CLEANING

A. Clean fixtures, faucets, and other fittings with manufacturers' recommended cleaning methods and materials. Do the following:

   1. Remove faucet spouts and strainers, remove sediment and debris, and reinstall strainers and spouts.
   2. Remove sediment and debris from drains.

B. After completing installation of exposed, factory-finished fixtures, faucets, and fittings, inspect exposed finishes and repair damaged finishes.

3.8 PROTECTION

A. Provide protective covering for installed fixtures and fittings.

B. Do not allow use of plumbing fixtures for temporary facilities unless approved in writing by Owner.

END OF SECTION

SECTION 230500
COMMON WORK RESULTS 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. This Section includes the following:
   1. Piping materials and installation instructions common to most piping systems.
   2. Transition fittings.
   3. Dielectric fittings.
   4. Grout.
   5. HVAC demolition.
   6. Equipment installation requirements common to equipment sections.
   7. Painting and finishing.
   8. Concrete bases.
   9. Supports and anchorages.

1.3 BASIS-OF-DESIGN

A. Equipment manufacturers listed on the equipment schedules are the basis-of-design. Manufactures listed in the specification other than the basis-of design manufacture are acceptable substitutions. Equipment schedules are on the drawings. Refer to specifications for unscheduled equipment.

1.4 DEFINITIONS

A. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe and duct chases, 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 chases.

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. CPVC: Chlorinated polyvinyl chloride plastic.
   2. PE: Polyethylene plastic.
   3. 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.

1.5 SUBMITTALS

A. Product Data: For the following:
   1. Transition fittings.
   2. Dielectric fittings.

3. Escutcheons.

B. Welding certificates.

C. Coordination Drawings: Submit one copy for the engineers use. Division 23 coordination drawings will not be returned.

1. Detail major elements, components, and systems of mechanical equipment and materials in relationship with other systems, installations, and building components. Show space requirements for installation and access. Indicate if sequence and coordination of installations are important to efficient flow of the Work. Include the following:
   a. Planned piping layout, including valve and specialty locations and valve-stem movement.
   b. Planned piping hanger layout including building attachments and building structural coordination.
   c. Clearances for installing and maintaining insulation.
   d. Clearances for servicing and maintaining equipment, accessories, and specialties, including space for disassembly required for periodic maintenance.
   e. Equipment and accessory service connections and support details
   f. Exterior wall and foundation penetrations.
   g. Fire- and smoke-rated wall and floor penetration.
   h. Sizes and locations of required concrete equipment curbs and bases.
   i. Scheduling, sequencing, movement, and positioning of large equipment into building during construction.
   j. Floor plans, elevations, and details to indicate penetrations in floors, walls, and ceilings and their relationship to other penetrations and installations.
   k. Access door and panel locations.
   l. Reflected ceiling plans to coordinate and integrate installation of air outlets and inlets, light fixtures, communication system components, sprinklers, and other ceiling-mounted items.

D. Equipment startup reports.

1. Reports will indicate equipment was started and tested according to the manufactures recommendations and is operating as specified. Included test data.

1.6 QUALITY ASSURANCE

A. Comply with ASHRAE Guideline 4 – 2008 Preparation of operating and maintenance documentation for building systems.

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

C. 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.

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

1.7 GUIDELINES, CODES AND STANDARDS

A. Refer to the most recently published edition for references to guidelines, and standards (examples: ASHRAE, NFPA, AWWA, ASTM) unless a specific edition is listed.

B. Installation and materials shall comply with applicable national, state, and local codes and ordinances.

1.8 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.

C. Deliver ducts and air handling equipment with factory or shop applied protective covering. Protective covering shall remain until installation.

D. Materials and equipment stored on site shall have a protective covering; open ends on equipment connections and ducts shall be covered. Duct liner shall be encapsulated.

1.9 COORDINATION

A. Arrange for pipe spaces, chases, slots, and openings in building structure during progress of construction, to allow for HVAC 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 HVAC items requiring access that are concealed behind finished surfaces. Access panels and doors are specified in Division 08 Section "Access Doors and Frames."

PART 2 PRODUCTS

2.1 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. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.

E. 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.

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

G. Solvent Cements for Joining Plastic Piping:

1. CPVC Piping: ASTM F 493.
2. PVC Piping: ASTM D 2564. Include primer according to ASTM F 656.

2.4 DIELECTRIC FITTINGS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Hart Industries, International, Incorporated (www.hartindustries.com)
   2. Pipeline Seal and Insulator, Incorporated (Pipeline Seal and Insulator, Incorporated)
   3. Watts Industries, Incorporated; Water Products Division (www.watts.com)

B. Description: Combination fitting of copper alloy and ferrous materials with threaded, solder-joint, plain, or weld-neck end connections that match piping system materials.

C. Dielectric Flanges: Factory-fabricated, companion-flange assembly, for 150- or 300-psig minimum working pressure as required to suit system pressures.

D. Dielectric-Flange Kits: Companion-flange assembly for field assembly. Include flanges, full-face- or ring-type neoprene or phenolic gasket, phenolic or polyethylene bolt sleeves, phenolic washers, and steel backing washers.
   1. Separate companion flanges and steel bolts and nuts shall have 150- or 300-psig minimum working pressure where required to suit system pressures.

E. Dielectric Nipples: Electroplated steel nipple with inert and noncorrosive, thermoplastic lining; plain, threaded, or grooved ends; and 300-psig minimum working pressure at 225 degrees F.

2.5 CONCRETE BASES

A. Refer to Division 03 Section "Cast-in-Place Concrete".

2.6 GROUT

A. Description: ASTM C 1107, Grade B, non-shrink and nonmetallic, dry hydraulic-cement grout.
   1. Characteristics: Post-hardening, volume-adjusting, non-staining, 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 HVAC DEMOLITION

A. Refer to Division 01 Section "Cutting and Patching" and Division 02 Section "Selective Structure Demolition" for general demolition requirements and procedures. Coordinate demolition with other disciplines, including architecture, electrical, structural and controls.

B. Where system shutdowns are required, schedule demolition work with building management.

C. Disconnect, demolish, and remove HVAC 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: Abandoned piping is to be removed in its entirety. Do not abandon piping in place.
   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: Abandoned ductwork is to be removed in its entirety. Do not abandon piping in place.
   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.

D. 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 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. Sleeves are not required for core-drilled holes through walls.

M. Verify final equipment locations for roughing-in.

N. Refer to equipment specifications in other Sections of these Specifications for roughing-in requirements.

3.3 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.

I. 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 Non-pressure Piping: Join according to ASTM D 2855.

3.4 PIPING CONNECTIONS

A. Make connections according to the following, unless otherwise indicated:
   1. Install unions, in steel 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. Wet Piping Systems: Install dielectric nipple fittings to connect piping materials of dissimilar metals.

3.5 EQUIPMENT INSTALLATION - COMMON REQUIREMENTS

A. Install HVAC equipment according to the equipment manufacturer’s installation instructions and as indicated on the drawings. Resolve conflicting instructions, with the architect before mounting equipment.

B. Install equipment to allow maximum possible headroom unless specific mounting heights are indicated.

C. Install equipment level and plumb, parallel and perpendicular to other building systems and components in exposed interior spaces, unless otherwise indicated.

D. Install HVAC 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.

E. Install equipment to allow right of way for piping installed at required slope.

F. Refer to equipment shop drawings for rough in locations; do not scale drawings.

3.6 PAINTING

A. Painting of HVAC systems, equipment, and components is specified in Division 09 Sections "Interior Painting" and "Exterior Painting."

B. Damage and Touchup: Repair marred and damaged factory-painted finishes with materials and procedures to match original factory finish.

3.7 CONCRETE BASES

A. Concrete Bases: Anchor equipment to concrete base according to equipment manufacturer's written instructions and according to seismic codes at Project.
   1. Construct concrete bases of dimensions indicated, but not less than 4 inches larger in both directions than supported unit.
   2. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of the base.
   3. Install epoxy-coated anchor bolts for supported equipment that extend through concrete base, and anchor into structural concrete floor.
   4. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
   5. Install anchor bolts to elevations required for proper attachment to supported equipment.
   6. Install anchor bolts according to anchor-bolt manufacturer's written instructions.
   7. Use 3000-psi, 28-day compressive-strength concrete and reinforcement as specified in Division 03 Section "Cast-in-Place Concrete”.

3.8 ERECTION OF METAL SUPPORTS AND ANCHORAGES

A. Refer to Division 05 Section "Metal Fabrications" for structural steel.

B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor HVAC materials and equipment.

C. Field Welding: Comply with AWS D1.1.

3.9 ERECTION OF WOOD SUPPORTS AND ANCHORAGES

A. Cut, fit, and place wood grounds, nailers, blocking, and anchorages to support, and anchor HVAC materials and equipment.

B. Select fastener sizes that will not penetrate members if opposite side will be exposed to view or will receive finish materials. Tighten connections between members. Install fasteners without splitting wood members.

C. Attach to substrates as required to support applied loads.

3.10 GROUTING

A. Mix and install grout for HVAC equipment base bearing surfaces, pump and other equipment base plates, and anchors.

B. Clean surfaces that will come into contact with grout.

C. Provide forms as required for placement of grout.

D. Avoid air entrapment during placement of grout.

E. Place grout, completely filling equipment bases.

F. Place grout on concrete bases and provide smooth bearing surface for equipment.

G. Place grout around anchors.

H. Cure placed grout.

3.11 SEALANTS

A. Comply with joint-sealant materials and applications specified in Section 078400 “Firestopping,” Section 078443 “Fire-resistant Joint Sealants,” Section 079000 “Joint Protection,” and Section 092900 “Gypsum Board: Acoustical sealants.”

3.12 RESPONSIBILITY MATRIX (RECOMMENDED)

A. The responsibility matrix is a partial list of items requiring coordination and is only a recommendation to the contractor. The contractor is responsible for the complete installation and operation of equipment and materials.

B. Refer to Division 22 Section “Common Work results for Plumbing” for additional requirements.

C. Key:

1. BAS: Building Automation System (Temperature Control Installer)
2. FP: Fire Protection (Division-21)
3. PLBG: Plumbing Installer (Division-22)
4. HVAC: Mechanical Installer (Division-23)
5. E = Electrical Installer (Division-26)
6. D = Data/Communication Cabling Installer (Division-27)
7. O = Other

System Description	Furnished By	Installed By	Wired/Piped By
Air Handling Unit			
Control damper(s) at unit RA, OA, EA	BAS	HVAC	-
Control damper actuators at unit RA, OA, EA	BAS	BAS	BAS
Control damper(s) remote from unit.	BAS	HVAC	-
Control damper actuator(s) remote from unit	BAS	BAS	BAS
Isolation damper(s)	BAS	HVAC	-

Isolation damper actuator(s)	BAS	BAS	BAS
Cooling coil bypass damper	BAS	HVAC	-
Cooling coil bypass damper actuator	BAS	BAS	BAS
Unit smoke damper(s) & actuator(s)	M	HVAC	BAS
HW/CHW/Humidifier control valve(s)	BAS	PLBG	BAS
Temperature/humidity sensor(s)	BAS	BAS	BAS
Pressure transmitter	BAS	BAS	BAS
Air Flow Measuring Station(s)	BAS	HVAC	BAS
Differential pressure switch	BAS	BAS	BAS
Control relay/current sensor	BAS	BAS	BAS
Variable Frequency Drive(s): Power/Control	HVAC	E	E/BAS
Temperature low limit	BAS	BAS	BAS
Humidity high limit	BAS	BAS	BAS
Static pressure switch	BAS	BAS	BAS
120v power to DDC control panel	E	E	E
Duct smoke detector fan interlock	E	-	-
Duct smoke detector to fire alarm system	E	E	E
Fan Powered VAV Air Terminal			
VAV air terminal unit controls	BAS	BAS	BAS
Temperature sensor	BAS	BAS	BAS
Hot water heating coil control valve	BAS	HVAC	BAS
Fan current sensor	BAS	BAS	BAS
Fan control relay	HVAC	HVAC	BAS
Control transformer	BAS	BAS	E
Fan	HVAC	HVAC	E
VAV Air Terminal			
VAV air terminal controls	BAS	BAS	BAS
Temperature sensor	BAS	BAS	BAS
Hot water heating coil control valve	BAS	HVAC	BAS
Hot Water Unit Heaters			
Thermostat or temperature sensor	BAS	BAS	BAS
Control valve	BAS	HVAC	BAS
Line voltage aquastat	BAS	BAS	BAS
Radiation (Steam Or Hot Water)			
Thermostat or temperature sensor	BAS	BAS	BAS
Control valve	BAS	HVAC	BAS
Exhaust Fan			
Control relay/current sensor	BAS	BAS	BAS
Control damper(s)	BAS	HVAC	-
Control damper actuator(s)	BAS	BAS	BAS
Power Roof Ventilators			
Control relay/current sensor	BAS	BAS	BAS
Control damper(s)	HVAC	HVAC	-
Control damper actuator(s)	HVAC	HVAC	BAS

Network			
LAN wiring to 1st tier supervisory TCP's	D	D	D
BAS 2nd tier (N2 Bus) communication wiring	BAS	BAS	BAS
Control Power			
120v power to DDC panels	E	E	E
120v power to VAV air terminal transformer panel	E	E	E
120v circuit breaker to DDC Panel	E	E	E
Control Wiring			
DDC panel input/output wiring	BAS	BAS	BAS
DDC panel to motor starter/VFD	BAS	BAS	BAS
24v power to dampers/valves	BAS	BAS	BAS
24v power to VAV air terminal	BAS	BAS	BAS
Smoke Damper			
Smoke damper(s) & actuator(s)	HVAC	HVAC	HVAC
120v power to smoke damper(s)	E	E	E
Fire alarm system interlock signal (soft)	E	-	-
Fire Damper			
Fire damper(s)	HVAC	HVAC	-
Combination Fire/Smoke Damper			
Combination fire/smoke damper(s)	HVAC	HVAC	-
Pneumatic actuator(s)	HVAC	HVAC	BAS
Electric actuator	HVAC	HVAC	E
120V to fire/smoke damper(s)	E	E	E
Fire alarm system interlock signal	E	-	-

END OF SECTION

SECTION 230514
VARIABLE-FREQUENCY MOTOR CONTROLLERS (VFC'S)

PART 1 GENERAL

1.1 SUMMARY

A. Section includes separately enclosed, preassembled, combination VFCs, rated 600 V and less, for speed control of three-phase, squirrel-cage induction motors.

B. Variable Frequency Motor Controller Bypass

C. VFC Filtering

D. Related Requirements:
   1. Section 260500 "Common Work Results for Electrical" for basic installation requirements.
   2. Section 260526 "Grounding and Bonding for Electrical Systems" for basic materials and installation of grounding.
   3. Section 262200 "Low-Voltage Transformers" for transformers to serve VFC's.
   4. Section 262813 "Fuses" for installation in VFC's and bypass units.
   5. Section 262816 "Enclosed Switches and Circuit Breakers" for disconnects and overcurrent protection of VFC's.

1.2 DEFINITIONS

A. CE: Conformite Europeene (European Compliance).

B. CPT: Control power transformer.

C. DDC: Direct digital control.

D. EMI: Electromagnetic interference.

E. LED: Light-emitting diode.

F. NC: Normally closed.

G. NO: Normally open.

H. OCPD: Overcurrent protective device.

I. PID: Control action, proportional plus integral plus derivative.

J. PWM: Pulse Width Modulation

K. RFI: Radio-frequency interference.

L. VFC: Variable-frequency motor controller.

1.3 ACTION SUBMITTALS

A. Product Data: For each type and rating of VFC indicated.
   1. Include dimensions and finishes for VFCs.
   2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. Shop Drawings: For each VFC indicated.
   1. Provide coversheet indicating project title, project location, and vendor contact information.
   2. Organize submittal into logical sections and provide table of contents.
   3. Provide itemized bill of materials indicating model number and quantity for each product.
   4. On datasheets with multiple products, indicate which product is provided under this project.
   5. Combine electronic submittals into one unified PDF document that is organized per the table of contents. The submittal shall be free of copyrighted files and proprietary file formats. Electronic links may be submitted to supplement product datasheets, but may not be used as a substitute for product datasheets that are required to be included in the unified PDF submittal.
   6. Manufacturers' catalog sheets with complete technical data for each item being furnished.
   7. Include mounting and attachment details.

8. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
9. Include diagrams for power, signal, and control wiring.
10. Detailed installation drawings including:
    a. Control terminals, designation, and locations
    b. Power circuit diagram identifying disconnects, bypass disconnect, filters or isolation transformer, and motor.
    c. Internal electrical wiring and control circuit diagram
    d. Wiring of auxiliary devices and optional inputs.
    e. Interconnection to harmonic filter traps, line reactors, and dV/dT filters.
11. Furnish a technical brochure or matrix detailing standard VFC features.
    a. Motor horse power and amperage rating.
    b. Power factor at full load.
    c. Input power characteristics.
    d. Full load Efficiency.
    e. Control interface requirements.
    f. Status display system.
    g. Options not listed in specifications.
12. Exceptions and variations from the specification.
13. Include steady state and fault current ratings.
14. Filter characteristics:
    a. Dimensional drawings with installed weight for each size.
    b. Power input characteristics.
    c. Wiring diagram

C. Contractor shall obtain all the VFC's from a single manufacturer for the entire Project. Coordinate between Division 23 prior to submitting shop drawings.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor plans, drawn to scale, showing dimensioned layout on which the following items are shown and coordinated with each other, using input from installers of the items involved:
   1. Required working clearances and required area above and around VFCs.
   2. Show VFC layout and relationships between electrical components and adjacent structural and mechanical elements.
   3. Show support locations, type of support, and weight on each support.
   4. Indicate field measurements.

B. Qualification Data: For testing agency.

C. Product Certificates: For each VFC from manufacturer.

D. Harmonic Analysis Report: Provide Project-specific calculations and manufacturer's statement of compliance with IEEE 519.

E. Source quality-control reports.

F. Field quality-control reports.

G. Sample Warranty: For special warranty.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For VFCs to include in emergency, operation, and maintenance manuals.
   1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:
      a. Manufacturer's written instructions for testing, adjusting, and reprogramming microprocessor control modules.
      b. Manufacturer's written instructions for setting field-adjustable timers, controls, and status and alarm points.

c. Load-Current and Overload-Relay Heater List: Compile after motors have been installed, and arrange to demonstrate that selection of heaters suits actual motor nameplate, full-load currents.

1.6 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Power Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.
2. Control Power Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than two of each size and type.
3. Indicating Lights: Two of each type and color installed.
4. Auxiliary Contacts: Furnish one spare(s) for each size and type of magnetic controller installed.
5. Power Contacts: Furnish three spares for each size and type of magnetic contactor installed.

1.7 QUALITY ASSURANCE

A. Testing Agency Qualifications: Member company of NETA or an NRTL.

1. Testing Agency's Field Supervisor: Currently certified by NETA to supervise on-site testing.

B. Provide Variable Frequency Controllers suitable for operating with NEMA Design B induction motors. VFC's shall be compatible with standard 3 phase high efficiency motors.

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.

1.8 DELIVERY, STORAGE, AND HANDLING

A. If stored in space that is not permanently enclosed and air conditioned, remove loose packing and flammable materials from inside controllers and install temporary electric heating, with at least 250 W per controller.

B. Product Selection for Restricted Space: Drawings indicate maximum dimensions for VFCs, including clearances between VFCs, and adjacent surfaces and other items.

1.9 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace VFCs that fail in materials or workmanship within specified warranty period.

1. VFC Warranty Period: Five years from date of Substantial Completion.
2. Filter Warranty Period: Three years from date of Substantial Completion.

PART 2 PRODUCTS

2.1 MANUFACTURERS

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

B. Basis-of-Design Product: Subject to compliance with requirements, provide [product indicated on Drawings] <Insert manufacturer's name; product name or designation> or comparable product by one of the following:

1. ABB Low-Voltage HVAC Drives
2. Danfoss Inc; Danfoss Drives Div.

C. Harmonic Trap Filters, dV/dT, Filters, and Input Line Reactor Manufacturers: Subject to compliance with requirements, [provide products by the following] [provide products by one of the following] [available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:

1. Trans Coil Inc.
2. MTE
3. Myron Zucker

4. Schaffner

2.2 VFC SYSTEM DESCRIPTION AND RATINGS

A. General Requirements for VFCs:

1. VFCs and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Comply with NEMA ICS 7, NEMA ICS 61800-2, and UL 508A.

B. Application: Constant torque or variable torque.

C. VFC Description: Variable-frequency motor controller, consisting of power converter that employs pulse-width-modulated inverter, factory built and tested in an enclosure, with integral disconnecting means and overcurrent and overload protection; listed and labeled by an NRTL as a complete unit; arranged to provide self-protection, protection, and variable-speed control of one or more three-phase induction motors by adjusting output voltage and frequency.

1. Units suitable for operation of NEMA MG 1, Design A and Design B motors, as defined by NEMA MG 1, Section IV, Part 30, "Application Considerations for Constant Speed Motors Used on a Sinusoidal Bus with Harmonic Content and General Purpose Motors Used with Adjustable-Voltage or Adjustable-Frequency Controls or Both."
2. Units suitable for operation of inverter-duty motors as defined by NEMA MG 1, Section IV, Part 31, "Definite-Purpose Inverter-Fed Polyphase Motors."
3. Listed and labeled for integrated short-circuit current (withstand) rating by an NRTL acceptable to authorities having jurisdiction.

D. Design and Rating: Match load type, such as fans, blowers, and pumps; and type of connection used between motor and load such as direct or through a power-transmission connection.

E. Output Rating: Three phase; 10 to 66 Hz, with torque constant as speed changes; maximum voltage equals input voltage.

F. Unit Operating Requirements:

1. Input AC Voltage Tolerance: Plus 10 and minus 10 percent of VFC input voltage rating.
2. Input AC Voltage Unbalance: Not exceeding 3 percent.
3. Input Frequency Tolerance: Plus or minus 3 percent of VFC frequency rating.
4. Minimum Efficiency: 97 percent at 100 percent speed and greater than 80 percent at 50 percent speed.
5. Minimum Power Factor: 95 percent at 100 percent speed and greater than 90 percent at 25 percent speed.
6. Bus capacitance voltage ratings
   a. 208-240V VFC's shall have a minimum bus voltage capacitance of 400 VDC.
   b. 460-480V VFC's shall have a minimum bus voltage capacitance of 800 VDC.
7. IGBT ratings
   a. 208-240V VFC's shall be equipped with IGBT's that have a minimum V_{ce} rating of 600V.
   b. 460-480V VFC's shall be equipped with IGBT's that have a minimum V_{ce} rating of 1200V.
8. Minimum Short-Circuit Current (Withstand) Rating: 100 kA.
9. Ambient Temperature Rating: Not less than 32 deg F (0 deg C) and not exceeding 104 deg F (40 deg C).
10. Humidity Rating: Less than 95 percent (noncondensing).
11. Altitude Rating: Not exceeding 3300 feet (1000 m).
12. Audible noise shall not exceed 85 dBa measured at a point 3 feet from the VFC.
13. Vibration Withstand: Comply with NEMA ICS 61800-2.
14. Overload Capability: 1.5 times the base load current for 60 seconds; minimum of 1.8 times the base load current for three seconds.
15. Starting Torque: Minimum 100 percent of rated torque from 3 to 60 Hz.
16. Speed Regulation: Plus or minus 10 percent.
17. Output Carrier Frequency: Selectable; 0.5 to 15 kHz.
18. Stop Modes: Programmable; includes fast, free-wheel, and dc injection braking.

G. Converter Section

1. Utilize six-pulse full wave diode or PWM bridge design to convert fixed voltage and frequency AC line power to fixed DC voltage.

2. Operation of the converter section shall be unaffected by phase rotation.
3. Input shall have MOVs (Metal Oxide Varistors) for surge protection.

H. DC Bus Section
   1. DC bus shall include a minimum 5% integrated DC link reactors to minimize harmonic distortion.
   2. DC bus shall have a passive capacitive filter to minimize ripple and maximize power-loss ride through.
   3. Provide balance discharge resistors to equalize charge voltage and permit safe discharge of capacitors upon loss of power.

I. Inverter Section
   1. Utilize isolated-gate bipolar transistors (IGBTs) to convert DC bus voltage to tree phase, variable frequency, and sinusoidal coded PWM waveform to control the motor. Six step and current source drives are not acceptable.
   2. PWM switching frequencies (Carrier Frequency): Selectable; 1.0 to 12 kHz. Factor set the carrier frequency at 3 kHz.
   3. VFC shall be capable of skipping over minimum of [two] critical frequencies to prevent the VFC from operating the load continuously at unstable speeds. VFC shall accelerate or decelerate through these ranges, but not be allowed to operate consistently in these ranges.

J. Inverter Logic: Microprocessor based, 32 bit, isolated from all power circuits.

K. Isolated Control Interface: Allows VFCs to follow remote-control signal over a minimum 40:1 speed range.
   1. Signal: Electrical.

L. Internal Adjustability Capabilities:
   1. Minimum Speed: 5 to 25 percent of maximum rpm.
   2. Maximum Speed: 80 to 100 percent of maximum rpm.
   3. Acceleration: 0.1 to 999.9 seconds.
   4. Deceleration: 0.1 to 999.9 seconds.
   5. Current Limit: 30 to minimum of 150 percent of maximum rating.

M. Self-Protection and Reliability Features:
   1. Surge Suppression: Factory installed as an integral part of the VFC, complying with UL 1449 SPD, Type 1 or Type 2.
   2. Surge Suppression: Field-mounted surge suppressors complying with Section 264313 "Surge Protection for Low-Voltage Electrical Power Circuits," UL 1449 SPD, Type 2.
   3. Loss of Input Signal Protection: Selectable response strategy, including speed default to a percent of the most recent speed, a preset speed, or stop; with alarm.
   4. Under- and overvoltage trips.
   5. Inverter overcurrent trips.
   6. VFC and Motor-Overload/Overtemperature Protection: Microprocessor-based thermal protection system for monitoring VFCs and motor thermal characteristics, and for providing VFC overtemperature and motor-overload alarm and trip; settings selectable via the keypad.
   7. Critical frequency rejection, with [three] <Insert number> selectable, adjustable deadbands.
   8. Instantaneous line-to-line and line-to-ground overcurrent trips.
   9. Loss-of-phase protection.
   10. Reverse-phase protection.
   11. Short-circuit protection.
   12. Motor-overtemperature fault.

N. Automatic Reset/Restart: Attempt three restarts after drive fault or on return of power after an interruption and before shutting down for manual reset or fault correction; adjustable delay time between restart attempts.

O. Power-Interruption Protection: To prevent motor from re-energizing after a power interruption until motor has stopped, unless "Bidirectional Autospeed Search" feature is available and engaged.

P. Bidirectional Autospeed Search: Capable of starting VFC into rotating loads spinning in either direction and returning motor to set speed in proper direction, without causing damage to drive, motor, or load.

Q. Torque Boost: Automatically varies starting and continuous torque to at least 1.5 times the minimum torque to ensure high-starting torque and increased torque at slow speeds.

R. Motor Temperature Compensation at Slow Speeds: Adjustable current fall-back based on output frequency for temperature protection of self-cooled, fan-ventilated motors at slow speeds.

2.3 PERFORMANCE REQUIREMENTS

A. If audible motor noise created by the VFC exceeds [5] dB of the motor noise generated when the motor is directly connected to line power through an across the line starter, the VFC supplier shall remedy the situation at no cost.

2.4 CONTROLS AND INDICATION

A. Electrically isolate the following circuit systems from the main power circuits:
   1. Internal control circuiting regulating DC bus voltage and inverter output frequency.
   2. Circuitry supplying various microprocessors, controllers, sensors, etc., which provide the VFC's operational and safety features.

B. Provide devices which will limit the following operational parameters:
   1. Permit field adjustment of minimum and maximum output frequency. The range shall be adjustable from 4 Hz to 60 Hz.
   2. Permit field adjustment of the acceleration rate intervals from 0% to 100% speed. Unless noted otherwise, set full range acceleration rates initially at 60 seconds.
   3. Permit field adjustment of the deceleration rate intervals from 0% to 100% speed. Unless noted otherwise, set full range deceleration rate at 60 seconds.

C. Status Lights: Door-mounted LED indicators displaying the following conditions:
   1. Power on.
   2. Run.
   3. Overvoltage.
   4. Line fault.
   5. Overcurrent.
   6. External fault.

D. Panel-Mounted Operator Station: Manufacturer's standard front-accessible, sealed keypad and plain-English-language digital display; allows complete programming, program copying, operating, monitoring, and diagnostic capability.
   1. Keypad: In addition to required programming and control keys, include keys for HAND, OFF, and AUTO modes.
   2. Security Access: Provide electronic security access to controls through identification and password with at least three levels of access: View only; view and operate; and view, operate, and service.
      a. Control Authority: Supports at least four conditions: Off, local manual control at VFC, local automatic control at VFC, and automatic control through a remote source.

E. Historical Logging Information and Displays:
   1. Real-time clock with current time and date.
   2. Running log of total power versus time.
   3. Total run time.
   4. Fault log, maintaining last four faults with time and date stamp for each.

F. Indicating Devices: Digital display and additional readout devices as required, mounted flush in VFC door and connected to display VFC parameters including, but not limited to:
   1. Output frequency (Hz).
   2. Motor speed (rpm).
   3. Motor status (running, stop, fault).
   4. Motor current (amperes).
   5. Motor torque (percent).
   6. Fault or alarming status (code).
   7. PID feedback signal (percent).
   8. DC-link voltage (V dc).

9. Set point frequency (Hz).
10. Motor output voltage (V ac).
11. Heat sink temperature
12. Operating hours (with reset function)
13. Megawatt hours (with reset function)

G. VFC Monitoring and Alarming

1. The VFC controller shall have the ability to display the following alarms and notifications at the VFC display as well as the relay the to the building automation system via communications interface.
    a. Status indicators
        1) On/Off status
        2) Input power Status
        3) Input power fault
        4) Over-current fault
        5) Ground fault
        6) Under-voltage
        7) Over-voltage
        8) Over-temperature fault
        9) Motor over-load fault
        10) Motor under-load fault
        11) DC braking
        12) Emergency off
        13) Retry
        14) Restart

    b. Alarms
        1) Over-voltage pre-alarm
        2) Over-current pre-alarm
        3) Under-voltage
        4) Overheat pre-alarm
        5) Overload pre-alarm
        6) Communications Error
        7) Tuning Error
        8) Point setting alarm
        9) Clear enabling indication
        10) Emergency Stop Enabling indication
        11) Setting Error Alarm
        12) Momentary power loss slowdown
        13) Lower-limit time-out stop
        14) VFD in bypass

    c. Faults
        1) Over-current (start up)
        2) Over-current (Acceleration, Deceleration, and Running)
        3) U-phase short
        4) V-phase short
        5) W-phase short
        6) Over-voltage (Acceleration, Deceleration, and Running)
        7) Under-voltage
        8) Over-frequency
        9) Under-frequency
        10) Over-heat
        11) Over-heat (external)
        12) Over-torque
        13) Inverter overload
        14) Motor overload
        15) Ground Fault
        16) Input phase failure
        17) Output phase failure

18) Sequence error
19) Speed error
20) V/Hz control error
21) Communications error
22) Logic voltage error
23) Self-diagnostics alarm
24) VFD in bypass

d. VFC shall be equipped of automatic reset and restart circuit which will restart the motor 20 seconds after self-protection shut down. The VFC shall attempt no more than 5 automatic restarts. Each successive attempt shall occur at least 120 seconds after the last.

H. Control Signal Interfaces (I/O):
1. Electric Input Signal Interface:
a. A minimum of [two] <Insert number> programmable analog inputs: [0- to 10-V dc] [4- to 20-mA dc] [Operator-selectable "x"- to "y"-mA dc] <Insert signal parameters>.
b. A minimum of [six] <Insert number> multifunction programmable digital inputs.
2. Pneumatic Input Signal Interface: 3 to 15 psig (20 to 104 kPa).
3. Remote Signal Inputs: Capability to accept any of the following speed-setting input signals from the DDC system for HVAC or other control systems:
a. 0- to 10-V dc.
b. 4- to 20-mA dc.
c. Potentiometer using up/down digital inputs.
d. Fixed frequencies using digital inputs.
4. VFC shall be equipped with a 120 VAC or 24 VDC safety circuit for fire alarm system shutdown.
5. Output Signal Interface: A minimum of one programmable analog output signal(s) (4- to 20-mA dc), which can be configured for any of the following:
a. Output frequency (Hz).
b. Output current (load).
c. DC-link voltage (V dc).
d. Motor torque (percent).
e. Motor speed (rpm).
f. Set point frequency (Hz).
g. <Insert indication>.
6. Remote Indication Interface: A minimum of two programmable dry-circuit relay outputs (120-V ac, 1 A) for remote indication of the following:
a. Motor running.
b. Set point speed reached.
c. Fault and warning indication (overtemperature or overcurrent).
d. PID high- or low-speed limits reached.

I. Communications Interface with DDC System for HVAC: Factory-installed hardware and software shall interface with DDC system for HVAC to monitor, control, display, and record data for use in processing reports. VFC settings shall be retained within VFC's nonvolatile memory.
1. Hardwired Points:
a. Monitoring: On-off status.
b. Control: On-off operation.
2. Communication Interface: Comply with [ASHRAE 135] <Insert type of interface>. Communication shall interface with DDC system for HVAC to remotely control and monitor lighting from a DDC system for HVAC operator workstation. Control features and monitoring points displayed locally at lighting panel shall be available through the DDC system for HVAC.
a. Coordinate with Division 23 and provide signal compatibility for a direct serial communications interface with:
1) Verify existing control system in existing building.

2.5 LINE CONDITIONING AND FILTERING

A. Provide UL listed Filters for the application.

B. Filters shall be located adjacent to the VFC or contained in a common enclosure as the VFC it is serving.

C. Filter enclosures shall be meet the same requirements as specified for VFC's.

D. Input Line Conditioning: Based on the manufacturer's harmonic analysis study and report, provide input filtering, as required, to limit total demand (harmonic current) distortion and total harmonic voltage demand at the defined point of common coupling to meet IEEE 519 recommendations.

E. Input Line Conditioning
   1. Provide a 5% input line reactor on the input of all VFC's greater than 50 HP in addition to any internal line reactors and filters.
   2. Provide harmonic filters on the input of all VFC's serving motors greater than 50 HP
      a. Provide contactor within filter to disconnect capacitors from line power to the VFC when signal is received from the VFC. VFC shall be programed to disconnect capacitors at 25% load and energize capacitors at 30% load.
      b. Provide contactor to bypass entire filter when VFD has been bypassed. Provide interlock between bypass switch and contactor.
   3. VFC disconnecting means shall disconnect power to input filter and reactors.

F. Output Filtering: Provide dV/dT filters for all locations where conductors between the motors and VFC are [75] feet or longer.

G. EMI/RFI Filtering: CE marked; certify compliance with IEC 61800-3 for Category C2.

2.6 BYPASS SYSTEMS

A. Bypass Operation: Safely transfers motor between power converter output and bypass circuit, manually, automatically, or both. Selector switches set modes and indicator lights indicate mode selected. Unit is capable of stable operation (starting, stopping, and running) with motor completely disconnected from power converter.
   1. Minimum Short-Circuit Current (Withstand) Rating: 100 kA.

B. Bypass Mode: Manual operation only; requires local operator selection at VFC. Transfer between power converter and bypass contactor, and retransfer shall only be allowed with the motor at zero speed.

C. Bypass Controller: Three-contactor-style bypass allows motor operation via the power converter or the bypass controller; with input isolating switch and barrier arranged to isolate the power converter input and output and permit safe testing and troubleshooting of the power converter, both energized and de-energized, while motor is operating in bypass mode.
   1. Bypass Contactor: Load-break, NEMA-rated contactor.
   2. Input and Output Isolating Contactors: Non-load-break, NEMA-rated contactors.
   3. Isolating Switch: Non-load-break switch arranged to isolate power converter and permit safe troubleshooting and testing of the power converter, both energized and de-energized, while motor is operating in bypass mode; pad-lockable, door-mounted handle mechanism.

D. Bypass Contactor Configuration: Full-voltage (across-the-line) for motors less than 40 HP, Reduced-voltage (autotransformer) for motors 40 HP and larger type.
   1. NORMAL/BYPASS selector switch.
   2. HAND/OFF/AUTO selector switch.
   3. NORMAL/TEST Selector Switch: Allows testing and adjusting of VFC while the motor is running in the bypass mode.
   4. Contactor Coils: Pressure-encapsulated type with coil transient suppressors.
      a. Operating Voltage: Depending on contactor NEMA size and line-voltage rating, manufacturer's standard matching control power or line voltage.
      b. Power Contacts: Totally enclosed, double break, and silver-cadmium oxide; assembled to allow inspection and replacement without disturbing line or load wiring.
   5. Control Circuits: 120-V ac; obtained from integral CPT, with primary and secondary fuses, with CPT of sufficient capacity to operate all integral devices and remotely located pilot, indicating, and control devices.
      a. CPT Spare Capacity: 50 VA.

6. Overload Relays: NEMA ICS 2.
   a. Solid-State Overload Relays:
      1) Switch or dial selectable for motor-running overload protection.
      2) Sensors in each phase.
      3) Class 10/20 selectable tripping characteristic selected to protect motor against voltage and current unbalance and single phasing.
      4) Class II ground-fault protection, with start and run delays to prevent nuisance trip on starting.
      5) Analog communication module.
   b. NC isolated overload alarm contact.
   c. External overload, reset push button.

2.7 ENCLOSURES

A. VFC Enclosures: NEMA 250, to comply with environmental conditions at installed location.
   1. Dry and Clean Indoor Locations: Type 1.
   2. Outdoor Locations: Type 3R.
   3. Kitchen and Wash-Down]Areas: Type 4X, stainless steel.
   4. Other Wet or Damp Indoor Locations: Type 4.
   5. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: Type 12.

B. Plenum Rating: UL 1995; NRTL certification label on enclosure, clearly identifying VFC as "Plenum Rated."

C. Internal cooling fans and filers shall be provided where required to maintain drive operating temperature.

D. Internal heating elements shall be provided where required to maintain drive operating temperature.

E. Provide lifting provisions for units weighing more than 80 pounds.

F. All units shall be provided with a grounding lug.

G. The enclosure shall have a through-the-door interlocking handle with padlocking provisions.

H. Wall units shall be provided with necessary mounting brackets.

2.8 ACCESSORIES

A. General Requirements for Control-Circuit and Pilot Devices: NEMA ICS 5; factory installed in VFC enclosure cover unless otherwise indicated.
   1. Push Buttons: Shielded.
   2. Pilot Lights: Push to test.
   3. Selector Switches: Rotary type.
   4. Stop and Lockout Push-Button Station: Momentary-break, push-button station with a factory-applied hasp arranged so padlock can be used to lock push button in depressed position with control circuit open.

B. Reversible NC/NO bypass contactor auxiliary contact(s).

C. Control Relays: Auxiliary and adjustable solid-state time-delay relays.

D. Phase-Failure, Phase-Reversal, and Undervoltage and Overvoltage Relays: Solid-state sensing circuit with isolated output contacts for hard-wired connections. Provide adjustable undervoltage, overvoltage, and time-delay settings.
   1. Current Transformers: Continuous current rating, basic impulse insulating level (BIL) rating, burden, and accuracy class suitable for connected circuitry. Comply with IEEE C57.13.

E. Supplemental Digital Meters:
   1. Elapsed-time meter.
   2. Kilowatt meter.
   3. Kilowatt-hour meter.

F. Breather and drain assemblies, to maintain interior pressure and release condensation in NEMA 250, Type 4X enclosures installed outdoors or in unconditioned interior spaces subject to humidity and temperature swings.

G. Sun shields installed on fronts, sides, and tops of enclosures installed outdoors and subject to direct and extended sun exposure.

2.9 SOURCE QUALITY CONTROL

A. Testing: Test and inspect VFCs according to requirements in NEMA ICS 61800-2.

1. Test each VFC while connected to its specified motor.
2. Verification of Performance: Rate VFCs according to operation of functions and features specified.

B. VFCs will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

PART 3 EXECUTION

3.1 EXAMINATION

A. Examine areas, surfaces, and substrates to receive VFCs, with Installer present, for compliance with requirements for installation tolerances, and other conditions affecting performance of the Work.

B. Examine VFC before installation. Reject VFCs that are wet, moisture damaged, or mold damaged.

C. Examine roughing-in for conduit systems to verify actual locations of conduit connections before VFC installation.

D. Prepare written report, endorsed by Installer, listing conditions detrimental to performance of the Work

E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 COORDINATION

A. The VFC manufacturer shall obtain information about any critical speeds, which must be locked out in the VFC controls to avoid noise and vibration caused by harmonic resonance in the mechanical system.

B. Contractor shall coordinate final VFC locations with VFC manufacturer and mechanical equipment layouts.

3.3 INSTALLATION

A. Wall-Mounting Controllers: Install with tops at uniform height and with disconnect operating handles not higher than 79 inches (2000 mm) above finished floor, unless otherwise indicated, and by bolting units to wall or mounting on lightweight structural-steel channels bolted to wall. For controllers not on walls, provide freestanding racks complying with Section 260529 "Hangers and Supports for Electrical Systems."

B. Floor-Mounting Controllers: Install VFCs on 4-inch (100-mm) nominal thickness concrete base. Comply with requirements for concrete base specified in Section 033000 "Cast-in-Place Concrete" or Section 033053 "Miscellaneous Cast-in-Place Concrete."

1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.
2. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
4. Install anchor bolts to elevations required for proper attachment to supported equipment.

C. Roof-Mounting Controllers: Install VFC on roofs with tops at uniform height and with disconnect operating handles not higher than 79 inches (2000 mm) above finished roof surface unless otherwise indicated, and by bolting units to curbs or mounting on freestanding, lightweight, structural-steel channels bolted to curbs. Seal roof penetrations after raceways are installed.

1. Curbs and roof penetrations are specified in Section 077200 "Roof Accessories."

2. Structural-steel channels are specified in Section 260529 "Hangers and Supports for Electrical Systems."

D. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.

E. Separate line, load, and control conductors in separate continuous metallic conduits. Provide ferrous metallic shielding around each VFC conductor group when conductors are installed in wire way or gutter. The contractor may submit shielded conductor cable assemblies designed for operation with VFC's.

F. Provide all power connection including wiring associated with any isolation transformer disconnect reactors, filters, and any accessories. Include power wiring from the VFC to the motor, as well as all grounding connections.

G. Where it is not possible to install motors within the sight of the VFC provide a disconnect switch at the motor as required by the NEC or required by the specifications. Provide an interlocking connection between the disconnect at the motor and the VFC to prevent the VFC from operating in a no load situation

H. All connections to the VFC shall be with a minimum 18 inches of seal tight flexible conduit, allowing for ease of maintenance.

I. Provide separate grounding conductor to the VFC and between the VFC and the motor in addition to the conduit system.

J. Temperature control contractor shall provide all control connections to the VFC from any sensors or control devices.

K. Provide separate overload protection for each motor when a VFC serve multiple motors.

L. Install fuses in each fusible-switch VFC.

M. Install fuses in control circuits if not factory installed. Comply with requirements in Section 262813 "Fuses."

N. Install heaters in thermal-overload relays. Select heaters based on actual nameplate full-load amperes after motors are installed.

O. Install, connect, and fuse thermal-protector monitoring relays furnished with motor-driven equipment.

P. Comply with NECA 1.

3.4 CONTROL WIRING INSTALLATION

A. Install wiring between VFCs and remote devices and facility's central-control system. Comply with requirements in Section 260523 "Control-Voltage Electrical Power Cables."

B. Bundle, train, and support wiring in enclosures.

C. Connect selector switches and other automatic-control devices where applicable.

1. Connect selector switches to bypass only those manual- and automatic-control devices that have no safety functions when switches are in manual-control position.
2. Connect selector switches with control circuit in both manual and automatic positions for safety-type control devices such as low- and high-pressure cutouts, high-temperature cutouts, and motor-overload protectors.

3.5 IDENTIFICATION

A. Identify VFCs, components, and control wiring. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.
2. Label each VFC with engraved nameplate.
3. Label each enclosure-mounted control and pilot device.

B. Operating Instructions: Frame printed operating instructions for VFCs, including control sequences and emergency procedures. Fabricate frame of finished metal, and cover instructions with clear acrylic plastic. Mount on front of VFC units.

3.6 FIELD QUALITY CONTROL

A. Perform tests and inspections with the assistance of a factory-authorized service representative.

B. Acceptance Testing Preparation:
   1. Test insulation resistance for each VFC element, bus, component, connecting supply, feeder, and control circuit.
   2. Test continuity of each circuit.

C. Tests and Inspections:
   1. Inspect VFC, wiring, components, connections, and equipment installation. Test and adjust controllers, components, and equipment.
   2. Test insulation resistance for each VFC element, component, connecting motor supply, feeder, and control circuits.
   3. Test continuity of each circuit.
   4. Verify that voltages at VFC locations are within 10 percent of motor nameplate rated voltages. If outside this range for any motor, notify Owner before starting the motor(s).
   5. Test each motor for proper phase rotation.
   6. Perform tests according to the Inspection and Test Procedures for Adjustable Speed Drives stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
   7. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
   8. Perform the following infrared (thermographic) scan tests and inspections, and prepare reports:
      a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each VFC. Remove front panels so joints and connections are accessible to portable scanner.
      b. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each VFC 11 months after date of Substantial Completion.
      c. Instruments and Equipment: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
   9. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.
   10. Test voltage distortion. Voltage distortion shall not exceed 3% and the line notch depth shall not exceed 10% as defined in IEEE Standard 519-1992 “IEEE Guide for Harmonic control and Reactive Compensation of Static Power Converters.” Provide necessary harmonic filters or line reactors to achieve these values. A written report shall be provided to the engineer showing all test results.

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

E. Prepare test and inspection reports, including a certified report that identifies the VFC and describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations made after remedial action.

3.7 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.
   1. Complete installation and startup checks according to manufacturer's written instructions.
   2. At a minimum perform the following operational checks and provide a report to the engineer that each VFC has met the following checks:
      a. Maximum output frequency = 60 Hz ± 1 Hz.
      b. Minimum output frequency = 4 Hz ± 1 Hz.
      c. Control signal setpoint ± 10% of that specified.
      d. Simulated power outage and control system reaction.
      e. Manual bypass switchover and operation tested.
      f. Starting into an already rotating motor load and determine if self-protection of the VFC is adequate.

g. Acceleration rate from a dead stop to full speed at the maximum and minimum rate adjustment.
h. Deceleration rate from full speed to dead stop at maximum and minimum rate adjustment.

3.8 ADJUSTING

A. Program microprocessors for required operational sequences, status indications, alarms, event recording, and display features. Clear events memory after final acceptance testing and prior to Substantial Completion.

B. Set field-adjustable switches, auxiliary relays, time-delay relays, timers, and overload-relay pickup and trip ranges.

C. Adjust the trip settings of instantaneous-only circuit breakers and thermal-magnetic circuit breakers with adjustable, instantaneous trip elements. Initially adjust to 6 times the motor nameplate full-load amperes and attempt to start motors several times, allowing for motor cool-down between starts. If tripping occurs on motor inrush, adjust settings in increments until motors start without tripping. Do not exceed 8 times the motor full-load amperes (or 11 times for NEMA Premium Efficient motors if required). Where these maximum settings do not allow starting of a motor, notify Owner before increasing settings.

D. Set the taps on reduced-voltage autotransformer controllers.

E. Set field-adjustable circuit-breaker trip ranges as specified in Section 260573 "Overcurrent Protective Device Coordination Study."

F. Set field-adjustable pressure switches.

3.9 PROTECTION

A. Temporary Heating: Apply temporary heat to maintain temperature according to manufacturer's written instructions until controllers are ready to be energized and placed into service.

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

3.10 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, reprogram, and maintain VFCs. The manufacturer shall arrange for and conduct a user training session(s) at the Project site, explaining the operation of each type of VFC package. Allow for a minimum 4 hours of training for the first VFC and 1 hours of training for each additional VFC up to a maximum of 15 hours. The supplier shall notify the Engineer of the training session at least 1 week prior to the scheduled date so the Engineer can make arrangement to attend.

END OF SECTION

SECTION 230517
SLEEVES AND SLEEVE SEALS FOR HVAC PIPING

PART 1 GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

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

1.3 ACTION SUBMITTALS

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

PART 2 PRODUCTS

2.1 SLEEVES

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

B. Galvanized-Steel-Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, zinc coated, with plain ends.

2.2 SLEEVE-SEAL SYSTEMS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Advance Products & Systems, Incorporated (www.apsonline.com)
2. CALPICO, Incorporated (www.calpicoinc.com)
3. Metraflex Company (The). (www.metraflex.com)
4. Pipeline Seal and Insulator, Incorporated (www.pipelineseal.com)
5. Proco Products, Incorporated (www.procoproducts.com)

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] [Plastic] [Stainless steel].
3. Connecting Bolts and Nuts: Stainless steel of length required to secure pressure plates to sealing elements.

2.3 GROUT

A. Standard: ASTM C 1107/C 1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.

B. Characteristics: Nonshrink; recommended for interior and exterior applications.

C. Design Mix: 5000-psi, 28-day compressive strength.

D. Packaging: Premixed and factory packaged.

PART 3 EXECUTION

3.1 SLEEVE INSTALLATION

A. Install sleeves for piping passing through penetrations in floors, partitions, roofs, and walls.

B. For sleeves that will have sleeve-seal system installed, select sleeves of size large enough to provide 1-inch annular clear space between piping and concrete slabs and walls.

C. Install sleeves in concrete floors, concrete roof slabs, and concrete walls as new slabs and walls are constructed.

1. 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.
2. Using grout, seal the space outside of sleeves in slabs and walls without sleeve-seal system.

D. Install sleeves for pipes passing through interior partitions.

1. Cut sleeves to length for mounting flush with both surfaces.
2. Install sleeves that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation.
3. Seal annular space between sleeve and piping or piping insulation; use joint sealants appropriate for size, depth, and location of joint. Comply with requirements for sealants specified in Section 079200 "Joint Sealants."

E. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Comply with requirements for firestopping specified in Section 078413 "Penetration Firestopping."

F. Acoustical Interior Wall Penetrations: Maintain indicated STC rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with acoustical sealant materials.

3.2 SLEEVE-SEAL-SYSTEM INSTALLATION

A. Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at service piping entries into building.

B. Select type, size, and number of sealing elements required for piping material and size and for sleeve ID or hole size. Position piping in center of sleeve. Center piping in penetration, assemble sleeve-seal system components, and install in annular space between piping and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make a watertight seal.

3.3 SLEEVE-SEAL-FITTING INSTALLATION

A. Install sleeve-seal fittings in new walls and slabs as they are constructed.

B. Assemble fitting components of length to be flush with both surfaces of concrete slabs and walls. Position water stop flange to be centered in concrete slab or wall.

C. Secure nailing flanges to concrete forms.

D. Using grout, seal the space around outside of sleeve-seal fittings.

3.4 SLEEVE AND SLEEVE-SEAL SCHEDULE

A. Use sleeves and sleeve seals for the following piping-penetration applications:

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

END OF SECTION

SECTION 230518
ESCUTCHEONS FOR HVAC PIPING

PART 1 GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

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

1.3 ACTION SUBMITTALS

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

PART 2 PRODUCTS

2.1 ESCUTCHEONS

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

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

C. One-Piece, Stamped-Steel Type: With chrome-plated finish and spring-clip fasteners.

D. Split-Casting Brass Type: With polished, chrome-plated and rough-brass finish and with concealed hinge and setscrew.

E. Split-Plate, Stamped-Steel Type: With chrome-plated finish, concealed and exposed-rivet hinge, and spring-clip fasteners.

2.2 FLOOR PLATES

A. One-Piece Floor Plates: Cast-iron flange with holes for fasteners.

B. Split-Casting Floor Plates: Cast brass with concealed hinge.

PART 3 EXECUTION

3.1 INSTALLATION

A. Install escutcheons for exposed piping penetrations of walls, ceilings, and finished floors.

B. Install escutcheons with ID to closely fit around pipe, tube, and insulation of piping and with OD that completely covers opening.
   1. Escutcheons for New Piping:
      a. Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep-pattern type.
      b. Chrome-Plated Piping: One-piece, cast-brass or split-casting brass type with polished, chrome-plated finish.
      c. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, cast-brass or split-casting brass type with polished, chrome-plated finish.
      d. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece, cast-brass or split-casting brass type with polished, chrome-plated finish.
      e. Bare Piping in Unfinished Service Spaces: One-piece, cast-brass or split-casting brass type with polished, chrome-plated rough-brass finish.

f. Bare Piping in Equipment Rooms: One-piece, cast-brass or split-casting brass type with polished, chrome-plated rough-brass finish.

2. Escutcheons for Existing Piping:
   a. Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep-pattern type.
   b. Chrome-Plated Piping: One-piece, cast-brass or split-casting brass type with polished, chrome-plated finish.
   c. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, cast-brass or split-casting brass type with polished, chrome-plated finish.
   d. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece, cast-brass or split-casting brass type with polished, chrome-plated finish.
   e. Bare Piping in Unfinished Service Spaces: One-piece, cast-brass or split-casting brass type with polished, chrome-plated rough-brass finish.
   f. Bare Piping in Equipment Rooms: One-piece, cast-brass or split-casting brass type with polished, chrome-plated rough-brass finish.

C. Install floor plates for piping penetrations of equipment-room floors.

D. Install floor plates with ID to closely fit around pipe, tube, and insulation of piping and with OD that completely covers opening.
   1. New Piping: One-piece, floor-plate type.
   2. Existing Piping: Split-casting, floor-plate type.

3.2 FIELD QUALITY CONTROL

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

END OF SECTION

SECTION 230519
METERS AND GAGES FOR HVAC PIPING

PART 1 GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
   1. Light-activated thermometers.
   2. Thermowells.
   3. Dial-type pressure gages.
   4. Gage attachments.
   5. Test plugs.
   6. Test-plug kits.

B. Related Sections:
   1. Division 23 Section "Facility 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. Product Certificates: For each type of meter and gage, from manufacturer.

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

PART 2 PRODUCTS

2.1 LIGHT-ACTIVATED THERMOMETERS

A. Direct-Mounted, Light-Activated Thermometers:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Flo Fab Incorporated
      b. REOTEMP Instrument Corporation.
      c. Trerice, H. O. Company
      d. Weiss Instruments, Incorporated
      e. WIKA Instrument Corporation - USA.
      f. Winters Instruments - U.S.
   2. Case: Plastic; 7-inch nominal size unless otherwise indicated.
   3. Scale(s): Degrees F and degrees C.
   4. Case Form: Adjustable angle.
   5. Connector: 1-1/4 inches, with ASME B1.1 screw threads.
   6. Stem: Aluminum and of length to suit installation.
      a. Design for Air-Duct Installation: With ventilated shroud.
      b. Design for Thermowell Installation: Bare stem.
   7. Display: 3/8-inch high LCD Digital.
   8. Accuracy: Plus or minus 1 degrees F.

2.2 DUCT-THERMOMETER MOUNTING BRACKETS

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

2.3 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: CNR or CUNI.
4. Material for Use with Steel Piping: CRES or CSA.
5. Type: Stepped shank unless straight or tapered shank is indicated.
6. External Threads: NPS 1/2, NPS 3/4, or NPS 1, 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.

2.4 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, Incorporated; U.S. Gauge.
   b. Ashcroft Incorporated
   c. Ernst Flow Industries.
   d. Flo Fab Incorporated
   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. Company
   l. Watts Regulator Company; a Division of Watts Water Technologies, Incorporated
   m. Weiss Instruments, Incorporated
   n. WIKA Instrument Corporation - USA.
   o. Winters Instruments - U.S.
2. Standard: ASME B40.100.
3. Case: Sealed type; cast aluminum; 4-1/2-inch nominal diameter.
4. Pressure-Element Assembly: Bourdon tube unless otherwise indicated.
5. Pressure Connection: Brass, with NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe threads and bottom-outlet type unless back-outlet type is indicated.
6. Movement: Mechanical, with link to pressure element and connection to pointer.
7. Dial: Nonreflective aluminum with permanently etched scale markings graduated in psi.
8. Pointer: Dark-colored metal.
9. Window: Glass.
10. Ring: Stainless steel.
11. Accuracy: Grade A, plus or minus 1 percent of middle half of scale range.

2.5 GAGE ATTACHMENTS

A. Snubbers: ASME B40.100, brass; with NPS 1/4 or NPS 1/2, 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 brass pipe with NPS 1/4 or NPS 1/2 pipe threads.

C. Valves: Brass ball, with NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe threads.

2.6 TEST PLUGS

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

1. Flow Design, Incorporated

2. Miljoco Corporation.
3. National Meter, Incorporated
4. Peterson Equipment Company, Incorporated
5. Sisco Manufacturing Company, Incorporated
6. Trerice, H. O. Company
7. Watts Regulator Company; a Division of Watts Water Technologies, Incorporated
8. Weiss Instruments, Incorporated

B. Description: Test-station fitting made for insertion into piping tee fitting.

C. Body: Brass or stainless steel with core inserts and gasketed and threaded cap. Include extended stem on units to be installed in insulated piping.

D. Thread Size: NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe thread.

E. Minimum Pressure and Temperature Rating: 500 psig at 275 degrees F.

F. Core Inserts: EPDM self-sealing rubber.

2.7 TEST-PLUG KITS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Flow Design, Incorporated
2. Miljoco Corporation.
3. National Meter, Incorporated
4. Peterson Equipment Company, Incorporated
5. Sisco Manufacturing Company, Incorporated
6. Trerice, H. O. Company
7. Watts Regulator Company; a Division of Watts Water Technologies, Incorporated
8. Weiss Instruments, Incorporated

B. Furnish two test-plug kits containing one thermometers, one pressure gage and adapter, and carrying case. Thermometer sensing elements, pressure gage, and adapter probes shall be of diameter to fit test plugs and of length to project into piping.

C. High-Range Thermometer: Small, bimetallic insertion type with 1- to 2-inch-diameter dial and tapered-end sensing element. Dial range shall be at least 0 to 220 degrees Fs 104 degrees C.

D. Pressure Gage: Small, Bourdon-tube insertion type with 2- to 3-inch-diameter dial and probe. Dial range shall be at least [0 to 200 psig] <Insert range>.

E. Carrying Case: Metal or plastic, with formed instrument padding.

PART 3 EXECUTION

3.1 INSTALLATION

A. Install thermowells with socket extending to center of pipe and in vertical position in piping tees.

B. Install thermowells of sizes required to match thermometer connectors. Include bushings if required to match sizes.

C. Install thermowells with extension on insulated piping.

D. Fill thermowells with heat-transfer medium.

E. Install direct-mounted thermometers in thermowells and adjust vertical and tilted positions.

F. Install direct-mounted pressure gages in piping tees with pressure gage located on pipe at the most readable position.

G. Install valve and snubber in piping for each pressure gage for fluids (except steam).

H. Install valve and syphon fitting in piping for each pressure gage for steam.

I. Install test plugs in piping tees.

J. Install connection fittings in accessible locations for attachment to portable indicators.

K. Install thermometers in the following locations:
   1. Inlet and outlet of each hydronic boiler.
   2. Two inlets and two outlets of each chiller.
   3. Inlet and outlet of each hydronic coil in air-handling units.
   4. Two inlets and two outlets of each hydronic heat exchanger.
   5. Inlet and outlet of each thermal-storage tank.

L. Install pressure gages in the following locations:
   1. Discharge of each pressure-reducing valve.
   2. Inlet and outlet of each chiller chilled-water and condenser-water connection.
   3. Suction and discharge of each pump. Refer to piping detail.

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 inlet and outlet of each hydronic zone shall be the following:
   1. Test plug with EPDM self-sealing rubber inserts.

B. Thermometers at inlet and outlet of each hydronic boiler shall be the following:
   1. Direct-mounted, light-activated type.
   2. Test plug with EPDM self-sealing rubber inserts.

C. Thermometers at inlets and outlets of each chiller shall be the following:
   1. Direct-mounted, light-activated type.
   2. Test plug with EPDM self-sealing rubber inserts.

D. Thermometers at inlet and outlet of each hydronic coil in air-handling units and built-up central systems shall be the following:
   1. Direct-mounted, light-activated type.
   2. Test plug with EPDM self-sealing rubber inserts. Air-handling units with multiple coils will have test plugs for each coil.

E. Thermometers at inlets and outlets of each hydronic heat exchanger shall be one of the following:
   1. Direct-mounted, light-activated type.
   2. Test plug with EPDM self-sealing rubber inserts.

F. Thermometer stems shall be of length to match thermowell insertion length.

3.5 THERMOMETER SCALE-RANGE SCHEDULE

A. Scale Range for Chilled-Water Piping: Minus 40 to plus 160 degrees F and minus 40 to plus 100 degrees C.

B. Scale Range for Condenser-Water Piping: zero to 100 degrees F and minus 20 to plus 50 degrees C.

C. Scale Range for Heating, Hot-Water Piping: 0 to 250 degrees F and 0 to 150 degrees C.

D. Scale Range for Steam and Steam-Condensate Piping: 0 to 250 degrees F and 0 to 150 degrees C.

3.6 PRESSURE-GAGE SCHEDULE

A. Pressure gages at inlet and outlet of each chiller chilled-water and condenser-water connection shall be one of the following:

1. Sealed, direct-mounted, metal case.

B. Pressure gages at suction and discharge of each pump shall be the following:
   1. Sealed, 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 Condenser-Water Piping: 0 to 100 psi.

C. Scale Range for Heating, Hot-Water Piping: 0 to 100 psi.

END OF SECTION

SECTION 230523
GENERAL-DUTY VALVES FOR HVAC PIPING

PART 1 GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Bronze ball valves.
2. Iron, single-flange butterfly valves.
3. Iron, grooved-end butterfly valves.
4. High-performance butterfly valves.
5. Bronze lift-check valves.
6. Bronze swing-check valves.
7. Iron swing check valves.
8. Iron swing check valves with closure control.
9. Iron, grooved-end swing-check valves.
10. Iron gate valves.
11. Iron globe valves.
12. Chainwheels.

B. Related Sections:

1. Division 23 HVAC piping Sections for specialty valves applicable to those Sections only.
2. Division 23 Section "Identification for HVAC Piping and Equipment" for valve tags and schedules.

1.3 DEFINITIONS

A. CWP: Cold working pressure.

B. EPDM: Ethylene propylene copolymer rubber.

C. NBR: Acrylonitrile-butadiene, Buna-N, or nitrile rubber.

D. NRS: Non-rising stem.

E. OS&Y: Outside screw and yoke.

F. RS: Rising stem.

G. SWP: Steam working pressure.

1.4 ACTION SUBMITTALS

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

1.5 QUALITY ASSURANCE

A. Source Limitations for Valves: Obtain each type of valve from single source from single manufacturer.

B. ASME Compliance:

1. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.
2. ASME B31.1 for power piping valves.
3. ASME B31.9 for building services piping valves.

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 GENERAL REQUIREMENTS FOR VALVES

A. Refer to HVAC valve schedule articles for applications of valves.

B. Valve Pressure and Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.

C. Valve Sizes: Same as upstream piping unless otherwise indicated.

D. Valve Actuator Types:
   1. Gear Actuator: For quarter-turn valves NPS 8 and larger.
   2. Handwheel: For valves other than quarter-turn types.
   3. Hand lever: For quarter-turn valves NPS 6 and smaller.
   4. Wrench: For plug valves with square heads. Furnish Owner with 1 wrench for every 5 plug valves, for each size square plug-valve head.
   5. Chainwheel: Device for attachment to valve handwheel, stem, or other actuator; of size and with chain for mounting height, as indicated in the "Valve Installation" Article.

E. Valves in Insulated Piping: With 2-inch stem extensions and the following features:
   1. Ball Valves: With extended operating handle of non-thermal-conductive material, and protective sleeve that allows operation of valve without breaking the vapor seal or disturbing insulation.
   2. Butterfly Valves: With extended neck.

F. Valve-End Connections:
   1. Flanged: With flanges according to ASME B16.1 for iron valves.
   2. Grooved: With grooves according to AWWA C606.
   3. Solder Joint: With sockets according to ASME B16.18.
   4. Threaded: With threads according to ASME B1.20.1.

G. Valve Bypass and Drain Connections: MSS SP-45.

2.2 BRONZE BALL VALVES

A. Two-Piece, Full-Port, Bronze Ball Valves with Stainless-Steel Trim; MSS-SP110:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Conbraco Industries, Incorporated; Apollo Valves. (Example: 70-140-xx) (www.apollovalves.com)
      b. Crane Company; Crane Valve Group; Crane Valves (www.cranevalve.com) (Example 9201-S)
      c. Hammond Valve. (www.hammondvalve.com) (www.hammondvalve.com) (Example 8503)
      d. Milwaukee Valve Company. (www.milwaukeevalve.com) (Example: 20BSOR-02)
      e. NIBCO Incorporated (www.nibco.com) (Example: T585-66)
   2. Description:
      a. Standard: MSS SP-110.
      b. SWP Rating: 150 psig.

c. CWP Rating: 600 psig.
d. Body Design: Two piece.
e. Body Material: Bronze.
f. Ends: Threaded.
g. Seats: PTFE or TFE.
h. Stem: Stainless steel.
i. Ball: Stainless steel, vented.
j. Port: Full.

B. Two-Piece, Regular-Port, Bronze Ball Valves with Bronze Trim; MSS-SP110:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Conbraco Industries, Incorporated; Apollo Valves. (Example 100-70-XX) (www.apollovalves.com)
   b. Crane Co.; Crane Valve Group; (Example 9210) (www.cranevalve.com)
   c. Hammond Valve. (www.hammondvalve.com) (Example 8501)
   d. Milwaukee Valve Company. (www.milwaukeevalve.com) (Example BA-100)
   e. NIBCO Incorporated (www.nibco.com) (Example T580-70)
2. Description:
   a. Standard: MSS SP-110.
   b. SWP Rating: 150 psig.
   c. CWP Rating: 600 psig.
   d. Body Design: Two piece.
   e. Body Material: Bronze.
   f. Ends: Threaded.
   g. Seats: PTFE or TFE.
   h. Stem: Bronze.
   i. Ball: Chrome-plated brass.
   j. Port: Regular.

2.3 IRON, SINGLE-FLANGE BUTTERFLY VALVES

A. 200 CWP, Iron, Single-Flange Butterfly Valves with EPDM Seat and Aluminum-Bronze Disc:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Conbraco Industries, Incorporated; Apollo Valves. (Example 143 Series) (www.apollovalves.com)
   b. Crane Company; Crane Valve Group; Stockham Division (www.stockham.com). (Example LD 712)
   c. Legend Valve. (www.legendvalve.com) (Example T365AB)
   d. Milwaukee Valve Company. (www.milwaukeevalve.com) (Example CL223-E)
   e. NIBCO Incorporated (www.nibco.com) (Example LD2000-3)
   f. Spence Strainers International; a division of CIRCOR International. (Example BF Series)
   g. Watts Regulator Co.; a division of Watts Water Technologies, (Example BF-03) (www.watts.com)
2. Description:
   a. Standard: MSS SP-67, Type I.
   b. CWP Rating: 200 psig.
   c. Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
   d. Body Material: ASTM A 126, cast iron or ASTM A 536, ductile iron.
   e. Seat: EPDM.
   f. Stem: One- or two-piece stainless steel.
   g. Disc: Aluminum bronze.

2.4 IRON, GROOVED-END BUTTERFLY VALVES

A. 175 CWP, Iron, Grooved-End Butterfly Valves:

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

        a. Mueller Steam Specialty; a division of SPX Corporation. (www.muellersteam.com) (Example: 89-GEN)
        b. NIBCO Incorporated. (www.nibco.com) (Example: GD4765-5)
        c. Victaulic Company. (www.victaulic.com) (Example: Series 761)
    2. Description:
        a. Standard: MSS SP-67, Type I.
        b. CWP Rating: 175 psig.
        c. Body Material: Coated, ductile iron.
        d. Stem: Two-piece stainless steel.
        e. Disc: Coated, ductile iron.
        f. Seal: EPDM.

B. 300 CWP, Iron, Grooved-End Butterfly Valves:
    1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
        a. Anvil International, (www.anvilintl.com) (Example: Series 7700)
        b. NIBCO Incorporated (www.nibco.com) (Example: #4775)
        c. Victaulic Company. (www.victaulic.com)
    2. Description:
        a. Standard: MSS SP-67, Type I.
        b. NPS 8 and Smaller CWP Rating: 300 psig.
        c. NPS 10 and Larger CWP Rating: 200 psig.
        d. Body Material: Coated, ductile iron.
        e. Stem: Two-piece stainless steel.
        f. Disc: Coated, ductile iron.
        g. Seal: EPDM.

2.5 HIGH-PERFORMANCE BUTTERFLY VALVES

A. Class 150, Single-Flange, High-Performance Butterfly Valves:
    1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
        a. ABZ Valve and Controls; a division of ABZ Manufacturing, (Example: Series 400) (www.abzvalve.com)
        b. DeZurik Water Controls. (Example: BHP) (www.dezurik.com)
        c. Hammond Valve. (www.hammondvalve.com) (Example: HP1LCS)
        d. Milwaukee Valve Company. (www.milwaukeevalve.com) (Example: HP1LCS)
        e. NIBCO Incorporated (www.nibco.com) (Example: LCS6822)
        f. Process Development & Control, (Example: Series 60)
        g. Tyco Valves & Controls; a unit of Tyco Flow Control. (Example: Venessa QTF 30000) (www.tycoflowcontrol.com/valves)
        h. Xomox Corporation. (Example: Series 821)
    2. Description:
        a. Standard: MSS SP-68.
        b. CWP Rating: 285 psig at 100 deg F.
        c. Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
        d. Body Material: Carbon steel, cast iron, ductile iron, or stainless steel.
        e. Seat: Reinforced PTFE or metal.
        f. Stem: Stainless steel; offset from seat plane.
        g. Disc: Carbon steel.
        h. Service: Bidirectional.

B. Class 300, Single-Flange, High-Performance Butterfly Valves:
    1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
        a. ABZ Valve and Controls; a division of ABZ Manufacturing, Incorporated. (www.abzvalve.com)
        b. DeZurik Water Controls. (Example: BHP) (www.dezurik.com)
        c. Hammond Valve. (www.hammondvalve.com) (Example: HP3LCS)
        d. Milwaukee Valve Company. (www.milwaukeevalve.com) (Example: HP3LCS)

e. NIBCO Incorporated (www.nibco.com) (Example: LC76822)
f. Process Development & Control, (Example: Series 60)
g. Tyco Valves & Controls; a unit of Tyco Flow Control. (Example: Venessa QTF 30000) (www.tycoflowcontrol.com/valves)
h. Xomox Corporation. (Example: Series 823)
i.

2. Description:
   a. Standard: MSS SP-68.
   b. CWP Rating: 720 psig at 100 deg F.
   c. Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
   d. Body Material: Carbon steel, cast iron, or ductile iron.
   e. Seat: Reinforced PTFE or metal.
   f. Stem: Stainless steel; offset from seat plane.
   g. Disc: Carbon steel.
   h. Service: Bidirectional.

2.6 BRONZE SWING CHECK VALVES

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

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Crane Company; Crane Valve Group; Crane Valves (www.cranevalve.com)
   b. Crane Company; Crane Valve Group; Jenkins Valves (www.jlvalve.com)
   c. Crane Company; Crane Valve Group; Stockham Division (www.stockham.com).
   d. Hammond Valve. (www.hammondvalve.com)
   e. Kitz Corporation. (www.kitz.com)
   f. Milwaukee Valve Company. (www.milwaukeevalve.com) (Example 509T)
   g. NIBCO Incorporated (www.nibco.com) (Example T-413-BY)
   h. Red-White Valve Corporation. (www.redwhitevalvecorp.com)
   i. Watts Regulator Co.; a division of Watts Water Technologies, Incorporated. (www.watts.com)
2. Description:
   a. Standard: MSS SP-80, Type 4.
   b. CWP Rating: 200 psig.
   c. Body Design: Horizontal flow.
   d. Body Material: ASTM B 62, bronze.
   e. Ends: Threaded.
   f. Disc: PTFE or TFE.

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

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Crane Company; Crane Valve Group; Crane Valves (www.cranevalve.com)
   b. Crane Company; Crane Valve Group; Jenkins Valves (www.jlvalve.com)
   c. Hammond Valve. (www.hammondvalve.com)
   d. Milwaukee Valve Company. (www.milwaukeevalve.com) (Example #510T)
   e. NIBCO Incorporated (www.nibco.com) (Example #T433-Y)
   f. Watts Regulator Co.; a division of Watts Water Technologies, Incorporated. (www.watts.com)
2. Description:
   a. Standard: MSS SP-80, Type 4.
   b. CWP Rating: 300 psig.
   c. Body Design: Horizontal flow.
   d. Body Material: ASTM B 62, bronze.
   e. Ends: Threaded.
   f. Disc: PTFE or TFE.

2.7 IRON SWING CHECK VALVES

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

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Crane Company; Crane Valve Group; Crane Valves (www.cranevalve.com) (Example: 373)
   b. Crane Company; Crane Valve Group; Jenkins Valves (www.jlvalve.com) (Example: 587J)
   c. Crane Company; Crane Valve Group; Stockham Division (www.stockham.com).
   d. Hammond Valve. (www.hammondvalve.com)
   e. Kitz Corporation. (www.kitz.com)
   f. Legend Valve. (www.legendvalve.com)
   g. Milwaukee Valve Company. (www.milwaukeevalve.com)
   h. NIBCO Incorporated (www.nibco.com)
   i. Powell valves. (www.powellvalves.com)
   j. Red-White Valve Corporation. (www.redwhitevalvecorp.com)
   k. Sure Flow Equipment Incorporated. (www.sureflowequipment.com)
   l. Watts Regulator Co.; a division of Watts Water Technologies, Incorporated. (www.watts.com)
   m. Zy-Tech Global Industries, Incorporated.
2. Description:
   a. Standard: MSS SP-71, Type I.
   b. NPS 2-1/2 to NPS 12, CWP Rating: 200 psig.
   c. NPS 14 to NPS 24, CWP Rating: 150 psig.
   d. Body Design: Clear or full waterway.
   e. Body Material: ASTM A 126, gray iron with bolted bonnet.
   f. Ends: Flanged.
   g. Trim: Bronze.
   h. Gasket: Asbestos free.

B. Class 250, Iron Swing Check Valves with Metal Seats:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Crane Company; Crane Valve Group; Crane Valves (www.cranevalve.com)
      b. Crane Company; Crane Valve Group; Jenkins Valves (www.jlvalve.com)
      c. Crane Company; Crane Valve Group; Stockham Division (www.stockham.com).
      d. Hammond Valve. (www.hammondvalve.com)
      e. Milwaukee Valve Company. (www.milwaukeevalve.com)
      f. NIBCO Incorporated (www.nibco.com)
      g. Watts Regulator Co.; a division of Watts Water Technologies, Incorporated. (www.watts.com)
   2. Description:
      a. Standard: MSS SP-71, Type I.
      b. NPS 2-1/2 to NPS 12, CWP Rating: 500 psig.
      c. NPS 14 to NPS 24, CWP Rating: 300 psig.
      d. Body Design: Clear or full waterway.
      e. Body Material: ASTM A 126, gray iron with bolted bonnet.
      f. Ends: Flanged.
      g. Trim: Bronze.
      h. Gasket: Asbestos free.

2.8 IRON SWING CHECK VALVES WITH CLOSURE CONTROL

A. Class 125, Iron Swing Check Valves with Lever- and Spring-Closure Control:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. NIBCO Incorporated (www.nibco.com) (Example W920-W)
   2. Description:
      a. Standard: MSS SP-71, Type I.
      b. NPS 2-1/2 to NPS 12, CWP Rating: 200 psig.
      c. NPS 14 to NPS 24, CWP Rating: 150 psig.
      d. Body Design: Clear or full waterway.
      e. Body Material: ASTM A 126, gray iron with bolted bonnet.
      f. Ends: Flanged.
      g. Trim: Bronze.

h. Gasket: Asbestos free.
i. Closure Control: Factory-installed, exterior lever and spring.

B. Class 125, Iron Swing Check Valves with Lever and Weight-Closure Control:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Crane Company; Crane Valve Group; Crane Valves (www.cranevalve.com)
b. Crane Company; Crane Valve Group; Jenkins Valves (www.jlvalve.com)
c. Crane Company; Crane Valve Group; Stockham Division (www.stockham.com).
d. Hammond Valve. (www.hammondvalve.com)
e. Milwaukee Valve Company. (www.milwaukeevalve.com)
f. NIBCO Incorporated (www.nibco.com) (Example F918-BL&S or F918-BLW)
g. Watts Regulator Co.; a division of Watts Water Technologies, Incorporated. (www.watts.com)
2. Description:
a. Standard: MSS SP-71, Type I.
b. NPS 2-1/2 to NPS 12, CWP Rating: 200 psig.
c. NPS 14 to NPS 24, CWP Rating: 150 psig.
d. Body Design: Clear or full waterway.
e. Body Material: ASTM A 126, gray iron with bolted bonnet.
f. Ends: Flanged.
g. Trim: Bronze.
h. Gasket: Asbestos free.
i. Closure Control: Factory-installed, exterior lever and weight.

2.9 IRON, GROOVED-END SWING-CHECK VALVES

A. 300 CWP, Iron, Grooved-End Swing Check Valves:
1. Manufacturers: Subject to compliance requirement, provide products by one fo the following:
a. Anvil International, Incorporated. (www.anvilintl.com)
b. Tyco Valves & Controls; a unit of Tyco Flow Control. (www.tycoflowcontrol.com/valves)
c. Victaulic Company. (www.victaulic.com)
2. Description:
a. CWP Rating: 300 psig.
b. Body Material: ASTM A 536, ductile iron.
c. Seal: EPDM.
d. Disc: Spring operated, ductile iron or stainless steel.

2.10 IRON GATE VALVES

A. Class 125, OS&Y, Iron Gate Valves:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Crane Company; Crane Valve Group; Crane Valves (www.cranevalve.com)
b. Crane Company; Crane Valve Group; Jenkins Valves (www.jlvalve.com)
c. Crane Company; Crane Valve Group; Stockham Division (www.stockham.com).
d. Flo Fab Incorporated. (www.flofab.com)
e. Hammond Valve. (www.hammondvalve.com)
f. Kitz Corporation. (www.kitz.com)
g. Legend Valve. (www.legendvalve.com)
h. Milwaukee Valve Company. (www.milwaukeevalve.com)
i. NIBCO Incorporated (www.nibco.com)
j. Powell valves. (www.powellvalves.com)
k. Red-White Valve Corporation. (www.redwhitevalvecorp.com)
l. Watts Regulator Co.; a division of Watts Water Technologies, Incorporated. (www.watts.com)
m. Zy-Tech Global Industries, Incorporated. (www.zycon.com)
2. Description:
a. Standard: MSS SP-70, Type I.
b. NPS 4 to NPS 12, CWP Rating: 200 psig.
c. NPS 14 to NPS 24, CWP Rating: 150 psig.

d. Body Material: ASTM A 126, gray iron with bolted bonnet.
e. Ends: Flanged.
f. Trim: Bronze.
g. Disc: Solid wedge.
h. Packing and Gasket: Asbestos free.

B. Class 250, OS&Y, Iron Gate Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    a. Crane Company; Crane Valve Group; Crane Valves (www.cranevalve.com)
    b. Crane Company; Crane Valve Group; Stockham Division (www.stockham.com).
    c. Hammond Valve. (www.hammondvalve.com)
    d. Milwaukee Valve Company. (www.milwaukeevalve.com)
    e. NIBCO Incorporated (www.nibco.com) (Example: F667-0)
    f. Powell valves. (www.powellvalves.com)
    g. Watts Regulator Co.; a division of Watts Water Technologies, Incorporated. (www.watts.com)
2. Description:
    a. Standard: MSS SP-70, Type I.
    b. NPS 4 to NPS 12, CWP Rating: 500 psig.
    c. NPS 14 to NPS 24, CWP Rating: 300 psig.
    d. Body Material: ASTM A 126, gray iron with bolted bonnet.
    e. Ends: Flanged.
    f. Trim: Bronze.
    g. Disc: Solid wedge.
    h. Packing and Gasket: Asbestos free.

2.11 IRON GLOBE VALVES

A. Class 125, Iron Globe Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    a. Crane Company; Crane Valve Group; Stockham Division (www.stockham.com). (Example: G 515)
    b. Hammond Valve. (www.hammondvalve.com) (Example: IR116-HI)
    c. Milwaukee Valve Company. (www.milwaukeevalve.com) (Example: F-2981-A)
    d. NIBCO Incorporated (www.nibco.com) (Example: F718-B)
2. Description:
    a. Standard: MSS SP-85, Type I.
    b. CWP Rating: 200 psig.
    c. Body Material: ASTM A 126, gray iron with bolted bonnet.
    d. Ends: Flanged.
    e. Trim: Bronze.
    f. Packing and Gasket: Asbestos free.

B. Class 250, Iron Globe Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    a. Crane Company; Crane Valve Group; Stockham Division (www.stockham.com). (Example F 532)
    b. Hammond Valve. (www.hammondvalve.com) (Example IR313)
    c. Milwaukee Valve Company. (www.milwaukeevalve.com) (Example: 2983)
    d. NIBCO Incorporated (www.nibco.com) (Example: F768-B)
2. Description:
    a. Standard: MSS SP-85, Type I.
    b. CWP Rating: 500 psig.
    c. Body Material: ASTM A 126, gray iron with bolted bonnet.
    d. Ends: Flanged.
    e. Trim: Bronze.
    f. Packing and Gasket: Asbestos free.

2.12 CHAINWHEELS

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Babbitt Steam Specialty Company (www.babbittsteam.com)
   b. Roto Hammer Industries. (www.rotohammerinc.com
   c. Trumbull Industries. (www.trumbull.com)

B. Description: Valve actuation assembly with sprocket rim, brackets, and chain.
   1. Brackets: Type, number, size, and fasteners required to mount actuator on valve.
   2. Attachment: For connection to ball, butterfly, and plug valve stems.
   3. Sprocket Rim with Chain Guides: Ductile iron of type and size required for valve. Include zinc coating.
   4. Chain: Hot-dip, galvanized steel of size required to fit sprocket rim.

PART 3 EXECUTION

3.1 EXAMINATION

A. Examine valve interior for cleanliness, freedom from foreign matter, and corrosion. Remove special packing materials, such as blocks, used to prevent disc movement during shipping and handling.

B. Operate valves in positions from fully open to fully closed. Examine guides and seats made accessible by such operations.

C. Examine threads on valve and mating pipe for form and cleanliness.

D. Examine mating flange faces for conditions that might cause leakage. Check bolting for proper size, length, and material. Verify that gasket is of proper size, that its material composition is suitable for service, and that it is free from defects and damage.

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

3.2 VALVE INSTALLATION

A. Install valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.

B. Locate valves for easy access and provide separate support where necessary.

C. Install valves in horizontal piping with stem at or above center of pipe.

D. Install valves in position to allow full stem movement.

E. Install chain wheels on operators for globe valves NPS 4 and larger and more than 96 inches above floor. Extend chains to 72 inches above finished floor.

F. Install check valves for proper direction of flow and as follows:
   1. Swing Check Valves: In horizontal position with hinge pin level.
   2. Lift Check Valves: With stem upright and plumb.

3.3 JOINT CONSTRUCTION

A. Refer to Division 23 Section "Common Work Results for HVAC" for basic piping joint construction.

3.4 ADJUSTING

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

3.5 GENERAL REQUIREMENTS FOR VALVE APPLICATIONS

A. If valve applications are not indicated, use the following:
   1. Shutoff Service: Ball, butterfly valves.
   2. Butterfly Valve Dead-End Service: Single-flange (lug) type.
   3. Throttling Service except Steam: Globe, ball, or butterfly valves.

4. Throttling Service, Steam: Globe valves.
5. Pump-Discharge Check Valves:
   a. NPS 2 and Smaller: Bronze swing check valves with bronze or nonmetallic disc.
   b. NPS 2-1/2 and Larger: Iron swing check valves with lever and weight or with spring or iron, center-guided, metal or resilient-seat check valves.

B. If valves with specified SWP classes or CWP ratings are not available, the same types of valves with higher SWP classes or CWP ratings may be substituted.

C. Select valves, except wafer types, with the following end connections:
   1. For Copper Tubing, NPS 3 and Smaller: Threaded ends.
   2. For Steel Piping, NPS 2-1/2 to NPS 4: Flanged ends except where threaded valve-end option is indicated in valve schedules below.
   3. For Steel Piping, NPS 5 and Larger: Flanged ends.
   4. For Grooved-End Steel Piping except Steam and Steam Condensate Piping: Valve ends may be grooved.

3.6 CHILLED-WATER VALVE SCHEDULE

A. Pipe NPS 3 and Smaller:
   1. Ball Valves, NPS 3 and Smaller: Two piece, 600-psig CWP rating, copper alloy.
   2. Bronze Swing Check Valves: Class 125, bronze disc.

B. Pipe NPS 4 and Larger:
   1. Butterfly Valves: Tapped Lug, 300-psig CWP rating, ferrous alloy, with EPDM liner.
   2. Grooved-End, Ductile-Iron Butterfly Valves: 300-psig CWP rating.
   3. High-Performance Butterfly Valves: Class 150, single flange.
   4. Iron Swing Check Valves: Class 125, metal seats.

3.7 CONDENSER-WATER VALVE SCHEDULE

A. Pipe NPS 3 and Smaller:
   1. Ball Valves, NPS 3 and Smaller: Two piece, 600-psig CWP rating, copper alloy.
   2. Bronze Swing Check Valves: Class 125, bronze disc.

B. Pipe NPS 4 and Larger:
   1. Butterfly Valves: Tapped Lug, 300-psig CWP rating, ferrous alloy, with EPDM liner.
   2. Grooved-End, Ductile-Iron Butterfly Valves: 300-psig CWP rating.
   3. High-Performance Butterfly Valves: Class 150, single flange.
   4. Iron Swing Check Valves: Class 125, metal seats.

3.8 HEATING-WATER VALVE SCHEDULE

A. Pipe NPS 3 and Smaller:
   1. Ball Valves, NPS 3 and Smaller: Two piece, 600-psig CWP rating, copper alloy.
   2. Bronze Swing Check Valves: Class 125, bronze disc.

B. Pipe NPS 4 and Larger:
   1. Butterfly Valves: Tapped Lug, 300-psig CWP rating, ferrous alloy, with EPDM liner.
   2. Grooved-End, Ductile-Iron Butterfly Valves: 300-psig CWP rating.
   3. High-Performance Butterfly Valves: Class 150, single flange.
   4. Iron Swing Check Valves: Class 125, metal seats.

3.9 LOW-PRESSURE STEAM VALVE SCHEDULE (15 PSIG OR LESS)

A. Pipe NPS 3 and Smaller:
   1. Ball Valves: Two-piece, 600-psig CWP rating, copper alloy.
   2. Swing Check Valves: Class 125, bronze.

B. Pipe NPS 4 and Larger:
   1. Iron Valves, NPS 4: May be provided with threaded ends instead of flanged ends.
   2. Iron Swing Check Valves: Class 125 metal seats.

3. Iron Gate Valves: Class 125 OS&Y.
4. Iron Globe Valves, NPS 4 to NPS 12: Class 125.

3.10 HIGH-PRESSURE STEAM VALVE SCHEDULE (MORE THAN 15 PSIG)

A. Pipe NPS 3 and Smaller:

1. Ball Valves: Two-piece, 600-psig CWP rating, copper alloy.
2. Swing Check Valves: Class 200, bronze.
3. Globe Valves, NPS 3 and Smaller: Type 1, Class 200, bronze.

B. Pipe Sizes NPS 4 and Larger:

1. Swing Check Valves: Class 250, gray Iron
2. Globe Valves: Class 250, bronze-mounted cast iron.

3.11 STEAM-CONDENSATE VALVE SCHEDULE

A. Pipe NPS 3 and Smaller:

1. Ball Valves: Two-piece, 600-psig CWP rating, copper alloy.
2. Swing Check Valves: Class 125, bronze.
3. Globe Valves: Class 125, bronze.

B. Pipe NPS 4 and Larger:

1. Swing Check Valves: Class 125, gray iron.
2. Globe Valves: Class 125, bronze-mounted cast iron.

END OF SECTION

SECTION 230529
HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT

PART 1 GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
   1. Metal pipe hangers and supports.
   2. Trapeze pipe hangers.
   3. Metal framing systems.
   4. Thermal-hanger shield inserts.
   5. Fastener systems.
   6. Pipe stands.
   7. Equipment supports.

B. Related Sections:
   1. Section 055000 "Metal Fabrications" for structural-steel shapes and plates for trapeze hangers for pipe and equipment supports.
   2. Section 230516 "Expansion Fittings and Loops for HVAC Piping" for pipe guides and anchors.
   3. Section 230548 "Vibration and Seismic Controls for HVAC" for vibration isolation devices.
   4. Section 233113 "Metal Ducts" for duct hangers and supports.

1.3 DEFINITIONS

A. MSS: Manufacturers Standardization Society of The Valve and Fittings Industry Inc.

1.4 PERFORMANCE REQUIREMENTS

A. Delegated Design: Design trapeze pipe hangers and equipment supports, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

B. Structural Performance: Hangers and supports for HVAC piping and equipment shall withstand the effects of gravity loads and stresses within limits and under conditions indicated according to ASCE/SEI 7.
   1. Design supports for multiple pipes, including pipe stands, capable of supporting combined weight of supported systems, system contents, and test water.
   2. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.

1.5 ACTION SUBMITTALS

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

1.6 QUALITY ASSURANCE

A. Structural Steel Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

B. Pipe Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code.

PART 2 PRODUCTS

2.1 METAL PIPE HANGERS AND SUPPORTS

A. Carbon-Steel Pipe Hangers and Supports:
   1. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
   2. Galvanized Metallic Coatings: Pre-galvanized or hot dipped.
   3. Nonmetallic Coatings: Plastic coating, jacket, or liner.
   4. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.
   5. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel or stainless steel.

B. Stainless-Steel Pipe Hangers and Supports:
   1. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
   2. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.
   3. Hanger Rods: Continuous-thread rod, nuts, and washer made of stainless steel.

C. Copper Pipe Hangers:
   1. Description: MSS SP-58, Types 1 through 58, copper-coated-steel, factory-fabricated components.
   2. Hanger Rods: Continuous-thread rod, nuts, and washer made of copper-coated steel or stainless steel.

2.2 TRAPEZE PIPE HANGERS

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

2.3 METAL FRAMING SYSTEMS

A. MFMA Manufacturer Metal Framing Systems:
   1. Manufacturers: Subject to compliance with requirements provide products by one of the following:
      a. Allied Tube & Conduit. (www.alliedtube.com)
      b. Cooper B-Line, Inc. (www.cooperindustries.com)
      c. Flex-Strut Inc. (www.flexstrut.com)
      d. Thomas & Betts Corporation. (www.tnb.com)
      e. Unistrut Corporation; Tyco International, Ltd. (www.unistrut.com)
      f. Wesanco, Inc. (www.wesanco.com)
   2. Description: Shop- or field-fabricated pipe-support assembly for supporting multiple parallel pipes.
   3. Standard: MFMA-4.
   4. Channels: Continuous slotted steel channel with in-turned lips.
   5. Channel Nuts: Formed or stamped steel nuts or other devices designed to fit into channel slot and, when tightened, prevent slipping along channel.
   6. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel or stainless steel.

2.4 THERMAL-HANGER SHIELD INSERTS

A. Manufacturers: Subject to compliance with requirements provide products by one of the following:
   1. Carpenter & Paterson, Inc. (www.carpenterandpaterson.com)
   2. Clement Support Services. (www.clementsupport.com)
   3. ERICO International Corporation. (www.erico.com)
   4. National Pipe Hanger Corporation. (www.nationalpipehanger.com)
   5. PHS Industries, Inc. (www.phsind.com)
   6. Pipe Shields, Inc.; a subsidiary of Piping Technology & Products, Inc. (www.pipingtech.com)
   7. Piping Technology & Products, Inc. (www.pipingtech.com)

8. Rilco Manufacturing Co., Inc. (www.rilcomfg.com)

B. Insulation-Insert Material for Cold Piping: ASTM C 552, Type II cellular glass with 100-psig or ASTM C 591, Type VI, Grade 1 polyisocyanurate with 125-psig minimum compressive strength and vapor barrier.

C. Insulation-Insert Material for Hot Piping: ASTM C 552, Type II cellular glass with 100-psig minimum compressive strength.

D. For Trapeze or Clamped Systems: Insert and shield shall cover entire circumference of pipe.

E. For Clevis or Band Hangers: Insert and shield shall cover lower 180 degrees of pipe.

F. Insert Length: Extend 2 inches beyond sheet metal shield for piping operating below ambient air temperature.

2.5 FASTENER SYSTEMS

A. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened Portland cement concrete with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

2.6 PIPE STANDS

A. General Requirements for Pipe Stands: Shop- or field-fabricated assemblies made of manufactured corrosion-resistant components to support roof-mounted piping.

B. Compact Pipe Stand: One-piece plastic unit with integral-rod roller, pipe clamps, or V-shaped cradle to support pipe, for roof installation without membrane penetration.

C. Low-Type, Single-Pipe Stand: One-piece plastic or stainless-steel base unit with plastic roller, for roof installation without membrane penetration.

D. High-Type, Single-Pipe Stand:

1. Description: Assembly of base, vertical and horizontal members, and pipe support, for roof installation without membrane penetration.
2. Base: [Plastic] [Stainless steel].
3. Vertical Members: Two or more cadmium-plated-steel or stainless-steel, continuous-thread rods.
4. Horizontal Member: Cadmium-plated-steel or stainless-steel rod with plastic or stainless-steel, roller-type pipe support.

E. High-Type, Multiple-Pipe Stand:

1. Description: Assembly of bases, vertical and horizontal members, and pipe supports, for roof installation without membrane penetration.
2. Bases: One or more; plastic.
3. Vertical Members: Two or more protective-coated-steel channels.
4. Horizontal Member: Protective-coated-steel channel.
5. Pipe Supports: Galvanized-steel, clevis-type pipe hangers.

F. Curb-Mounted-Type Pipe Stands: Shop- or field-fabricated pipe supports made from structural-steel shapes, continuous-thread rods, and rollers, for mounting on permanent stationary roof curb.

2.7 EQUIPMENT SUPPORTS

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

2.8 MISCELLANEOUS MATERIALS

A. Structural Steel: ASTM A 36/A 36M, carbon-steel plates, shapes, and bars; black and galvanized.

B. Grout: ASTM C 1107, factory-mixed and -packaged, dry, hydraulic-cement, non-shrink and non-metallic grout; suitable for interior and exterior applications.

1. Properties: Non-staining, noncorrosive, and nongaseous.
2. Design Mix: 5000-psi, 28-day compressive strength.

PART 3 EXECUTION

3.1 HANGER AND SUPPORT INSTALLATION

A. Metal Pipe-Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Install hangers, supports, clamps, and attachments as required to properly support piping from the building structure.

B. Metal Trapeze Pipe-Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Arrange for grouping of parallel runs of horizontal piping, and support together on field-fabricated trapeze pipe hangers.

1. Pipes of Various Sizes: Support together and space trapezes for smallest pipe size or install intermediate supports for smaller diameter pipes as specified for individual pipe hangers.
2. Field fabricate from ASTM A 36/A 36M, carbon-steel shapes selected for loads being supported. Weld steel according to AWS D1.1/D1.1M.

C. Metal Framing System Installation: Arrange for grouping of parallel runs of piping, and support together on field-assembled metal framing systems.

D. Thermal-Hanger Shield Installation: Install in pipe hanger or shield for insulated piping.

E. Fastener System Installation:

1. Install powder-actuated fasteners for use in lightweight concrete or concrete slabs less than 4 inches thick in concrete after concrete is placed and completely cured. Use operators that are licensed by powder-actuated tool manufacturer. Install fasteners according to powder-actuated tool manufacturer's operating manual.
2. Install mechanical-expansion anchors in concrete after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.

F. Pipe Stand Installation:

1. Pipe Stand Types except Curb-Mounted Type: Assemble components and mount on smooth roof surface. Do not penetrate roof membrane.
2. Curb-Mounted-Type Pipe Stands: Assemble components or fabricate pipe stand and mount on permanent, stationary roof curb. See Section 077200 "Roof Accessories" for curbs.

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

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

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. Install lateral bracing with pipe hangers and supports to prevent swaying.

K. Install building attachments within concrete slabs or attach to structural steel. Install additional attachments at concentrated loads, including valves, flanges, and strainers, NPS 2-1/2 and larger and at changes in direction of piping. Install concrete inserts before concrete is placed; fasten inserts to forms and install reinforcing bars through openings at top of inserts.

L. Load Distribution: Install hangers and supports so that piping live and dead loads and stresses from movement will not be transmitted to connected equipment.

M. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and to not exceed maximum pipe deflections allowed by ASME B31.9 for building services piping.

N. Insulated Piping:

1. Attach clamps and spacers to piping.
   a. Piping Operating above Ambient Air Temperature: Clamp may project through insulation.
   b. Piping Operating below Ambient Air Temperature: Use thermal-hanger shield insert with clamp sized to match OD of insert.
   c. Do not exceed pipe stress limits allowed by ASME B31.9 for building services piping.
2. Install MSS SP-58, Type 39, protection saddles if insulation without vapor barrier is indicated. Fill interior voids with insulation that matches adjoining insulation.
   a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.

3. Install MSS SP-58, Type 40, protective shields on cold piping with vapor barrier. Shields shall span an arc of 180 degrees.
   a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.
4. Shield Dimensions for Pipe: Not less than the following:
   a. NPS 1/4 to NPS 3-1/2: 12 inches long and 0.048 inch thick.
   b. NPS 4: 12 inches long and 0.06 inch thick.
   c. NPS 5 and NPS 6: 18 inches long and 0.06 inch thick.
   d. NPS 8 to NPS 14: 24 inches long and 0.075 inch thick.
   e. NPS 16 to NPS 24: 24 inches long and 0.105 inch thick.
5. Pipes NPS 8 and Larger: Include wood or reinforced calcium-silicate-insulation inserts of length at least as long as protective shield.
6. Thermal-Hanger Shields: Install with insulation same thickness as piping insulation.

3.2 EQUIPMENT SUPPORTS

A. Fabricate structural-steel stands to suspend equipment from structure overhead or to support equipment above floor.

B. Grouting: Place grout under supports for equipment and make bearing surface smooth.

C. Provide lateral bracing, to prevent swaying, for equipment supports.

3.3 METAL FABRICATIONS

A. Cut, drill, and fit miscellaneous metal fabrications for trapeze pipe hangers and equipment supports.

B. Fit exposed connections together to form hairline joints. Field weld connections that cannot be shop welded because of shipping size limitations.

C. Field Welding: Comply with AWS D1.1/D1.1M procedures for shielded, metal arc welding; appearance and quality of welds; and methods used in correcting welding work; and with the following:
   1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
   2. Obtain fusion without undercut or overlap.
   3. Remove welding flux immediately.
   4. Finish welds at exposed connections so no roughness shows after finishing and so contours of welded surfaces match adjacent contours.

3.4 ADJUSTING

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

B. Trim excess length of continuous-thread hanger and support rods to 1-1/2 inches.

3.5 PAINTING

A. Touchup: Cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal are specified in Section 099113 "Exterior Painting"; Section 099123 "Interior Painting" and Section 099600 "High Performance Coatings."

B. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

3.6 HANGER AND SUPPORT SCHEDULE

A. Specific hanger and support requirements are in Sections specifying piping systems and equipment.

B. Comply with MSS SP-69 for pipe-hanger selections and applications that are not specified in piping system Sections.

C. Use hangers and supports with galvanized metallic coatings for piping and equipment that will not have field-applied finish.

D. Use nonmetallic coatings on attachments for electrolytic protection where attachments are in direct contact with copper tubing.

E. Use carbon-steel pipe hangers and supports, metal trapeze pipe hangers, and metal framing systems and attachments for general service applications.

F. Use stainless-steel pipe hangers and [stainless-steel attachments for hostile environment applications.

G. Use copper-plated pipe hangers and copper attachments for copper piping and tubing.

H. Use padded hangers for piping that is subject to scratching.

I. Use thermal-hanger shield inserts for insulated piping and tubing.

J. Horizontal-Piping Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of non-insulated or insulated, stationary pipes NPS 1/2 to NPS 30.
2. Yoke-Type Pipe Clamps (MSS Type 2): For suspension of up to 1050 deg F, pipes NPS 4 to NPS 24, requiring up to 4 inches of insulation.
3. Carbon- or Alloy-Steel, Double-Bolt Pipe Clamps (MSS Type 3): For suspension of pipes NPS 3/4 to NPS 36, requiring clamp flexibility and up to 4 inches of insulation.
4. Steel Pipe Clamps (MSS Type 4): For suspension of cold and hot pipes NPS 1/2 to NPS 24 if little or no insulation is required.
5. Pipe Hangers (MSS Type 5): For suspension of pipes NPS 1/2 to NPS 4, to allow off-center closure for hanger installation before pipe erection.
6. Adjustable, Swivel Split- or Solid-Ring Hangers (MSS Type 6): For suspension of non-insulated, stationary pipes NPS 3/4 to NPS 8.
7. Adjustable, Steel Band Hangers (MSS Type 7): For suspension of non-insulated, stationary pipes NPS 1/2 to NPS 8.
8. Adjustable Band Hangers (MSS Type 9): For suspension of non-insulated, stationary pipes NPS 1/2 to NPS 8.
9. Adjustable, Swivel-Ring Band Hangers (MSS Type 10): For suspension of non-insulated, stationary pipes NPS 1/2 to NPS 8.
10. Split Pipe Ring with or without Turnbuckle Hangers (MSS Type 11): For suspension of non-insulated, stationary pipes NPS 3/8 to NPS 8.
11. Extension Hinged or Two-Bolt Split Pipe Clamps (MSS Type 12): For suspension of non-insulated, stationary pipes NPS 3/8 to NPS 3.
12. U-Bolts (MSS Type 24): For support of heavy pipes NPS 1/2 to NPS 30.
13. Clips (MSS Type 26): For support of insulated pipes not subject to expansion or contraction.
14. Pipe Saddle Supports (MSS Type 36): For support of pipes NPS 4 to NPS 36, with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate.
15. Pipe Stanchion Saddles (MSS Type 37): For support of pipes NPS 4 to NPS 36, with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate, and with U-bolt to retain pipe.
16. Adjustable Pipe Saddle Supports (MSS Type 38): For stanchion-type support for pipes NPS 2-1/2 to NPS 36 if vertical adjustment is required, with steel-pipe base stanchion support and cast-iron floor flange.
17. Single-Pipe Rolls (MSS Type 41): For suspension of pipes NPS 1 to NPS 30, from two rods if longitudinal movement caused by expansion and contraction might occur.
18. Adjustable Roller Hangers (MSS Type 43): For suspension of pipes NPS 2-1/2 to NPS 24, from single rod if horizontal movement caused by expansion and contraction might occur.
19. Complete Pipe Rolls (MSS Type 44): For support of pipes NPS 2 to NPS 42 if longitudinal movement caused by expansion and contraction might occur but vertical adjustment is not necessary.
20. Pipe Roll and Plate Units (MSS Type 45): For support of pipes NPS 2 to NPS 24 if small horizontal movement caused by expansion and contraction might occur and vertical adjustment is not necessary.
21. Adjustable Pipe Roll and Base Units (MSS Type 46): For support of pipes NPS 2 to NPS 30 if vertical and lateral adjustment during installation might be required in addition to expansion and contraction.

K. Vertical-Piping Clamps: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

   1. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers NPS 3/4 to NPS 24.
   2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers NPS 3/4 to NPS 24 if longer ends are required for riser clamps.

L. Hanger-Rod Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

   1. Steel Turnbuckles (MSS Type 13): For adjustment up to 6 inches 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.

M. Building Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

   1. Steel or Malleable Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.
   2. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joist construction, to attach to top flange of structural shape.
   3. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.
   4. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.
   5. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.
   6. C-Clamps (MSS Type 23): For structural shapes.
   7. Top-Beam Clamps (MSS Type 25): For top of beams if hanger rod is required tangent to flange edge.
   8. Side-Beam Clamps (MSS Type 27): For bottom of steel I-beams.
   9. Steel-Beam Clamps with Eye Nuts (MSS Type 28): For attaching to bottom of steel I-beams for heavy loads.
   10. Linked-Steel Clamps with Eye Nuts (MSS Type 29): For attaching to bottom of steel I-beams for heavy loads, with link extensions.
   11. Malleable-Beam Clamps with Extension Pieces (MSS Type 30): For attaching to structural steel.
   12. Welded-Steel Brackets: For support of pipes from below or for suspending from above by using clip and rod. Use one of the following for indicated loads:
       a. Light (MSS Type 31): 750 lb.
       b. Medium (MSS Type 32): 1500 lb.
       c. Heavy (MSS Type 33): 3000 lb.
   13. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.
   14. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.
   15. Horizontal Travelers (MSS Type 58): For supporting piping systems subject to linear horizontal movement where headroom is limited.

N. Saddles and Shields: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

   1. Steel-Pipe-Covering Protection Saddles (MSS Type 39): To fill interior voids with insulation that matches adjoining insulation.
   2. Protection Shields (MSS Type 40): Of length recommended in writing by manufacturer to prevent crushing insulation.
   3. Thermal-Hanger Shield Inserts: For supporting insulated pipe.

O. Comply with MSS SP-69 for trapeze pipe-hanger selections and applications that are not specified in piping system Sections.

P. Comply with MFMA-103 for metal framing system selections and applications that are not specified in piping system Sections.

Q. Use powder-actuated fasteners instead of building attachments where required in concrete construction.

END OF SECTION

SECTION 230593
TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 1 GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
   1. Balancing Air Systems:
      a. Constant-volume air systems.
      b. Dual-duct systems.
      c. Variable-air-volume systems.
      d. Multizone systems.
      e. Induction-unit systems.
   2. Balancing Hydronic Piping Systems:
      a. Constant-flow hydronic systems.
      b. Variable-flow hydronic systems.
      c. Primary-secondary hydronic systems.
   3. Steam systems.
   4. HVAC equipment quantitative-performance settings.
   5. Existing systems TAB.
   6. Verifying that automatic control devices are functioning properly.
   7. Reporting results of activities and procedures specified in this Section.

1.3 DEFINITIONS

A. Adjust: To regulate fluid flow rate and air patterns at the terminal equipment, such as to reduce fan speed or adjust a damper.

B. Balance: To proportion flows within the distribution system, including sub mains, branches, and terminals, according to indicated quantities.

C. Barrier or Boundary: Construction, either vertical or horizontal, such as walls, floors, and ceilings that are designed and constructed to restrict the movement of airflow, smoke, odors, and other pollutants.

D. Draft: A current of air, when referring to localized effect caused by one or more factors of high air velocity, low ambient temperature, or direction of airflow, whereby more heat is withdrawn from a person's skin than is normally dissipated.

E. Procedure: An approach to and execution of a sequence of work operations to yield repeatable results.

F. Report Forms: Test data sheets for recording test data in logical order.

G. Smoke-Control System: An engineered system that uses fans to produce airflow and pressure differences across barriers to limit smoke movement.

H. Smoke-Control Zone: A space within a building that is enclosed by smoke barriers and is a part of a zoned smoke-control system.

I. Stair Pressurization System: A type of smoke-control system that is intended to positively pressurize stair towers with outdoor air by using fans to keep smoke from contaminating the stair towers during an alarm condition.

J. Static Head: The pressure due to the weight of the fluid above the point of measurement. In a closed system, static head is equal on both sides of the pump.

K. Suction Head: The height of fluid surface above the centerline of the pump on the suction side.

L. System Effect: A phenomenon that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system.

M. System Effect Factors: Allowances used to calculate a reduction of the performance ratings of a fan when installed under conditions different from those presented when the fan was performance tested.

N. TAB: Testing, adjusting, and balancing.

O. Terminal: A point where the controlled medium, such as fluid or energy, enters or leaves the distribution system.

P. Test: A procedure to determine quantitative performance of systems or equipment.

Q. Testing, Adjusting, and Balancing (TAB) Firm: The entity responsible for performing and reporting TAB procedures.

R. AABC: Associated Air Balance Council.

S. NEBB: National Environmental Balancing Bureau.

T. TAB: Testing, adjusting, and balancing.

U. TABB: Testing, Adjusting, and Balancing Bureau.

V. TAB Specialist: An entity engaged to perform TAB Work.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: Within [30] 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 [30] days of Contractor's Notice to Proceed, submit the Contract Documents review report as specified in Part 3.

C. Strategies and Procedures Plan: Within [30] days of Contractor's Notice to Proceed, submit TAB strategies and step-by-step procedures as specified in "Preparation" Article.

D. System Readiness Checklists: Within [30] days of Contractor's Notice to Proceed, submit system readiness checklists as specified in "Preparation" Article.

E. Certified TAB Reports: Submit two copies of reports prepared, as specified in this Section, on approved forms certified by TAB firm.

F. Examination Report: Submit a summary report of the examination review required in "Examination" Article.

G. Sample Report Forms: Submit two sets of sample TAB report forms.

H. Instrument calibration reports, to include the following:

1. Instrument type and make.
2. Serial number.
3. Application.
4. Dates of use.
5. Dates of calibration.

I. Warranties specified in this Section.

1.5 QUALITY ASSURANCE

A. TAB Contractor Qualifications: Engage a TAB entity certified by either AABC or NEBB.

1. TAB Technician: Employee of the TAB contractor and who is certified by AABC, NEBB, or TABB as a TAB technician.

B. TAB Conference: Meet with Architect, Owners representatives 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.

C. Coordination of documentation and communication flow. Certification of TAB Reports: Certify TAB field data reports. This certification includes the following:
    1. Review field data reports to validate accuracy of data and to prepare certified TAB reports.
    2. Certify that TAB team complied with approved TAB plan and the procedures specified and referenced in this Specification.

D. TAB Report Forms: Use standard forms from AABC's "National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems." or NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems.

E. Instrumentation Type, Quantity, and Accuracy: As described in AABC's "National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems or NEBB's " Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems, "Section II, " Required Instrumentation for NEBB Certification."

F. Instrumentation Calibration: Calibrate instruments at least every six months or more frequently if required by instrument manufacturer.
    1. Keep an updated record of instrument calibration that indicates date of calibration and the name of party performing instrument calibration.

G. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 7.2.2 - "Air Balancing."

H. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6.7.2.3 - "System Balancing."

1.6 FIELD CONDITIONS

A. Full Owner Occupancy: Owner will occupy the site and existing building during entire TAB period. Cooperate with Owner during TAB operations to minimize conflicts with Owner's operations.

B. Partial Owner Occupancy: Owner may occupy completed areas of building before Substantial Completion. Cooperate with Owner during TAB operations to minimize conflicts with Owner's operations.

1.7 COORDINATION

A. Coordinate the efforts of factory-authorized service representatives for systems and equipment, HVAC controls installers, and other mechanics to operate HVAC systems and equipment to support and assist TAB activities.

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

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

1.8 WARRANTY

1. The certified TAB firm has tested and balanced systems according to the Contract Documents.
2. Systems are balanced to optimum performance capabilities within design and installation limits.

PART 2 PRODUCTS (Not Applicable)

PART 3 EXECUTION

3.1 EXAMINATION

A. Examine the Contract Documents to become familiar with Project requirements and to discover conditions in systems' designs that may preclude proper TAB of systems and equipment.

B. Examine 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 under floor 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 "Metal Ducts" division 23 "Nonmetal 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.

3.2 PREPARATION

A. Prepare a TAB plan that includes the following:

1. Equipment and systems to be tested.
2. Strategies and step-by-step procedures for balancing the systems.
3. Instrumentation to be used.
4. Sample forms with specific identification for all equipment.

B. Perform system-readiness checks of HVAC systems and equipment to verify system readiness for TAB work and prepare reports. Include, at a minimum, the following:

1. General:
   a. Permanent electrical-power wiring is complete.
   b. Automatic temperature-control systems are operational.
   c. Windows and doors can be closed so indicated conditions for system operations can be met.

2. Airside:
    a. Verify that leakage and pressure tests on air distribution systems have been satisfactorily completed.
    b. Duct systems are complete with terminals installed.
    c. Volume, smoke, and fire dampers are open and functional.
    d. Clean filters are installed.
    e. Fans are operating, free of vibration, and rotating in correct direction.
    f. Variable-frequency controllers' startup is complete and safeties are verified.
    g. Automatic temperature-control systems are operational.
    h. Ceilings are installed.
    i. Windows and doors are installed.
    j. Suitable access to balancing devices and equipment is provided.
    k. Equipment and duct access doors are securely closed.
3. Hydronics:
    a. Verify leakage and pressure tests on water distribution systems have been satisfactorily completed.
    b. Piping is complete with terminals installed.
    c. Water treatment is complete.
    d. Systems are flushed, filled, and air purged.
    e. Strainers are pulled and cleaned.
    f. Control valves are functioning per the sequence of operation.
    g. Shutoff and balance valves have been verified to be 100 percent open.
    h. Pumps are started and proper rotation is verified.
    i. Pump gage connections are installed directly at pump inlet and outlet flanges or in discharge and suction pipe prior to valves or strainers.
    j. Variable-frequency controllers' startup is complete and safeties are verified.
    k. Suitable access to balancing devices and equipment is provided.

3.3 CONSTRUCTION CHECKLIST

A. On projects with commissioning, contractor is responsible for utilizing the construction checklists supplied by the Commissioning Authority under Specification Section 019113, in accordance with the procedures defined for construction checklists.

3.4 FUNCTIONAL TESTING

A. On projects with commissioning, contractor is responsible for utilizing functional test procedures supplied by the Commissioning Authority under Specification Section 019113, in accordance with the procedures defined for functional test procedures.

3.5 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", ASHRAE 111, NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems", SMACNA's "HVAC Systems - Testing, Adjusting, and Balancing", AABC's "National Standards for Total System Balance" or NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems" and in this Section.
    1. Comply with requirements in ASHRAE 62.1, 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.

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.

3.6 GENERAL PROCEDURES FOR BALANCING AIR SYSTEMS

A. Prepare test reports for both fans and outlets. Obtain manufacturer's outlet factors and recommended testing procedures. Crosscheck the summation of required outlet volumes with required fan volumes.

B. Prepare schematic diagrams of systems' "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 "Metal Ducts."

3.7 PROCEDURES FOR CONSTANT-VOLUME AIR SYSTEMS

A. Adjust fans to deliver total indicated airflows within the maximum allowable fan speed listed by fan manufacturer.

1. Measure total airflow.
    a. Set outside-air, return-air, and relief-air dampers for proper position that simulates minimum outdoor-air conditions.
    b. Where duct conditions allow, measure airflow by Pitot-tube traverse. If necessary, perform multiple Pitot-tube traverses to obtain total airflow.
    c. Where duct conditions are not suitable for Pitot-tube traverse measurements, a coil traverse may be acceptable.
    d. If a reliable Pitot-tube traverse or coil traverse is not possible, measure airflow at terminals and calculate the total airflow.
2. Measure fan static pressures as follows to determine actual static pressure:
    a. Measure static pressure directly at the fan outlet or through the flexible connection.
    b. Measure static pressure directly at the fan inlet or through the flexible connection.
    c. Measure static pressure across each component that makes up the air-handling system.
        1) Measure static pressures entering and leaving other devices, such as sound traps, heat-recovery equipment, and air washers, under final balanced conditions.
    d. Report the artificial loading of filters at the time static pressures are measured.
    e. Measure static pressures entering and leaving other devices, such as sound traps, heat-recovery equipment, and air washers, under final balanced conditions.
3. Obtain approval from Architect for adjustment of fan speed higher or lower than indicated speed. Comply with requirements in HVAC Sections for air-handling units for adjustment of fans, belts, and pulley sizes to achieve indicated air-handling-unit performance.
4. 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. Adjust submain branch duct volume dampers for specified airflows.

3. Re-measure 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.

1. Set airflow patterns of adjustable outlets for proper distribution without drafts.
2. Measure inlets and outlets airflow
3. 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.
    a. Make adjustments using branch volume dampers rather than extractors and the dampers at air terminals.
4. Re-measure each inlet and outlet after they have been adjusted.

E. Verify final system conditions.

1. Re-measure and confirm that minimum outdoor, return, and relief airflows are within design. Readjust to design if necessary.
2. Re-measure and confirm that total airflow is within design.
3. Re-measure all final fan operating data, rpms, volts, amps, and static profile.
4. Mark all final settings.
5. Test system in economizer mode. Verify proper operation and adjust if necessary.
6. Measure and record all operating data.
7. Record final fan-performance data.

3.8 PROCEDURES FOR DUAL-DUCT SYSTEMS

A. Adjust the dual-duct system as follows:

1. Verify that the system static pressure sensor is located as indicated on the drawings. On systems with separate hot-deck and cold-deck fans, verify the location of the sensor on each deck.
2. Verify that the system is under static pressure control.
3. Select the terminal unit that is most critical to the supply-fan airflow. Measure inlet static pressure, and adjust system static pressure control set point so the entering static pressure for the critical terminal unit is not less than the sum of the terminal-unit manufacturer's recommended minimum inlet static pressure plus the static pressure needed to overcome terminal-unit discharge system losses.
4. Calibrate and balance each terminal unit's hot deck and cold deck for maximum and minimum design airflow as follows:
    a. Adjust controls so that terminal is calling for full cooling. Some controllers require starting with minimum set point. Verify calibration procedure for specific project.
    b. Measure airflow and adjust calibration factors as required for design cold-deck maximum airflow and hot-deck minimum airflow. Record calibration factors.
    c. When maximum airflow is correct, balance the air outlets downstream from terminal units.
    d. Adjust controls so that terminal is calling for full heating.
    e. Measure airflow and adjust calibration factors as required for design cold-deck minimum airflow and hot-deck maximum airflow. Record calibration factors. If no minimum calibration is available, note any deviation from design airflow.
5. After terminals have been calibrated and balanced, test and adjust system for total airflow. Adjust fans to deliver total design airflows within the maximum allowable fan speed listed by fan manufacturer.
    a. Set outside-air, return-air, and relief-air dampers for proper position that simulates minimum outdoor-air conditions.
    b. Set terminals for maximum airflow. If system design includes diversity (cooling coil or fan), adjust terminals for maximum and minimum airflow so that connected total matches cooling coil or fan selection and simulates actual load in the building. In systems with separate hot-deck and cold-deck fans, diversity consideration applies to each individual fan.
    c. Where duct conditions allow, measure airflow by Pitot-tube traverse. If necessary, perform multiple Pitot-tube traverses to obtain total airflow.

d. Where duct conditions are not suitable for Pitot-tube traverse measurements, a coil traverse may be acceptable.
e. If a reliable Pitot-tube traverse or coil traverse is not possible, measure airflow at terminals and calculate the total airflow.
6. Measure the fan(s) static pressures as follows:
    a. Measure static pressure directly at the fan outlet or through the flexible connection.
    b. Measure static pressure directly at the fan inlet or through the flexible connection.
    c. Measure static pressure across each component that makes up the air-handling system.
    d. Report any artificial loading of filters at the time static pressures are measured.
7. Set final return and outside airflow to the fan(s) while operating at maximum return airflow and minimum outdoor airflow.
    a. Balance the return-air ducts and inlets the same as described for constant-volume air systems.
    b. Verify that all terminal units are meeting design airflow under system maximum flow.
8. Re-measure the inlet static pressure at the most critical terminal unit and adjust the system static pressure set point to the most energy-efficient set point to maintain the optimum system static pressure. Record set point and give to controls contractor.
9. Verify final system conditions as follows:
    a. Re-measure and confirm that minimum outdoor, return, and relief airflows are within design. Readjust to match design if necessary.
    b. Re-measure and confirm that total airflow is within design.
    c. Re-measure final fan operating data, rpms, volts, amps and static profile.
    d. Mark final settings.
    e. Test system in economizer mode. Verify proper operation and adjust if necessary. Measure and record all operating data.
    f. Verify tracking between supply and return fans.
10. Record final fan-performance data.

B. Adjust variable-air-volume, dual-duct systems in the same way as constant-volume, dual-duct systems; adjust maximum- and minimum-airflow setting of each mixing box.

1. 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 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.

C. Do not over pressurize ducts.

3.9 PROCEDURES FOR VARIABLE-AIR-VOLUME SYSTEMS

A. Adjust the variable-air-volume systems as follows:

1. Verify that the system static pressure sensor is located two-thirds of the distance down the duct from the fan discharge.
2. Verify that the system is under static pressure control.
3. Select the terminal unit that is most critical to the supply-fan airflow. Measure inlet static pressure, and adjust system static pressure control set point so the entering static pressure for the critical terminal unit is not less than the sum of the terminal-unit manufacturer's recommended minimum inlet static pressure plus the static pressure needed to overcome terminal-unit discharge system losses.
4. Calibrate and balance each terminal unit for maximum and minimum design airflow as follows:
    a. Adjust controls so that terminal is calling for maximum airflow. Some controllers require starting with minimum airflow. Verify calibration procedure for specific project.
    b. Measure airflow and adjust calibration factor as required for design maximum airflow. Record calibration factor.
    c. When maximum airflow is correct, balance the air outlets downstream from terminal units.
    d. Adjust controls so that terminal is calling for minimum airflow.
    e. Measure airflow and adjust calibration factor as required for design minimum airflow. Record calibration factor. If no minimum calibration is available, note any deviation from design airflow.
        1) Check air outlets for a proportional reduction in airflow the same as described for constant-volume air systems.

2) If air outlets are out of balance at minimum airflow, report the condition but leave outlets balanced for maximum airflow.

f. On constant volume terminals, in critical areas where room pressure is to be maintained, verify that the airflow remains constant over the full range of full cooling to full heating. Note any deviation from design airflow or room pressure.

5. After terminals have been calibrated and balanced, test and adjust system for total airflow. Adjust fans to deliver total design airflows within the maximum allowable fan speed listed by fan manufacturer.
   a. Set outside-air, return-air, and relief-air dampers for proper position that simulates minimum outdoor-air conditions.
   b. Set terminals for maximum airflow. If system design includes diversity, adjust terminals for maximum and minimum airflow so that connected total matches fan selection and simulates actual load in the building.
   c. Where duct conditions allow, measure airflow by Pitot-tube traverse. If necessary, perform multiple Pitot-tube traverses to obtain total airflow.
   d. Where duct conditions are not suitable for Pitot-tube traverse measurements, a coil traverse may be acceptable.
   e. If a reliable Pitot-tube traverse or coil traverse is not possible, measure airflow at terminals and calculate the total airflow.
6. Measure fan static pressures as follows:
   a. Measure static pressure directly at the fan outlet or through the flexible connection.
   b. Measure static pressure directly at the fan inlet or through the flexible connection.
   c. Measure static pressure across each component that makes up the air-handling system.
   d. Report any artificial loading of filters at the time static pressures are measured.
7. Set final return and outside airflow to the fan while operating at maximum return airflow and minimum outdoor airflow.
   a. Balance the return-air ducts and inlets the same as described for constant-volume air systems.
   b. Verify that terminal units are meeting design airflow under system maximum flow.
8. Re-measure the inlet static pressure at the most critical terminal unit and adjust the system static pressure set point to the most energy-efficient set point to maintain the optimum system static pressure. Record set point and give to controls contractor.
9. Verify final system conditions as follows:
   a. Re-measure and confirm that minimum outdoor, return, and relief airflows are within design. Readjust to match design if necessary.
   b. Re-measure and confirm that total airflow is within design.
   c. Re-measure final fan operating data, rpms, volts, amps, and static profile.
   d. Mark final settings.
   e. Test system in economizer mode. Verify proper operation and adjust if necessary. Measure and record all operating data.
   f. Verify tracking between supply and return fans.

B. 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 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.

3.10 PROCEDURES FOR MULTIZONE SYSTEMS

A. Position the unit's automatic zone dampers for maximum flow through the cooling coil.

B. The procedures for multizone systems will utilize the zone balancing dampers to achieve the indicated airflow within the zone.

C. After balancing, place the unit's automatic zone dampers for maximum heating flow. Retest zone airflows and record any variances.

D. Adjust fans to deliver total indicated airflows within the maximum allowable fan speed listed by fan manufacturer.

1. Measure total airflow.

a. Set outside-air, return-air and relief-air dampers for proper position that simulates minimum outdoor air conditions.
b. Where duct conditions allow, measure airflow by Pitot-tube traverse. If necessary, perform multiple Pitot-tube traverses to obtain total airflow.
c. Where duct conditions are not suitable for Pitot-tube traverse measurements, a coil traverse may be acceptable.
d. If a reliable Pitot-tube traverse or coil traverse is not possible, measure airflow at terminals and calculate the total airflow.

2. Measure fan static pressures as follows:
   a. Measure static pressure directly at the fan outlet or through the flexible connection.
   b. Measure static pressure directly at the fan inlet or through the flexible connection.
   c. Measure static pressure across each component that makes up the air-handling system.
   d. Report artificial loading of filters at the time static pressures are measured.
3. Review Record Documents to determine variations in design static pressures versus actual static pressures. Calculate actual system-effect factors. Recommend adjustments to accommodate actual conditions.
4. Obtain approval from Architect and Owner for adjustment of fan speed higher or lower than indicated speed. Comply with requirements in HVAC Sections for air-handling units for adjustment of fans, belts, and pulley sizes to achieve indicated air-handling-unit performance.
5. Do not make fan-speed adjustments that result in motor overload. Consult equipment manufacturers about fan-speed safety factors. Modulate dampers and measure fan-motor amperage to ensure that no overload occurs. Measure amperage in full-cooling, full-heating, economizer, and any other operating mode to determine the maximum required brake horsepower.

E. Adjust volume dampers for main duct, submain ducts, and major branch ducts to indicated airflows.
   1. Measure airflow of submain and branch ducts.
   2. Adjust submain and branch duct volume dampers for specified airflow.
   3. Re-measure each submain and branch duct after all have been adjusted.

F. Adjust air inlets and outlets for each space to indicated airflows.
   1. Set airflow patterns of adjustable outlets for proper distribution without drafts.
   2. Measure inlets and outlets airflow.
   3. Adjust each inlet and outlet for specified airflow.
   4. Re-measure each inlet and outlet after they have been adjusted.

G. Verify final system conditions.
   1. Re-measure and confirm that minimum outdoor, return, and relief airflows are within design. Readjust to match design if necessary.
   2. Re-measure and confirm that total airflow is within design.
   3. Re-measure all final fan operating data, rpms, volts, amps, and static profile.
   4. Mark all final settings.
   5. Test system in economizer mode. Verify proper operation and adjust if necessary.
   6. Measure and record all operating data.
   7. Record final fan-performance data.

3.11 PROCEDURES FOR INDUCTION-UNIT SYSTEMS

A. Balance primary-air risers by measuring static pressure at the nozzles of the top and bottom units of each riser to determine which risers must be throttled. Adjust risers to indicated airflow within specified tolerances.

B. Adjust each induction unit.

C. Adjust fans to deliver total indicated airflows within the maximum allowable fan speed listed by fan manufacturer.
   1. Measure total airflow.
      a. Set outside-air, return-air, and relief-air dampers for proper position that simulates minimum outdoor-air conditions.
      b. Where duct conditions allow, measure airflow by Pitot-tube traverse. If necessary, perform multiple Pitot-tube traverses to obtain total airflow.
      c. Where duct conditions are not suitable for Pitot-tube traverse measurements, a coil traverse may be acceptable.

   d. If a reliable Pitot-tube traverse or coil traverse is not possible, measure airflow at terminals and calculate the total airflow.
2. Measure fan static pressures as follows:
   a. Measure static pressure directly at the fan outlet or through the flexible connection.
   b. Measure static pressure directly at the fan inlet or through the flexible connection.
   c. Measure static pressure across each component that makes up the air-handling system.
   d. Report artificial loading of filters at the time static pressures are measured.
3. Review Record Documents to determine variations in design static pressures versus actual static pressures. Calculate actual system-effect factors. Recommend adjustments to accommodate actual conditions.
4. Obtain approval from Architect and Owner for adjustment of fan speed higher or lower than indicated speed. Comply with requirements in HVAC Sections for air-handling units for adjustment of fans, belts, and pulley sizes to achieve indicated air-handling-unit performance.
5. Do not make fan-speed adjustments that result in motor overload. Consult equipment manufacturers about fan-speed safety factors. Modulate dampers and measure fan-motor amperage to ensure that no overload occurs. Measure amperage in full-cooling, full-heating, economizer, and any other operating mode to determine the maximum required brake horsepower.

D. Adjust volume dampers for main duct, submain ducts, and major branch ducts to indicated airflows.
   1. Measure airflow of submain and branch ducts.
   2. Adjust submain and branch duct volume dampers for specified airflow.
   3. Re-measure each submain and branch duct after all have been adjusted.

E. Balance airflow to each induction unit by measuring the nozzle pressure and comparing it to the manufacturer's published data for nozzle pressure versus cfm. Adjust the unit's inlet damper to achieve the required nozzle pressure for design cfm.

F. Verify final system conditions.
   1. Re-measure and confirm that minimum outdoor, return, and relief airflows are within design. Readjust to match design if necessary.
   2. Re-measure and confirm that total airflow is within design.
   3. Re-measure all final fan operating data, rpms, volts, amps, and static profile.
   4. Mark all final settings.
   5. Test system in economizer mode. Verify proper operation and adjust if necessary.
   6. Measure and record all operating data.
   7. Record final fan-performance data.

3.12 GENERAL PROCEDURES FOR HYDRONIC SYSTEMS

A. Prepare test reports for pumps, coils heat exchangers and other hydronic equipment with pertinent design data, and number in sequence starting at pump to end of system. Obtain approved submittals and manufacturer-recommended testing procedures. Crosscheck the summation of required coil, heat exchanger and other hydronic equipment flow rates with pump design flow rate. 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. In addition to requirement sin “Preparation” Article, prepare hydronic systems for testing and balancing according to the following:
   1. Check liquid level in expansion tank.
   2. Check highest vent for adequate pressure
   3. Check flow-control valves for proper position as specified in sequence of operation, and set at indicated flow.
   4. Locate start-stop and disconnect switches, electrical interlocks, and motor starters
   5. verify that motor starters are equipped with properly sized thermal protection.
   6. Check that air has been purged from the system .
      a. Check air vents for a forceful liquid flow exiting from vents when manually operated. Open all manual valves for maximum flow.
   7. 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.

8. Set system controls so automatic valves are wide open to heat exchangers.
9. Check pump-motor load. If motor is overloaded, throttle main flow-balancing device so motor nameplate rating is not exceeded.
10. Check makeup water-station pressure gage for adequate pressure for highest vent.

3.13 PROCEDURES FOR CONSTANT-FLOW HYDRONIC SYSTEMS

A. Adjust pumps to deliver total design gpm.
   1. Measure total water flow.
      a. Position valves for full flow through coils.
      b. Measure flow by main flow meter, if installed.
      c. If main flow meter is not installed, determine flow by pump TDH or exchanger pressure drop.
   2. Measure pump TDH except for positive-displacement pumps as follows:
      a. Measure discharge pressure directly at the pump outlet flange or in discharge pipe prior to any valves.
      b. Measure inlet pressure directly at the pump inlet flange or in suction pipe prior to any valves or strainers.
      c. Convert pressure to head and correct for differences in gage heights.
      d. Verify pump impeller size by measuring the TDH with the discharge valve closed. Read pressure differential across the pump. Convert pressure to head and correct for differences in gage heights. Note the point on manufacturer's pump curve at zero flow, and verify that the pump has the intended impeller size.
         1) If impeller sizes must be adjusted to achieve pump performance, obtain approval from Architect and Owner and comply with requirements in Section 232123 "Hydronic Pumps."
      e. With valves open, read pump TDH. Adjust pump discharge valve until design water flow is achieved. Note the point on the manufacturer's pump curve.
   3. Monitor motor performance during procedures and do not operate motor in an overloaded condition.
   4. Verify pump-motor brake horsepower. Calculate the intended brake horsepower for the system based on pump manufacture's performance data. Compare calculated brake horsepower with nameplate data on the pump motor. Report conditions where actual amperage exceeds motor nameplate amperage.

B. Measure flow at all automatic flow control valve to verify that valves are functioning as designed.

C. Set calibrated balancing valves, if installed, at calculated pre-settings.

D. Adjust flow-measuring devices installed in mains and branches to within specified tolerance of design water flows.
   1. System components that have a Cv rating or accurately cataloged flow-pressure-drop relationship may be used as a flow-indicating device.
   2. Measure flow in main and branch pipes.
   3. Adjust main and branch balance valves for design flow.
   4. Re-measure each main and branch after all have been adjusted.
   5. Record settings and mark balancing devices.

E. Adjust flow-measuring devices installed at terminals for each space to within specified tolerances of design water flows.
   1. System components that have a Cv rating or accurately cataloged flow-pressure-drop relationship may be used as a flow-indicating device.
   2. Measure flow at terminals.
   3. Adjust each terminal to design flow.
   4. Re-measure each terminal after it is adjusted.
   5. Position control valves to bypass the coil, and adjust the bypass valve to maintain design flow.
   6. Perform temperature tests after flows have been balanced.
   7. Record settings and mark balancing devices.

F. For systems with pressure-independent valves at terminals:
   1. Measure differential pressure and verify that it is within manufacturer's specified range.

2. Measure flow at all pressure-independent control valves with valves in the fully open position to verify that valves are functioning as designed.
3. Perform temperature tests after flows have been verified.

G. For systems without pressure-independent valves or flow-measuring devices at terminals:

1. Measure and balance coils by either coil pressure drop or temperature method.
2. If balanced by coil pressure drop, perform temperature tests after flows have been verified.
3. Record settings and mark balancing devices.

H. Verify final system conditions as follows:

1. Re-measure, confirm and report final pump flow.
2. Re-measure, confirm and report that total water flow is within design.
3. Re-measure and report final pumps' operating data, TDH, volts, amps, rpm, and static profile.
4. Measure and report the final systems' pressures and temperatures including outdoor-air temperature.
5. Mark final settings.

I. Mark final settings and verify that memory stops have been set.

J. Measure and report the differential-pressure-control-valve settings existing at the conclusion of balancing.

K. Check settings and operation of each safety valve. Record settings.

3.14 PROCEDURES FOR VARIABLE-FLOW HYDRONIC SYSTEMS

A. Balance systems with automatic two- and three-way control valves by setting systems at maximum flow through heat-exchange terminals, and proceed as specified above for hydronic systems.

B. Adjust the variable-flow hydronic system as follows:

1. Verify that the differential-pressure sensor is located as indicated.
2. Determine whether there is diversity in the system.

C. For systems with no diversity:

1. Adjust pumps to deliver total design gpm.
    a. Measure total water flow.
        1) Position valves for full flow through coils.
        2) Measure flow by main flow meter, if installed.
        3) If main flow meter is not installed, determine flow by pump TDH or exchanger pressure drop.
    b. Measure pump TDH except for positive-displacement pumps as follows:
        1) Measure discharge pressure directly at the pump outlet flange or in discharge pipe prior to any valves.
        2) Measure inlet pressure directly at the pump inlet flange or in suction pipe prior to any valves or strainers.
        3) Convert pressure to head and correct for differences in gage heights.
        4) Verify pump impeller size by measuring the TDH with the discharge valve closed. Read pressure differential across the pump. Convert pressure to head and correct for differences in gage heights. Note the point on manufacturer's pump curve at zero flow and verify that the pump has the intended impeller size.
            (a) If impeller sizes must be adjusted to achieve pump performance, obtain approval from Architect and Owner comply with requirements in Section 232123 "Hydronic Pumps."
        5) With valves open, read pump TDH. Adjust pump discharge valve until design water flow is achieved. Note the point on the manufacturer's pump curve.
    c. Monitor motor performance during procedures and do not operate motor in an overloaded condition.
    d. Verify pump-motor brake horsepower. Calculate the intended brake horsepower for the system based on pump manufacture's performance data. Compare calculated brake horsepower with nameplate data on the pump motor. Report conditions where actual amperage exceeds motor nameplate amperage.
2. Measure flow at all automatic flow control valve to verify that valves are functioning as designed.

3. Set calibrated balancing valves, if installed, at calculated pre-settings.
4. Adjust flow-measuring devices installed in mains and branches to within specified tolerance of design water flows.
   a. System components that have a Cv rating or accurately cataloged flow-pressure-drop relationship may be used as a flow-indicating device.
   b. Measure flow in main and branch pipes.
   c. Adjust main and branch balance valves for design flow.
   d. Re-measure each main and branch after all have been adjusted.
   e. Record settings and mark balancing devices.
5. Adjust flow-measuring devices installed at terminals for each space to design water flows.
   a. System components that have a Cv rating or accurately cataloged flow-pressure-drop relationship may be used as a flow-indicating device.
   b. Measure flow at terminals.
   c. Adjust each terminal to design flow.
   d. Re-measure each terminal after it is adjusted.
   e. Position control valves to bypass the coil and adjust the bypass valve to maintain design flow.
   f. Perform temperature tests after flows have been balanced.
   g. Record settings and mark balancing devices.
6. For systems with pressure-independent valves at terminals:
   a. Measure differential pressure and verify that it is within manufacturer's specified range.
   b. Measure flow at all pressure-independent control valves with valves in the fully open position to verify that valves are functioning as designed.
   c. Perform temperature tests after flows have been verified.
7. For systems without pressure-independent valves or flow-measuring devices at terminals:
   a. Measure and balance coils by either coil pressure drop or temperature method.
   b. If balanced by coil pressure drop, perform temperature tests after flows have been verified.
   c. Record settings and mark balancing devices.
8. Prior to verifying final system conditions, determine the system differential-pressure set point.
9. If the pump discharge valve was used to set total system flow with variable-frequency controller at 60 Hz, at completion open discharge valve 100 percent and allow variable-frequency controller to control system differential-pressure set point. Record pump data under both conditions.
10. Mark final settings and verify that all memory stops have been set.
11. Verify final system conditions as follows:
    a. Re-measure, confirm and report final pump flow.
    b. Re-measure, confirm and report that total water flow is within design.
    c. Re-measure and report final pumps' operating data, TDH, volts, amps, rpm, and static profile.
    d. Measure and report the final systems’ pressures and temperatures including outdoor-air temperature.
    e. Mark final settings.
12. Mark final settings and verify that memory stops have been set.
13. Measure and report the differential-pressure-control-valve settings existing at the conclusion of balancing.
14. Check settings and operation of each safety valve. Record settings.

D. For systems with diversity:

1. Determine diversity factor.
2. Simulate system diversity by closing required number of control valves, as approved by the design engineer. Note the control valves that were closed to maintain diversity.
3. Adjust pumps to deliver total design gpm.
   a. Measure total water flow.
      1) Position valves for full flow through coils.
      2) Measure flow by main flow meter, if installed.
      3) If main flow meter is not installed, determine flow by pump TDH or exchanger pressure drop.
   b. Measure pump TDH as follows except for positive-displacement pumps as follows:
      1) Measure discharge pressure directly at the pump outlet flange or in discharge pipe prior to any valves.

2) Measure inlet pressure directly at the pump inlet flange or in suction pipe prior to any valves or strainers.
3) Convert pressure to head and correct for differences in gage heights.
4)
5) Verify pump impeller size by measuring the TDH with the discharge valve closed. Read pressure differential across the pump. Convert pressure to head and correct for differences in gage heights. Note the point on manufacturer's pump curve at zero flow and verify that the pump has the intended impeller size.
6) If impeller sizes must be adjusted to achieve pump performance, obtain approval from Architect and Owner and comply with requirements in Section 232123 "Hydronic Pumps."
7) With valves open, read pump TDH. Adjust pump discharge valve until design water flow is achieved. Note the point on the manufacturer’s pump curve.

c. Monitor motor performance during procedures and do not operate motor in an overloaded condition.
d. Verify pump-motor brake horsepower. Calculate the intended brake horsepower for the system based on pump manufacture’s performance data. Compare calculated brake horsepower with nameplate data on the pump motor. Report conditions where actual amperage exceeds motor nameplate amperage.

4. Measure flow at all automatic flow control valve to verify that valves are functioning as designed.
5. Set calibrated balancing valves, if installed, at calculated pre-settings.
6. Adjust flow-measuring devices installed in mains and branches to within specified tolerance of design water flows.
   a. System components that have a Cv rating or accurately cataloged flow-pressure-drop relationship may be used as a flow-indicating device.
   b. Measure flow in main and branch pipes.
   c. Adjust main and branch balance valves for design flow.
   d. Re-measure each main and branch after all have been adjusted.
   e. Record settings and mark balancing devices.
7. Adjust flow-measuring devices installed at terminals for each space to design water flows.
   a. System components that have a Cv rating or accurately cataloged flow-pressure-drop relationship may be used as a flow-indicating device.
   b. Measure flow at terminals.
   c. Adjust each terminal to design flow.
   d. Re-measure each terminal after it is adjusted.
   e. Position control valves to bypass the coil, and adjust the bypass valve to maintain design flow.
   f. Perform temperature tests after flows have been balanced.
   g. Record settings and mark balancing devices.
8. For systems with pressure-independent valves at terminals:
   a. Measure differential pressure, and verify that it is within manufacturer's specified range.
   b. Measure flow at all pressure-independent control valves with valves in the fully open position to verify that valves are functioning as designed.
   c. Perform temperature tests after flows have been verified.
9. For systems without pressure-independent valves or flow-measuring devices at terminals:
   a. Measure and balance coils by either coil pressure drop or temperature method.
   b. If balanced by coil pressure drop, perform temperature tests after flows have been verified.
   c. Record settings and mark balancing devices.
10. Open control valves that were shut. Close a sufficient number of control valves that were previously open to maintain diversity, and balance terminals that were just opened. Note the control valves that were closed to maintain diversity.
11. Prior to verifying final system conditions, determine system differential-pressure set point.
12. If the pump discharge valve was used to set total system flow with variable-frequency controller at 60 Hz, at completion open discharge valve 100 percent and allow variable-frequency controller to control system differential-pressure set point. Record pump data under both conditions.
13. Mark final settings and verify that memory stops have been set.
14. Verify final system conditions as follows:
   a. Re-measure, confirm and report final pump flow.
   b. Re-measure and confirm that total water flow is within design.

c. Re-measure final pumps' operating data, TDH, volts, amps, rpm, and static profile.
d. Measure and report the final systems' pressures and temperatures including outdoor-air temperature.
e. Mark final settings.

15. Mark final settings and verify that memory stops have been set.
16. Measure and report the differential-pressure-control-valve settings existing at the conclusion of balancing.
17. Check settings and operation of each safety valve. Record settings.

3.15 PROCEDURES FOR PRIMARY-SECONDARY HYDRONIC SYSTEMS

A. Balance the primary circuit flow first.

1. Balance the primary circuit for constant-flow or variable-flow hydronic systems as previously described.

B. Balance the secondary circuits after the primary circuits are complete.

1. Balance the secondary circuits for constant-flow or variable-flow hydronic systems as previously described.

3.16 PROCEDURES FOR MOTORS

A. Motors, 1/2 HP and Larger: Test at final balanced conditions and record the following data:

1. Manufacturer's name, model number, and serial number.
2. Motor horsepower rating.
3. Motor rpm.
4. Phase and hertz
5. Efficiency rating.
6. Nameplate and measured voltage, each phase.
7. Nameplate and measured amperage, each phase.
8. Starter thermal-protection-element rating.
9. Service factor and frame size.

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.

3.17 PROCEDURES FOR CONDENSING UNITS

A. Verify proper rotation of fans.

B. Measure entering- and leaving-air temperatures.

C. Record compressor data.

3.18 PROCEDURES FOR HEAT-TRANSFER COILS

A. Measure, adjust, and record the following data for each water coil:

1. Entering- and leaving-water temperature.
2. Water flow rate.
3. Water pressure drop.
4. Dry-bulb temperature of entering and leaving air.
5. Wet-bulb temperature of entering and leaving air for cooling coils.
6. Airflow.
7. Air pressure drop.

B. Measure, adjust, and record the following data for each electric heating coil:

1. Nameplate data.
2. Airflow.
3. Entering- and leaving-air temperature at full load.
4. Voltage and amperage input of each phase at full load and at each incremental stage.
5. Calculated kilowatt at full load.
6. Fuse or circuit-breaker rating for overload protection.

C. Measure, adjust, and record the following data for each steam coil:
   1. Dry-bulb temperature of entering and leaving air.
   2. Airflow.
   3. Air pressure drop.
   4. Inlet steam pressure.

D. Measure, adjust, and record the following data for each refrigerant coil:
   1. Dry-bulb temperature of entering and leaving air.
   2. Wet-bulb temperature of entering and leaving air.
   3. Airflow.
   4. Air pressure drop.
   5. Refrigerant suction pressure and temperature.

3.19 PROCEDURES FOR TEMPERATURE MEASUREMENTS

A. During TAB, report the need for adjustment in temperature regulation within the automatic temperature-control system.

B. Measure indoor wet- and dry-bulb temperatures every other hour for a period of two successive eight-hour days, in each separately controlled zone, to prove correctness of final temperature settings. Measure when the building or zone is occupied.

C. Measure outside-air, wet- and dry-bulb temperatures.

3.20 PROCEDURES FOR TESTING, ADJUSTING, AND BALANCING EXISTING SYSTEMS

A. Perform a preconstruction inspection of existing equipment that is to remain and be reused.
   1. Measure and record the operating speed, airflow, and static pressure of each fan.
   2. Measure motor voltage and amperage. Compare the values to motor nameplate information.
   3. Check the refrigerant charge.
   4. Check the condition of filters.
   5. Check the condition of coils.
   6. Check the operation of the drain pan and condensate-drain trap.
   7. Check bearings and other lubricated parts for proper lubrication.
   8. Report on the operating condition of the equipment and the results of the measurements taken. Report deficiencies.

B. Before performing testing and balancing of existing systems, inspect existing equipment that is to remain and be reused to verify that existing equipment has been cleaned and refurbished. Verify the following:
   1. New filters are installed.
   2. Coils are clean and fins combed.
   3. Drain pans are clean.
   4. Fans are clean.
   5. Bearings and other parts are properly lubricated.
   6. Deficiencies noted in the preconstruction report are corrected.

C. Perform testing and balancing of existing systems to the extent that existing systems are affected by the renovation work.
   1. Compare the indicated airflow of the renovated work to the measured fan airflows, and determine the new fan speed and the face velocity of filters and coils.
   2. Verify that the indicated airflows of the renovated work result in filter and coil face velocities and fan speeds that are within the acceptable limits defined by equipment manufacturer.
   3. If calculations increase or decrease the air flow rates and water flow rates by more than 5 percent, make equipment adjustments to achieve the calculated rates. If increase or decrease is 5 percent or less, equipment adjustments are not required.
   4. Balance each air outlet.

3.21 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 5 to plus 10 percent.

2. Air Outlets and Inlets: 0 to minus 10 percent.
3. Heating-Water Flow Rate: 0 to minus 10 percent.
4. Cooling-Water Flow Rate: 0 to minus 5 percent.

3.22 PROGRESS REPORTING

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

B. Status Reports: As work progress prepare 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.

3.23 FINAL REPORT

A. General: Prepare a certified written report; tabulate and divide the report into separate sections for tested systems and balanced systems.
   1. Include a certification sheet at the front of the report's binder, signed and sealed by the certified testing and balancing engineer.
   2. Include a list of instruments used for procedures, along with proof of calibration.
   3. Certify validity and accuracy of field data.

B. Final Report Contents: In addition to certified field-report data, include the following:
   1. Pump curves.
   2. Fan curves.
   3. Manufacturers' test data.
   4. Field test reports prepared by system and equipment installers.
   5. Other information relative to equipment performance; do not include Shop Drawings and product data.

C. General Report Data: In addition to form titles and entries, include the following data:
   1. Title page.
   2. Name and address of the TAB 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: Include the following:
   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. Sheave dimensions, center-to-center, and amount of adjustments in inches.
   j. Number of belts, make, and size.
   k. Number of filters, type, and size.
2. Motor Data:
   a. 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. Sheave dimensions, center-to-center, and amount of adjustments in inches.
3. Test Data (Indicated and Actual Values):
   a. Total airflow rate in cfm.
   b. Total system static pressure in inches wg.
   c. Fan rpm.
   d. Discharge static pressure in inches w.g.
   e. Filter static-pressure differential in inches w.g.
   f. Preheat coil static-pressure differential in inches w.g.
   g. Cooling coil static-pressure differential in inches w.g.
   h. Heating coil static-pressure differential in inches w.g.
   i. Outside airflow in cfm.
   j. Return airflow in cfm.
   k. Outside-air damper position.
   l. Return-air damper position.
   m. Vortex damper position.

F. Apparatus-Coil Test Reports:

1. Coil Data:
   a. System identification.
   b. Location.
   c. Coil type.
   d. Number of rows.
   e. Fin spacing in fins per inch o.c.
   f. Make and model number.
   g. Face area in sq. ft.
   h. Tube size in NPS.
   i. Tube and fin materials.
   j. Circuiting arrangement.
2. Test Data (Indicated and Actual Values):
   a. Airflow rate in cfm.
   b. Average face velocity in fpm.

c. Air pressure drop in inches w.g.
d. Outside-air, wet- and dry-bulb temperatures in degrees F.
e. Return-air, wet- and dry-bulb temperatures in degrees F.
f. Entering-air, wet- and dry-bulb temperatures in degrees F.
g. Leaving-air, wet- and dry-bulb temperatures in degrees F.
h. Water flow rate in gpm.
i. Water pressure differential in feet of head or psig.
j. Entering-water temperature in degrees F.
k. Leaving-water temperature in degrees F.
l. Refrigerant expansion valve and refrigerant types.
m. Refrigerant suction pressure in psig.
n. Refrigerant suction temperature in degrees F.
o. Inlet steam pressure in psig.

G. Electric-Coil Test Reports: For electric furnaces, duct coils, and electric coils installed in central-station air-handling units, include the following:

1. Unit Data:
   a. System identification.
   b. Location.
   c. Coil identification.
   d. Capacity in Btuh.
   e. Number of stages.
   f. Connected volts, phase, and hertz.
   g. Rated amperage.
   h. Airflow rate in cfm.
   i. Face area in sq. ft.
   j. Minimum face velocity in fpm.
2. Test Data (Indicated and Actual Values):
   a. Heat output in Btuh.
   b. Airflow rate in cfm.
   c. Air velocity in fpm.
   d. Entering-air temperature in degrees F.
   e. Leaving-air temperature in degrees F.
   f. Voltage at each connection.
   g. Amperage for each phase.

H. Fan Test Reports: For supply, return, and exhaust fans, include the following:

1. Fan Data:
   a. System identification.
   b. Location.
   c. Make and type.
   d. Model number and size.
   e. Manufacturer's serial number.
   f. Arrangement and class.
   g. Sheave make, size in inches, and bore.
   h. Sheave dimensions, center-to-center, and amount of adjustments in inches.
2. Motor Data:
   a. 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. Sheave dimensions, center-to-center, and amount of adjustments in inches.
   g. Number of belts, make, and size.
3. Test Data (Indicated and Actual Values):
   a. Total airflow rate in cfm.
   b. Total system static pressure in inches w.g.
   c. Fan rpm.
   d. Discharge static pressure in inches w.g.
   e. Suction static pressure in inches w.g.

I. Round, Flat-Oval, and Rectangular Duct Traverse Reports: Include a diagram with a grid representing the duct cross-section and record the following:
   1. Report Data:
      a. System and air-handling unit number.
      b. Location and zone.
      c. Traverse air temperature in degrees F.
      d. Duct static pressure in inches w.g.
      e. Duct size in inches.
      f. Duct area in sq. ft.
      g. Indicated airflow rate in cfm.
      h. Indicated velocity in fpm.
      i. Actual airflow rate in cfm.
      j. Actual average velocity in fpm.
      k. Barometric pressure in psig.

J. Air-Terminal-Device Reports:
   1. Unit Data:
      a. System and air-handling unit identification.
      b. Location and zone.
      c. Test apparatus used.
      d. Area served.
      e. Air-terminal-device make.
      f. Air-terminal-device number from system diagram.
      g. Air-terminal-device type and model number.
      h. Air-terminal-device size.
      i. Air-terminal-device effective area in sq. ft.
   2. Test Data (Indicated and Actual Values):
      a. Airflow rate in cfm.
      b. Air velocity in fpm.
      c. Preliminary airflow rate as needed in cfm.
      d. Preliminary velocity as needed in fpm.
      e. Final airflow rate in cfm.
      f. Final velocity in fpm.
      g. Space temperature in degrees F.

K. System-Coil Reports: For reheat coils and water coils of terminal units, include the following:
   1. Unit Data:
      a. System and air-handling unit identification.
      b. Location and zone.
      c. Room or riser served.
      d. Coil make and size.
      e. Flowmeter type.
   2. Test Data (Indicated and Actual Values):
      a. Airflow rate in cfm.
      b. Entering-water temperature in degrees F.
      c. Leaving-water temperature in degrees F.
      d. Water pressure drop in feet of head or psig.
      e. Entering-air temperature in degrees F.
      f. Leaving-air temperature in degrees F.

L. Compressor and Condenser Reports: For refrigerant side of unitary systems, stand-alone refrigerant compressors, air-cooled condensing units, or water-cooled condensing units, include the following:
   1. Unit Data:
      a. Unit identification.
      b. Location.
      c. Unit make and model number.
      d. Compressor make.
      e. Compressor model and serial numbers.
      f. Refrigerant weight in lb (kg).
      g. Low ambient temperature cutoff in degrees F.

2. Test Data (Indicated and Actual Values):
   a. Inlet-duct static pressure in inches w.g.
   b. Outlet-duct static pressure in inches w.g.
   c. Entering-air, dry-bulb temperature in degrees F.
   d. Leaving-air, dry-bulb temperature in degrees F.
   e. Condenser entering-water temperature in degrees F.
   f. Condenser leaving-water temperature in degrees F.
   g. Condenser-water temperature differential in degrees F.
   h. Condenser entering-water pressure in feet of head or psig.
   i. Condenser leaving-water pressure in feet of head or psig.
   j. Condenser-water pressure differential in feet of head or psig.
   k. Control settings.
   l. Unloader set points.
   m. Low-pressure-cutout set point in psig.
   n. High-pressure-cutout set point in psig.
   o. Suction pressure in psig.
   p. Suction temperature in degrees F.
   q. Condenser refrigerant pressure in psig.
   r. Condenser refrigerant temperature in degrees F.
   s. Oil pressure in psig.
   t. Oil temperature in degrees F.
   u. Voltage at each connection.
   v. Amperage for each phase.
   w. Kilowatt input.
   x. Crankcase heater kilowatt.
   y. Number of fans.
   z. Condenser fan rpm.
   aa. Condenser fan airflow rate in cfm.
   bb. Condenser fan motor make, frame size, rpm, and horsepower.
   cc. Condenser fan motor voltage at each connection.
   dd. Condenser fan motor amperage for each phase.

M. Pump Test Reports: Calculate impeller size by plotting the shutoff head on pump curves and include the following:
   1. Unit Data:
      a. Unit identification.
      b. Location.
      c. Service.
      d. Make and size.
      e. Model and serial numbers.
      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 (mm).
      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.

N. Instrument Calibration Reports:
1. Report Data:
a. Instrument type and make.
b. Serial number.
c. Application.
d. Dates of use.
e. Dates of calibration.

3.24 VERIFICATION OF TAB REPORT

A. Initial Verification:
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 Verification:
1. Architect, Owner and 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.
2. 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."
3. 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.
4. TAB firm shall recheck all measurements and make adjustments. Revise the final report and balancing device settings to include all changes and resubmit the final report and request a second final inspection.

C. Prepare test and inspection reports.

3.25 ADDITIONAL TESTS

A. Within 90 days of completing TAB, perform additional TAB to verify that balanced conditions are being maintained throughout and to correct unusual conditions.

B. Seasonal Periods: If initial TAB procedures were not performed during near-peak summer and winter conditions, perform additional TAB during near-peak summer and winter conditions.

END OF SECTION

SECTION 230713
DUCT INSULATION

PART 1 GENERAL

1.1 SUMMARY

A. Section includes insulating the following duct services:
   1. Indoor, concealed supply and outdoor air.
   2. Indoor, exposed supply and outdoor air.
   3. Indoor, concealed return located in unconditioned space.
   4. Indoor, exposed return located in unconditioned space.
   5. Indoor, concealed exhaust between isolation damper and penetration of building exterior.
   6. Indoor, exposed exhaust between isolation damper and penetration of building exterior.
   7. Outdoor, concealed supply, return, and exhaust air.
   8. Outdoor, exposed supply, return, and exhaust air.

B. Related Sections:
   1. Section 230716 "HVAC Equipment Insulation."
   2. Section 230719 "HVAC Piping Insulation."
   3. Section 233113 "Metal Ducts" for duct liners.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include thermal conductivity, water-vapor permeance thickness, and jackets (both factory- and field-applied if any).

1.3 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.4 QUALITY ASSURANCE

A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or another craft training program certified by the Department of Labor, Bureau of Apprenticeship and Training.

B. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products according to ASTM E 84, by a testing agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing agency.
   1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.
   2. Insulation Installed Outdoors: Flame-spread index of 75 or less, and smoke-developed index of 150 or less.

1.5 DELIVERY, STORAGE, AND HANDLING

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

1.6 COORDINATION

A. Coordinate sizes and locations of supports, hangers, and insulation shields specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

B. Coordinate clearance requirements with duct Installer for duct insulation application. Before preparing ductwork Shop Drawings, establish and maintain clearance requirements for installation of insulation and field-applied jackets and finishes and for space required for maintenance.

1.7 SCHEDULING

A. Schedule insulation application after pressure testing systems and, where required. Insulation application may begin on segments that have satisfactory test results.

PART 2 PRODUCTS

2.1 INSULATION MATERIALS

A. Comply with requirements in "Duct Insulation Schedule, General," "Indoor Duct and Plenum Insulation Schedule," and "Aboveground, Outdoor Duct and Plenum Insulation Schedule" articles for where insulating materials shall be applied.

B. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C 871.

C. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C 795.

D. Flexible Elastomeric Insulation: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C 534, Type II for sheet materials.

1. Products: Subject to compliance with requirements, provide one of the following:
   a. Aeroflex USA, Inc.; Aerocel.
   b. Armacell LLC; AP Armaflex.
   c. K-Flex USA; Insul-Sheet, K-Flex Gray Duct Liner, and K-FLEX LS.

E. Mineral-Fiber Blanket Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 553, Type II and ASTM C 1290, Type III with factory-applied FRK jacket. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

1. Products: Subject to compliance with requirements, provide one of the following:
   a. CertainTeed Corp.; SoftTouch Duct Wrap.
   b. Johns Manville; Microlite.
   c. Knauf Insulation; Friendly Feel Duct Wrap.
   d. Manson Insulation Inc.; Alley Wrap.
   e. Owens Corning; SOFTR All-Service Duct Wrap.

F. Mineral-Fiber Board Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 612, Type IA or Type IB. For duct and plenum applications, provide insulation with factory-applied FRK jacket. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

1. Products: Subject to compliance with requirements, provide one of the following:
   a. CertainTeed Corp.; Commercial Board.
   b. Fibrex Insulations Inc.; FBX.
   c. Johns Manville; 800 Series Spin-Glas.
   d. Knauf Insulation; Insulation Board.
   e. Manson Insulation Inc.; AK Board.
   f. Owens Corning; Fiberglas 700 Series.

G. Polyolefin: Unicellular, polyethylene thermal plastic insulation. Comply with ASTM C 534 or ASTM C 1427, Type I, Grade 1 for tubular materials and Type II, Grade 1 for sheet materials.

1. Products: Subject to compliance with requirements, provide one of the following:
   a. Armacell LLC; Tubolit.
   b. Nomaco Insulation; IMCOLOCK, IMCOSHEET, NOMALOCK, and NOMAPLY. .

H. Polystyrene: Rigid, extruded cellular polystyrene intended for use as thermal insulation. Comply with ASTM C 518, Type IV or Type XIII, except thermal conductivity (k-value) shall not exceed 0.20 (R=5.0) Btu x in./h x sq. ft. x degrees F after 180 days of aging. Fabricate shapes according to ASTM C 450 and ASTM C 585. Compressive strength 25 psi.

1. Products:
   a. Dow Chemical Company (The); Styrofoam.
   b. Knauf Insulation; Knauf Polystyrene.
   c. Owens Corning;

2.2 ADHESIVES

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

B. Flexible Elastomeric and Polyolefin Adhesive: Comply with MIL-A-24179A, Type II, Class I.

1. Products: Subject to compliance with requirements, provide one of the following:
   a. Aeroflex USA, Inc.; Aeroseal.
   b. Armacell LLC; Armaflex 520 Adhesive.
   c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 85-75.K-Flex USA; R-373 Contact Adhesive.

C. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.

1. Products: Subject to compliance with requirements, provide one of the following:
   a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-127.Eagle Bridges - Marathon Industries; 225.
   b. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 85-60/85-70.Mon-Eco Industries, Inc.; 22-25.

D. ASJ Adhesive, and FSK Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.

1. Products: Subject to compliance with requirements, provide one of the following:
   a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-82.
   b. Eagle Bridges - Marathon Industries; 225.
   c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 85-50.Mon-Eco Industries, Inc.; 22-25.

E. PVC Jacket Adhesive: Compatible with PVC jacket.

1. Products: Subject to compliance with requirements, provide one of the following:
   a. Dow Corning Corporation; 739, Dow Silicone.
   b. Johns Manville; Zeston Perma-Weld, CEEL-TITE Solvent Welding Adhesive.
   c. P.I.C. Plastics, Inc.; Welding Adhesive.
   d. Speedline Corporation; Polyco VP Adhesive.

2.3 FACTORY-APPLIED JACKETS

A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:

1. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C 1136, Type II.

2.4 FIELD-APPLIED JACKETS

A. Field-applied jackets shall comply with ASTM C 921, Type I, unless otherwise indicated.

B. Outdoor Jacket, Prefabricated, Self-Adhering, Sheet-Type Waterproofing Membrane: 60-mil- thick, laminated vapor barrier and waterproofing membrane for installation over insulation located aboveground outdoors; consisting of a rubberized bituminous resin on a cross laminated polyethylene film covered with stucco-embossed aluminum-foil facing.

1. Products: Subject to compliance with requirements, provide one of the following:
   a. Polyguard Products, Inc.; Alumaguard All Weather

C. Outdoor Jacket, Prefabricated, Self-Adhering, Sheet-Type Waterproofing Membrane Jacket: 3-mil-thick, laminated vapor barrier and waterproofing membrane for installation over insulation located aboveground; consisting of 5 layers of aluminum foil and polyester film.

1. Products:
   a. VentureClad 1577CW
2. Requirements:
   a. Tear Resistance, ASTM D 1424, 2 kg.
   b. Elongation, ASTM D 412, Minimum: 166 percent.
   c. Application temperature: minus 10^{o}F to 248^{o}F.

d. Maximum Temperature; continuous use: 330°F.
e. Water Vapor Transmission, ASTM E 96: 0 perms.
f. Flame Spread Index, ASTM E 84: 0.
g. Smoke Density Index, ASTM E 84: 0.
h. Wind-Driven Rain, SFBC TAS-110-95, 100 mph: No leakage or failure.
i. UV Stability: Excellent.

2.5 TAPES

A. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive.
   1. Products: Subject to compliance with requirements, provide one of the following:
      a. ABI, Ideal Tape Division; 488 AWF.
      b. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0800.
      c. Compac Corporation; 120.
      d. Venture Tape; 3520 CW.
   2. Width: 2 inches.
   3. Thickness: 3.7 mils.
   4. Adhesion: 100 ounces force/inch in width.
   5. Elongation: 5 percent.
   6. Tensile Strength: 34 lbf/inch in width.

2.6 SECUREMENTS

A. Insulation Pins and Hangers:
   1. Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.105-inch diameter shank, length to suit depth of insulation indicated.
      a. Products: Subject to compliance with requirements, provide one of the following:
         (a) AGM Industries, Inc.; CWP-1.
         (b) GEMCO; CD.
         (c) Midwest Fasteners, Inc.; CD.
         (d) Nelson Stud Welding; TPA, TPC, and TPS.
   2. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.105-inch diameter shank, length to suit depth of insulation indicated with integral 1-1/2-inch galvanized carbon-steel washer.
      a. Products: Subject to compliance with requirements, provide one of the following:
         (a) AGM Industries, Inc.; CHP-1.
         (b) GEMCO; Cupped Head Weld Pin.
         (c) Midwest Fasteners, Inc.; Cupped Head.
         (d) Nelson Stud Welding; CHP.
   3. Metal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, and securely in position indicated when self-locking washer is in place. Comply with the following requirements:
      a. Products: Subject to compliance with requirements, provide one of the following:
         1) AGM Industries, Inc.; Tactoo Perforated Base Insul-Hangers.
         2) GEMCO; Perforated Base.
         3) Midwest Fasteners, Inc.; Spindle.
      b. Baseplate: Perforated, galvanized carbon-steel sheet, 0.030 inch thick by 2 inches square.
      c. Spindle: Copper- or zinc-coated, low-carbon steel, fully annealed, 0.106-inch- diameter shank, length to suit depth of insulation indicated.
      d. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.
   4. Nonmetal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate fastened to projecting spindle that is capable of holding insulation, of thickness indicated, and securely in position indicated when self-locking washer is in place. Comply with the following requirements:
      a. Products: Subject to compliance with requirements, provide one of the following:
         1) GEMCO; Nylon Hangers.
         2) Midwest Fasteners, Inc.; Nylon Insulation Hangers.
      b. Baseplate: Perforated, nylon sheet, 0.030 inch thick by 1-1/2 inches in diameter.

c. Spindle: Nylon, 0.106-inch- diameter shank, length to suit depth of insulation indicated, up to 2-1/2 inches.
d. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.

5. Self-Sticking-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, and securely in position indicated when self-locking washer is in place. Comply with the following requirements:
   a. Products: Subject to compliance with requirements, provide one of the following:
      1) AGM Industries, Inc.; Tactoo Self-Adhering Insul-Hangers.
      2) GEMCO; Peel & Press.
      3) Midwest Fasteners, Inc.; Self Stick.
   b. Baseplate: Galvanized carbon-steel sheet, 0.030 inch thick by 2 inches square.
   c. Spindle: Copper- or zinc-coated, low-carbon steel, fully annealed, 0.106-inch- diameter shank, length to suit depth of insulation indicated.
   d. Adhesive-backed base with a peel-off protective cover.

B. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch- thick, galvanized-steel sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.

1. Products: Subject to compliance with requirements, provide one of the following:
   a. AGM Industries, Inc.; RC-150.
   b. GEMCO; R-150.
   c. Midwest Fasteners, Inc.; WA-150.
   d. Nelson Stud Welding; Speed Clips.
2. Protect ends with capped self-locking washers incorporating a spring steel insert to ensure permanent retention of cap in exposed locations.

C. Nonmetal Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch- thick nylon sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.

1. Products: Subject to compliance with requirements, provide one of the following:
   a. GEMCO.
   b. Midwest Fasteners, Inc.

D. Staples: Outward-clinching insulation staples, nominal 3/4-inch- wide, stainless steel or Monel.

E. Wire: 0.062-inch soft-annealed, stainless steel.

1. Products: Subject to compliance with requirements, provide one of the following:
   a. C & F Wire.

PART 3 EXECUTION

3.1 EXAMINATION

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

1. Verify that systems to be insulated have been tested and are free of defects.
2. Verify that surfaces to be insulated are clean and dry.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.

3.3 GENERAL INSTALLATION REQUIREMENTS

A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of ducts and fittings.

B. Install insulation materials, vapor barriers or retarders, jackets, and thicknesses required for each item of duct system as specified in insulation system schedules.

C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.

D. Install insulation with longitudinal seams at top and bottom of horizontal runs.

E. Install multiple layers of insulation with longitudinal and end seams staggered.

F. Keep insulation materials dry during application and finishing.

G. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.

H. Install insulation with least number of joints practical.

I. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.

1. Install insulation continuously through hangers and around anchor attachments.
2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.
3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.

J. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.

K. Install insulation with factory-applied jackets as follows:

1. Draw jacket tight and smooth.
2. Cover circumferential joints with 3-inch- wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches o.c.
3. Overlap jacket longitudinal seams at least 1-1/2 inches. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 2 inches o.c.
   a. For below ambient services, apply vapor-barrier mastic over staples.
4. Cover joints and seams with tape, according to insulation material manufacturer's written instructions, to maintain vapor seal.
5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to duct flanges and fittings.

L. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.

M. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.

N. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.

3.4 PENETRATIONS

A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.

1. Seal penetrations with flashing sealant.
2. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
3. Extend jacket of outdoor insulation outside roof flashing at least 2 inches below top of roof flashing.
4. Seal jacket to roof flashing with flashing sealant.

B. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.

1. Seal penetrations with flashing sealant.
2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches.
4. Seal jacket to wall flashing with flashing sealant.

C. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.

D. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Terminate insulation at fire damper sleeves for fire-rated wall and partition penetrations. Externally insulate damper sleeves to match adjacent insulation and overlap duct insulation at least 2 inches.

1. Comply with requirements in Section 078413 "Penetration Firestopping"irestopping and fire-resistive joint sealers.

E. Insulation Installation at Floor Penetrations:

1. Duct: For penetrations through fire-rated assemblies, terminate insulation at fire damper sleeves and externally insulate damper sleeve beyond floor to match adjacent duct insulation. Overlap damper sleeve and duct insulation at least 2 inches.
2. Seal penetrations through fire-rated assemblies. Comply with requirements in Section 078413 "Penetration Firestopping."

3.5 INSTALLATION OF FLEXIBLE ELASTOMERIC INSULATION

A. Seal longitudinal seams and end joints with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

3.6 INSTALLATION OF MINERAL-FIBER INSULATION

A. Blanket Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.

1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 75 percent coverage of duct and plenum surfaces.
2. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.
3. Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:
   a. On duct sides with dimensions 18 inches and smaller, place pins along longitudinal centerline of duct. Space 3 inches maximum from insulation end joints, and 16 inches o.c.
   b. On duct sides with dimensions larger than 18 inches, place pins 16 inches o.c. each way and 3 inches maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.
   c. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
   d. Do not over compress insulation during installation.
   e. Impale insulation over pins and attach speed washers.
   f. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.
4. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches from one edge and one end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch outward-clinching staples, 1 inch o.c. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.
   a. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.
   b. Install vapor stops for ductwork and plenums operating below 50 deg F at 18-foot intervals. Vapor stops shall consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover insulation face and surface to be insulated a width equal to two times the insulation thickness, but not less than 3 inches.

5. Overlap unfaced blankets a minimum of 2 inches on longitudinal seams and end joints. At end joints, secure with steel bands spaced a maximum of 18 inches o.c.
6. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.
7. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch- wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches o.c.

B. Board Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.

1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 75 percent coverage of duct and plenum surfaces.
2. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.
3. Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:
    a. On duct sides with dimensions 18 inches and smaller, place pins along longitudinal centerline of duct. Space 3 inches maximum from insulation end joints, and 16 inches o.c.
    b. On duct sides with dimensions larger than 18 inches, space pins 16 inches o.c. each way, and 3 inches maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.
    c. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
    d. Do not over compress insulation during installation.
    e. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.
4. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches from one edge and one end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch outward-clinching staples, 1 inch o.c. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.
    a. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.
    b. Install vapor stops for ductwork and plenums operating below 50 deg F at 18-foot intervals. Vapor stops shall consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover insulation face and surface to be insulated a width equal to two times the insulation thickness, but not less than 3 inches.
5. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Groove and score insulation to fit as closely as possible to outside and inside radius of elbows. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.
6. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch- wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches o.c.

3.7 FIELD-APPLIED JACKET INSTALLATION

A. Where FSK jackets are indicated, install as follows:

1. Draw jacket material smooth and tight.
2. Install lap or joint strips with same material as jacket.
3. Secure jacket to insulation with manufacturer's recommended adhesive.
4. Install jacket with 1-1/2-inch 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-barrier mastic.

B. Where PVC jackets are indicated, install with 1-inch overlap at longitudinal seams and end joints; for horizontal applications, install with longitudinal seams along top and bottom of tanks and vessels. Seal with manufacturer's recommended adhesive.

1. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge.

3.8 DUCT INSULATION SCHEDULE, GENERAL

A. Plenums and Ducts Requiring Insulation:
   1. Indoor, concealed supply and outdoor air.
   2. Indoor, exposed supply and outdoor air.
   3. Indoor, concealed return located in unconditioned space.
   4. Indoor, exposed return located in unconditioned space.
   5. Indoor, concealed exhaust between isolation damper and penetration of building exterior.
   6. Indoor, exposed exhaust between isolation damper and penetration of building exterior.
   7. Outdoor, concealed supply, return, and exhaust.
   8. Outdoor, exposed supply, return, and exhaust.

B. Items Not Insulated:
   1. Metal ducts with duct liner of sufficient thickness to comply with energy code and ASHRAE/IESNA 90.1.
   2. Factory-insulated flexible ducts.
   3. Factory-insulated plenums and casings.
   4. Flexible connectors.
   5. Vibration-control devices.
   6. Factory-insulated access panels and doors.

3.9 INDOOR DUCT AND PLENUM INSULATION SCHEDULE

A. Concealed, rectangular, round, and flat-oval, plenum and supply-air duct insulation shall be one of the following:
   1. Mineral-Fiber Blanket: 1-1/2 inches thick and 0.75-lb/cu. ft. nominal density.

B. Concealed, rectangular, round, and flat-oval, plenum and supply-air duct located in unconditioned spaces; insulation shall be the following:
   1. Mineral-Fiber Blanket: 3-inches thick and 0.75-lb/cu. ft. nominal density.

C. Concealed, rectangular, round, and flat-oval, plenum and return-air duct located in unconditioned spaces; insulation shall be the following:
   1. Mineral-Fiber Blanket: 3-inches thick and 0.75-lb/cu. ft. nominal density.

D. Concealed, rectangular, round, and flat-oval, plenum and outdoor-air duct insulation shall be one of the following:
   1. Mineral-Fiber Blanket: 3 inches thick and 0.75-lb/cu. ft. nominal density.

E. Concealed, rectangular, round, and flat oval, plenum and exhaust-air duct insulation between isolation damper and penetration of building exterior (minimum length; 10-feet) shall be the following:
   1. Mineral-Fiber Blanket: 3 inches thick and 0.75-lb/cu. ft. nominal density.

F. Exposed, round and flat-oval, supply-air duct insulation shall be the following:
   1. Mineral-Fiber Blanket: 1-1/2 inches thick and 0.75-lb/cu. ft. nominal density.

G. Exposed, round and flat-oval, supply-air duct located in unconditioned spaces: insulation shall be the following:
   1. Mineral-Fiber Blanket: 3-inches thick and 0.75-lb/cu. ft. nominal density.

H. Exposed, round and flat-oval, return-air duct located in unconditioned spaces: insulation shall be the following:
   1. Mineral-Fiber Blanket: 3-inches thick and 0.75-lb/cu. ft. nominal density.

I. Exposed, round and flat-oval, outdoor-air duct insulation shall be the following:
   1. Mineral-Fiber Blanket: 3 inches thick and 0.75-lb/cu. ft. nominal density.

J. Exposed, rectangular, plenum and supply-air duct insulation shall be the following:
   1. Mineral-Fiber Board: 1-1/2 inches thick and 3-lb/cu. ft. nominal density.

K. Exposed, rectangular, supply-air duct located in unconditioned spaces: insulation shall be the following:

1. Mineral-Fiber Board: 2 inches thick and 3-lb/cu. ft. nominal density.

L. Exposed, rectangular, return-air duct located in unconditioned spaces: insulation shall be the following:

1. Mineral-Fiber Board: 2 inches thick and 3-lb/cu. ft. nominal density.

M. Exposed, rectangular, outdoor-air duct insulation shall be the following:

1. Mineral-Fiber Board: 2 inches thick and 3-lb/cu. ft. nominal density.

N. Exposed, rectangular, round, and flat-oval, plenum and exhaust-air duct located with 10-feet of the exterior wall penetration; insulation shall be the following:

1. Mineral-Fiber Board: 2 inches thick and 3-lb/cu. ft. nominal density.

O. Exposed, outdoor-air plenum insulation shall be the following:

1. Mineral-Fiber Board: 2 inches thick and 3-lb/cu. ft. nominal density.

3.10 INDOOR, FIELD-APPLIED JACKET SCHEDULE

A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.

B. If more than one material is listed, selection from materials listed is Contractor's option.

C. Ducts and Plenums, Concealed:

1. None.

D. Ducts and Plenums, Exposed:

1. None.

END OF SECTION

SECTION 230716
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. Section includes insulating the following HVAC equipment that is not factory insulated:
   1. Chillers.
   2. Heat exchangers.
   3. Chilled-water pumps.
   4. Heating, hot-water pumps.
   5. Expansion/compression tanks.
   6. Air separators.
   7. Thermal storage tanks.
   8. Piping system filtration unit housings.

B. Related Sections:
   1. Section 230713 "Duct Insulation."
   2. Section 230719 "HVAC Piping Insulation."

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include thermal conductivity, water-vapor permeance thickness, and jackets (both factory- and field-applied if any).

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified Installer.

B. Field quality-control reports.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or another craft training program certified by the Department of Labor, Bureau of Apprenticeship and Training.

B. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products according to ASTM E 84, by a testing agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing agency.
   1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.
   2. Insulation Installed Outdoors: Flame-spread index of 75 or less, and smoke-developed index of 150 or less.

1.6 DELIVERY, STORAGE, AND HANDLING

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

1.7 COORDINATION

A. Coordinate sizes and locations of supports, hangers, and insulation shields specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

B. Coordinate clearance requirements with equipment Installer for equipment insulation application.

C. Coordinate installation and testing of heat tracing.

1.8 SCHEDULING

A. Schedule insulation application after pressure testing systems and, where required, after installing and testing heat tracing. Insulation application may begin on segments that have satisfactory test results.

B. Complete installation and concealment of plastic materials as rapidly as possible in each area of construction.

PART 2 PRODUCTS

2.1 INSULATION MATERIALS

A. Comply with requirements in "Breeching Insulation Schedule" and "Equipment Insulation Schedule" articles for where insulating materials shall be applied.

B. Products shall not contain asbestos, lead, mercury, or mercury compounds.

C. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C 871.

D. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C 795.

E. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.

F. Calcium Silicate:

1. Products: Subject to compliance with requirements, provide the following:
   a. Industrial Insulation Group (IIG); Thermo-12 Gold.
2. Flat-, curved-, and grooved-block sections of noncombustible, inorganic, hydrous calcium silicate with a non-asbestos fibrous reinforcement. Comply with ASTM C 533, Type I.

G. Flexible Elastomeric 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. Products: Subject to compliance with requirements, provide the following:
   a. Aeroflex USA, Inc.; Aerocel.
   b. Armacell LLC; AP Armaflex.
   c. K-Flex USA; Insul-Sheet and K-FLEX LS.

H. Mineral-Fiber Blanket Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 553, Type II and ASTM C 1290, Type III with factory-applied FSK jacket. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

1. Products: Subject to compliance with requirements, provide the following:
   a. CertainTeed Corp.; SoftTouch Duct Wrap.
   b. Johns Manville; Microlite.
   c. Knauf Insulation; Friendly Feel Duct Wrap.
   d. Manson Insulation Inc.; Alley Wrap.
   e. Owens Corning; SOFTR All-Service Duct Wrap.

I. High-Temperature, Mineral-Fiber Blanket Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 553, Type V, without factory-applied jacket.

1. Products: Subject to compliance with requirements, provide the following:
   a. Industrial Insulation Group (IIG); MinWool-1200 Flexible Batt.
   b. Johns Manville; HTB 26 Spin-Glas.
   c. Roxul Inc.; Roxul RW.

J. Mineral-Fiber Board Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 612, Type IA or Type IB. Provide insulation with factory-applied FSK jacket. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

1. Products: Subject to compliance with requirements, provide the following:
   a. CertainTeed Corp.; CertaPro Commercial Board.

b. Fibrex Insulations Inc.; FBX.
c. Johns Manville; 800 Series Spin-Glas.
d. Knauf Insulation; Insulation Board.
e. Manson Insulation Inc.; AK Board.
f. Owens Corning; Fiberglas 700 Series.

K. High-Temperature, Mineral-Fiber Board Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 612, Type III, without factory-applied jacket.

1. Products: Subject to compliance with requirements, provide the following:
   a. Fibrex Insulations Inc.; FBX.Industrial Insulation Group (IIG); MinWool-1200 Industrial Board.
   b. Rock Wool; Delta Board.
   c. Roxul Inc.; RHT and RockBoard.
   d. Thermafiber, Inc.; Thermafiber Industrial Felt.

L. Mineral-Fiber, Preformed Pipe Insulation:

1. Products: Subject to compliance with requirements, provide the following:
   a. Fibrex Insulations Inc.; Coreplus 1200.
   b. Johns Manville; Micro-Lok.
   c. Knauf Insulation; 1000-Degree Pipe Insulation.
   d. Manson Insulation Inc.; Alley-K.
   e. Owens Corning; Fiberglas Pipe Insulation.
2. Type I, 850 Deg F Materials: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 547, Type I, Grade A, with factory-applied ASJ-SSL. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

M. Mineral-Fiber, Pipe and Tank Insulation: Mineral or glass fibers bonded with a thermosetting resin. Semirigid board material with factory-applied ASJ complying with ASTM C 1393, Type II or Type IIIA Category 2, or with properties similar to ASTM C 612, Type IB. Nominal density is 2.5 lb/cu. ft. or more. Thermal conductivity (k-value) at 100 deg F is 0.29 Btu x in./h x sq. ft. x deg F or less. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

1. Products: Subject to compliance with requirements, provide the following:
   a. CertainTeed Corp.; CrimpWrap.
   b. Johns Manville; MicroFlex.
   c. Knauf Insulation; Pipe and Tank Insulation.
   d. Manson Insulation Inc.; AK Flex.
   e. Owens Corning; Fiberglas Pipe and Tank Insulation.

N. Phenolic:

1. Products: Subject to compliance with requirements, provide the following:
   a. Kingspan Tarec Industrial Insulation NV; Koolphen K.
   b. Resolco International BV; Insul-phen.
2. Block insulation of rigid, expanded, closed-cell structure. Comply with ASTM C 1126, Type II, Grade 1.
3. Factory fabricate shapes according to ASTM C 450 and ASTM C 585.
4. Factory-Applied Jacket: [None] [ASJ]. Requirements are specified in "Factory-Applied Jackets" Article.

O. Polyisocyanurate: Unfaced, preformed, rigid cellular polyisocyanurate material intended for use as thermal insulation.

1. Products: Subject to compliance with requirements, provide the following:
   a. Dow Chemical Company (The); Trymer 2000 XP.
   b. Duna USA Inc.; Corafoam.
   c. Dyplast Products; ISO-25.
   d. Elliott Company of Indianapolis; Elfoam.
2. Comply with ASTM C 591, Type I or Type IV, except thermal conductivity (k-value) shall not exceed 0.19 Btu x in./h x sq. ft. x deg F at 75 deg F after 180 days of aging.
3. Flame-spread index shall be 25 or less and smoke-developed index shall be 50 or less for thickness up to 1 inch as tested by ASTM E 84.
4. Fabricate shapes according to ASTM C 450 and ASTM C 585.
5. Factory-Applied Jacket: Requirements are specified in "Factory-Applied Jackets" Article.

a. Equipment Applications: PVDC-SSL.

P. Polyolefin: Unicellular, polyethylene thermal plastic insulation. Comply with ASTM C 534 or ASTM C 1427, Type I, Grade 1 for tubular materials and Type II, Grade 1 for sheet materials.

1. Products: Subject to compliance with requirements, provide the following:
   a. Armacell LLC; Tubolit.
   b. Nomaco Insulation; IMCOLOCK, IMCOSHEET, NOMALOCK, and NOMAPLY.

2.2 MASS LOADED VINYL LAGGING

A. Composite limp vinyl sheet consisting of two layers of vinyl over a 1.4 psf barrier layer with a minimum STC rating of 28 and a 1" fiberglass batting decoupler layer.

B. Products

1. Kinetics Noise Control KNM-100ALQ
2. Acoustical Surfaces B-10 QFA-9
3. Barymat BM-1C
4. Engineer Approved Equal

C. Product Characteristics

1. The barrier shall be constructed of a 0.12" thick mass loaded, limp vinyl sheet bonded to a thin layer of reinforced aluminum foil on one side.
   a. Nominal density of barrier: 1.6 psf
   b. Minimum STC rating: 30
   c. Minimum Flammability rating per Federal Test Standard No. 191-5903:
      1) 0.0 seconds flame-out
      2) 0.2" char length
   d. NFPA 90A Flame Spread / Smoke Developed characteristics:
      1) Flame Spread: 10
      2) Smoke Developed: 40
   e. Minimum thermal conductivity barrier layer:
      1) K value of 0.29
   f. Rated service temperature range
      1) – 40 degrees F to 220 degrees F
2. Decoupler layer
   a. 1" fibrous glass batting
   b. Non woven porous scrim-coated glass cloth
   c. Quilting
      1) 4" diamond stitch to encapsulate glass fibers
3. Seams
   a. 6" overlap tab for field joint sealing
      1) 54" nominal barrier width
      2) 48" nominal decoupler width

2.3 INSULATING CEMENTS

A. Mineral-Fiber Insulating Cement: Comply with ASTM C 195.

1. Products: Subject to compliance with requirements, provide the following:
   a. Ramco Insulation, Inc.; Super-Stik.

B. Expanded or Exfoliated Vermiculite Insulating Cement: Comply with ASTM C 196.

1. Products: Subject to compliance with requirements, provide the following:
   a. Ramco Insulation, Inc.; Thermokote V.

C. Mineral-Fiber, Hydraulic-Setting Insulating and Finishing Cement: Comply with ASTM C 449.

1. Products: Subject to compliance with requirements, provide the following:
   a. Ramco Insulation, Inc.; Ramcote 1200 and Quik-Cote.

2.4 ADHESIVES

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

B. Calcium Silicate Adhesive: Fibrous, sodium-silicate-based adhesive with a service temperature range of 50 to 800 deg F.

1. Products: Subject to compliance with requirements, provide the following:
   a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-97.
   b. Eagle Bridges - Marathon Industries; 290.
   c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 81-27.
   d. Mon-Eco Industries, Inc.; 22-30.
   e. Vimasco Corporation; 760.
2. For indoor applications, adhesive shall have a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
3. Adhesive shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

C. Phenolic and Polyisocyanurate Adhesive: Solvent-based resin adhesive, with a service temperature range of minus 75 to plus 300 deg F.

1. Products: Subject to compliance with requirements, provide the following:
   a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-96.
   b. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 81-33.
2. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
3. Adhesive shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

D. Flexible Elastomeric and Polyolefin Adhesive: Comply with MIL-A-24179A, Type II, Class I.

1. Products: Subject to compliance with requirements, provide the following:
   a. Aeroflex USA, Inc.; Aeroseal.
   b. Armacell LLC; Armaflex 520 Adhesive.
   c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 85-75.
   d. K-Flex USA; R-373 Contact Adhesive.
2. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
3. Adhesive shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

E. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.

1. Products: Subject to compliance with requirements, provide the following:
   a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-127.
   b. Eagle Bridges - Marathon Industries; 225.
   c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 85-60/85-70.
   d. Mon-Eco Industries, Inc.; 22-25.
2. For indoor applications, adhesive shall have a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
3. Adhesive shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

F. ASJ Adhesive, and FSK and PVDC Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.

1. Products: Subject to compliance with requirements, provide the following:
   a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-82.

b. Eagle Bridges - Marathon Industries; 225.
c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 85-50.
d. Mon-Eco Industries, Inc.; 22-25.
2. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
3. Adhesive shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

G. PVC Jacket Adhesive: Compatible with PVC jacket.

1. Products: Subject to compliance with requirements, provide the following:
a. Dow Corning Corporation; 739, Dow Silicone.
b. Johns Manville; Zeston Perma-Weld, CEEL-TITE Solvent Welding Adhesive.
c. P.I.C. Plastics, Inc.; Welding Adhesive.
d. Speedline Corporation; Polyco VP Adhesive.
2. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
3. Adhesive shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

2.5 LAGGING ADHESIVES

A. Description: Comply with MIL-A-3316C, Class I, Grade A and shall be compatible with insulation materials, jackets, and substrates.

1. For indoor applications, use lagging adhesives that have a VOC content of 75 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
2. Products: Subject to compliance with requirements, provide the following:
a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-50 AHV2.
b. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 30-36.
c. Vimasco Corporation; 713 and 714.
3. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over equipment insulation.
4. Service Temperature Range: 0 to plus 180 deg F.
5. Color: White.

2.6 SEALANTS

A. Joint Sealants:

1. Products: Subject to compliance with requirements, provide the following:
a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-76.
b. Eagle Bridges - Marathon Industries; 405.
c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 30-45.
d. Mon-Eco Industries, Inc.; 44-05.
e. Pittsburgh Corning Corporation; Pittseal 444.
2. Materials shall be compatible with insulation materials, jackets, and substrates.
3. Permanently flexible, elastomeric sealant.
4. Service Temperature Range: Minus 100 to plus 300 deg F.
5. Color: White or gray.
6. For indoor applications, sealants shall have a VOC content of 75 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
7. Sealants shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

B. FSK and Metal Jacket Flashing Sealants:

1. Products: Subject to compliance with requirements, provide the following:
    a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-76.
    b. Eagle Bridges - Marathon Industries; 405.
    c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 95-44.
    d. Mon-Eco Industries, Inc.; 44-05.
2. Materials shall be compatible with insulation materials, jackets, and substrates.
3. Fire- and water-resistant, flexible, elastomeric sealant.
4. Service Temperature Range: Minus 40 to plus 250 deg F.
5. Color: Aluminum.
6. For indoor applications, sealants shall have a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
7. Sealants shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

C. ASJ Flashing Sealants, and Vinyl, PVDC, and PVC Jacket Flashing Sealants:
1. Products: Subject to compliance with requirements, provide the following:
    a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-76.
2. Materials shall be compatible with insulation materials, jackets, and substrates.
3. Fire- and water-resistant, flexible, elastomeric sealant.
4. Service Temperature Range: Minus 40 to plus 250 deg F.
5. Color: White.
6. For indoor applications, sealants shall have a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
7. Sealants shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

2.7 FACTORY-APPLIED JACKETS

A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:
1. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C 1136, Type I.
2. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C 1136, Type I.
3. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C 1136, Type II.
4. FSP Jacket: Aluminum-foil, fiberglass-reinforced scrim with polyethylene backing; complying with ASTM C 1136, Type II.
5. PVDC Jacket for Indoor Applications: 4-mil- thick, white PVDC biaxially oriented barrier film with a permeance at 0.02 perm when tested according to ASTM E 96/E 96M and with a flame-spread index of 5 and a smoke-developed index of 20 when tested according to ASTM E 84.
6. Products: Subject to compliance with requirements, provide the following:
    1) Dow Chemical Company (The); Saran 540 Vapor Retarder Film and Saran 560 Vapor Retarder Film.
7. PVDC Jacket for Outdoor Applications: 6-mil- thick, white PVDC biaxially oriented barrier film with a permeance at 0.01 perm when tested according to ASTM E 96/E 96M and with a flame-spread index of 5 and a smoke-developed index of 25 when tested according to ASTM E 84.
8. Products: Subject to compliance with requirements, provide the following:
    1) Dow Chemical Company (The); Saran 540 Vapor Retarder Film and Saran 560 Vapor Retarder Film.
9. PVDC-SSL Jacket: PVDC jacket with a self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip.
10. Products: Subject to compliance with requirements, provide the following:
    1) Dow Chemical Company (The); Saran 540 Vapor Retarder Film and Saran 560 Vapor Retarder Film.

11. Vinyl Jacket: White vinyl with a permeance of 1.3 perms when tested according to ASTM E 96/E 96M, Procedure A, and complying with NFPA 90A and NFPA 90B.

2.8 FIELD-APPLIED JACKETS

A. Field-applied jackets shall comply with ASTM C 921, Type I, unless otherwise indicated.

B. FSK Jacket: Aluminum-foil-face, fiberglass-reinforced scrim with kraft-paper backing.

C. PVC Jacket: High-impact-resistant, UV-resistant PVC complying with ASTM D 1784, Class 16354-C; thickness as scheduled; roll stock ready for shop or field cutting and forming. Thickness is indicated in field-applied jacket schedules.
   1. Products: Subject to compliance with requirements, provide the following:
      a. Johns Manville; Zeston.
      b. P.I.C. Plastics, Inc.; FG Series.
      c. Proto Corporation; LoSmoke.
      d. Speedline Corporation; SmokeSafe.
   2. Adhesive: As recommended by jacket material manufacturer.
   3. Color: Color-code jackets based on system within mechanical rooms. White elsewhere.
   4. Factory-fabricated tank heads and tank side panels.

D. Metal Jacket:
   1. Products: Subject to compliance with requirements, provide the following:
      a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; Metal Jacketing Systems.
      b. ITW Insulation Systems; Aluminum and Stainless Steel Jacketing.
      c. RPR Products, Inc.; Insul-Mate.
   2. Aluminum Jacket: Comply with ASTM B 209, Alloy 3003, 3005, 3105, or 5005, Temper H-14.
      a. Factory cut and rolled to size.
      b. Finish and thickness are indicated in field-applied jacket schedules.
      c. Moisture Barrier for Indoor Applications: 2.5-mil- thick polysurlyn.
      d. Moisture Barrier for Outdoor Applications: 2.5-mil- thick polysurlyn.
      e. Factory-Fabricated Fitting Covers:
         1) Same material, finish, and thickness as jacket.
         2) Preformed two-piece or gore, 45- and 90-degree, short- and long-radius elbows.
         3) Tee covers.
         4) Flange and union covers.
         5) End caps.
         6) Beveled collars.
         7) Valve covers.
         8) Field fabricate fitting covers only if factory-fabricated fitting covers are not available.

E. Outdoor Jacket, Prefabricated, Self-Adhering, Sheet-Type Waterproofing Membrane: 60-mil- thick, laminated vapor barrier and waterproofing membrane for installation over insulation located aboveground outdoors; consisting of a rubberized bituminous resin on a cross laminated polyethylene film covered with stucco-embossed aluminum-foil facing.
   1. Products: Subject to compliance with requirements, provide one of the following:
      a. Polyguard Products, Inc.; Alumaguard All Weather

F. PVDC Jacket for Indoor Applications: 4-mil- thick, white PVDC biaxially oriented barrier film with a permeance at 0.02 perm when tested according to ASTM E 96/E 96M and with a flame-spread index of 5 and a smoke-developed index of 20 when tested according to ASTM E 84.
   1. Products: Subject to compliance with requirements, provide the following:
      a. Dow Chemical Company (The), Saran 540 Vapor Retarder Film.

G. PVDC Jacket for Outdoor Applications: 6-mil- thick, white PVDC biaxially oriented barrier film with a permeance at 0.01 perm when tested according to ASTM E 96/E 96M and with a flame-spread index of 5 and a smoke-developed index of 25 when tested according to ASTM E 84.
   1. Products: Subject to compliance with requirements, provide the following:
      a. Dow Chemical Company (The), Saran 560 Vapor Retarder Film.

H. PVDC-SSL Jacket: PVDC jacket with a self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip.

1. Products: Subject to compliance with requirements, provide the following:
    a. Dow Chemical Company (The); Saran 540 Vapor Retarder Film and Saran 560 Vapor Retarder Film.

2.9 TAPES

A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C 1136.
    1. Products: Subject to compliance with requirements, provide the following:
        a. ABI, Ideal Tape Division; 428 AWF ASJ.
        b. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0836.
        c. Compac Corporation; 104 and 105.
        d. Venture Tape; 1540 CW Plus, 1542 CW Plus, and 1542 CW Plus/SQ.
    2. Width: 3 inches.
    3. Thickness: 11.5 mils.
    4. Adhesion: 90 ounces force/inch in width.
    5. Elongation: 2 percent.
    6. Tensile Strength: 40 lbf/inch in width.
    7. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.

B. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C 1136.
    1. Products: Subject to compliance with requirements, provide the following:
        a. ABI, Ideal Tape Division; 491 AWF FSK.
        b. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0827.
        c. Compac Corporation; 110 and 111.
        d. Venture Tape; 1525 CW NT, 1528 CW, and 1528 CW/SQ.
    2. Width: 3 inches.
    3. Thickness: 6.5 mils.
    4. Adhesion: 90 ounces force/inch in width.
    5. Elongation: 2 percent.
    6. Tensile Strength: 40 lbf/inch in width.
    7. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.

C. PVC Tape: White vapor-retarder tape matching field-applied PVC jacket with acrylic adhesive; suitable for indoor and outdoor applications.
    1. Products: Subject to compliance with requirements, provide the following:
        a. ABI, Ideal Tape Division; 370 White PVC tape.
        b. Compac Corporation; 130.
        c. Venture Tape; 1506 CW NS.
    2. Width: 2 inches.
    3. Thickness: 6 mils.
    4. Adhesion: 64 ounces force/inch in width.
    5. Elongation: 500 percent.
    6. Tensile Strength: 18 lbf/inch in width.

D. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive.
    1. Products: Subject to compliance with requirements, provide the following:
        a. ABI, Ideal Tape Division; 488 AWF.
        b. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0800.
        c. Compac Corporation; 120.
        d. Venture Tape; 3520 CW.
    2. Width: 2 inches.
    3. Thickness: 3.7 mils.
    4. Adhesion: 100 ounces force/inch in width.
    5. Elongation: 5 percent.
    6. Tensile Strength: 34 lbf/inch in width.

E. PVDC Tape for Indoor Applications: White vapor-retarder PVDC tape with acrylic adhesive.
    1. Products: Subject to compliance with requirements, provide the following:
        a. Dow Chemical Company (The); Saran 540 Vapor Retarder Tape.

2. Width: 3 inches.
3. Film Thickness: 4 mils.
4. Adhesive Thickness: 1.5 mils.
5. Elongation at Break: 145 percent.
6. Tensile Strength: 55 lbf/inch in width.

F. PVDC Tape for Outdoor Applications: White vapor-retarder PVDC tape with acrylic adhesive.

1. Products: Subject to compliance with requirements, provide the following:
   a. Dow Chemical Company (The); Saran 560 Vapor Retarder Tape.
2. Width: 3 inches.
3. Film Thickness: 6 mils.
4. Adhesive Thickness: 1.5 mils.
5. Elongation at Break: 145 percent.
6. Tensile Strength: 55 lbf/inch in width.

2.10 SECUREMENTS

A. Bands:

1. Products: Subject to compliance with requirements, provide the following:
   a. ITW Insulation Systems; Gerrard Strapping and Seals.
   b. RPR Products, Inc.; Insul-Mate Strapping, Seals, and Springs.
2. Aluminum: ASTM B 209, Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch thick, 3/4 inch wide with wing seal.
3. Springs: Twin spring set constructed of stainless steel with ends flat and slotted to accept metal bands. Spring size determined by manufacturer for application.

B. Insulation Pins and Hangers:

1. Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.135-inch- diameter shank, length to suit depth of insulation indicated.
2. Products: Subject to compliance with requirements, provide the following:
   1) AGM Industries, Inc.; CWP-1.
   2) GEMCO; CD.
   3) Midwest Fasteners, Inc.; CD.
   4) Nelson Stud Welding; TPA, TPC, and TPS.
3. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.135-inch- diameter shank, length to suit depth of insulation indicated with integral 1-1/2-inch galvanized carbon-steel washer.
4. Products: Subject to compliance with requirements, provide the following:
   1) AGM Industries, Inc.; CHP-1.
   2) GEMCO; Cupped Head Weld Pin.
   3) Midwest Fasteners, Inc.; Cupped Head.
   4) Nelson Stud Welding; CHP.
5. Nonmetal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate fastened to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place.
   a. Products: Subject to compliance with requirements, provide the following:
      1) GEMCO; Nylon Hangers.
      2) Midwest Fasteners, Inc.; Nylon Insulation Hangers.
   b. Baseplate: Perforated, nylon sheet, 0.030 inch thick by 1-1/2 inches in diameter.
   c. Spindle: Nylon, 0.106-inch- diameter shank, length to suit depth of insulation indicated, up to 2-1/2 inches.
   d. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.
6. Self-Sticking-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place.
   a. Products: Subject to compliance with requirements, provide the following:
      1) AGM Industries, Inc.; Tactoo Self-Adhering Insul-Hangers, Series.
      2) GEMCO; Peel & Press.
      3) Midwest Fasteners, Inc.; Self Stick.

b. Baseplate: Galvanized carbon-steel sheet, 0.030 inch thick by 2 inches square.
c. Spindle: Aluminum, fully annealed, 0.106-inch- diameter shank, length to suit depth of insulation indicated.
d. Adhesive-backed base with a peel-off protective cover.

7. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch- thick, aluminum sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.
   a. Products: Subject to compliance with requirements, provide the following:
      1) AGM Industries, Inc.; RC-150.
      2) GEMCO; R-150.
      3) Midwest Fasteners, Inc.; WA-150.
      4) Nelson Stud Welding; Speed Clips.
   b. Protect ends with capped self-locking washers incorporating a spring steel insert to ensure permanent retention of cap in exposed locations.
8. Nonmetal Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch- thick nylon sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.
   a. Products: Subject to compliance with requirements, provide the following:
      1) GEMCO.
      2) Midwest Fasteners, Inc.

2.11 CORNER ANGLES

A. PVC Corner Angles: 30 mils thick, minimum 1 by 1 inch, PVC according to ASTM D 1784, Class 16354-C. White or color-coded to match adjacent surface.

B. Aluminum Corner Angles: 0.040 inch thick, minimum 1 by 1 inch, aluminum according to ASTM B 209, Alloy 3003, 3005, 3105, or 5005; Temper H-14.

C. Stainless-Steel Corner Angles: 0.024 inch thick, minimum 1 by 1 inch, stainless steel according to ASTM A 167 or ASTM A 240/A 240M, Type 304.

PART 3 EXECUTION

3.1 EXAMINATION

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

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.

B. Coordinate insulation installation with the trade installing heat tracing. Comply with requirements for heat tracing that apply to insulation.

C. Mix insulating cements with clean potable water; if insulating cements are to be in contact with stainless-steel surfaces, use demineralized water.

3.3 GENERAL INSTALLATION REQUIREMENTS

A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of equipment.

B. Install insulation materials, forms, vapor barriers or retarders, jackets, and thicknesses required for each item of equipment as specified in insulation system schedules.

C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.

D. Install insulation with longitudinal seams at top and bottom of horizontal runs.

E. Install multiple layers of insulation with longitudinal and end seams staggered.

F. Keep insulation materials dry during application and finishing.

G. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.

H. Install insulation with least number of joints practical.

I. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.

1. Install insulation continuously through hangers and around anchor attachments.
2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.
3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.
4. Cover inserts with jacket material matching adjacent insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.

J. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.

K. Install insulation with factory-applied jackets as follows:

1. Draw jacket tight and smooth.
2. Cover circumferential joints with 3-inch- wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches o.c.
3. Overlap jacket longitudinal seams at least 1-1/2 inches. Clean and dry surface to receive self-sealing lap. Unless jackets with self-sealing layers are used, staple laps with outward clinching staples along edge at 4 inches o.c.
   a. For below ambient services, apply vapor-barrier mastic over staples.
4. Cover joints and seams with tape, according to insulation material manufacturer's written instructions, to maintain vapor seal.
5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints.

L. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.

M. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.

N. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.

O. For above ambient services, do not install insulation to the following:

1. Vibration-control devices.
2. Testing agency labels and stamps.
3. Nameplates and data plates.
4. Manholes.
5. Handholes.
6. Cleanouts.

3.4 INSTALLATION OF EQUIPMENT, TANK, AND VESSEL INSULATION

A. Mineral-Fiber, Pipe and Tank Insulation Installation for Tanks and Vessels: Secure insulation with adhesive and anchor pins and speed washers.

1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 50 percent coverage of tank and vessel surfaces.
2. Groove and score insulation materials to fit as closely as possible to equipment, including contours. Bevel insulation edges for cylindrical surfaces for tight joints. Stagger end joints.
3. Protect exposed corners with secured corner angles.

4. Install adhesively attached or self-sticking insulation hangers and speed washers on sides of tanks and vessels as follows:
   a. Do not weld anchor pins to ASME-labeled pressure vessels.
   b. Select insulation hangers and adhesive that are compatible with service temperature and with substrate.
   c. On tanks and vessels, maximum anchor-pin spacing is 3 inches from insulation end joints, and 16 inches o.c. in both directions.
   d. Do not overcompress insulation during installation.
   e. Cut and miter insulation segments to fit curved sides and domed heads of tanks and vessels.
   f. Impale insulation over anchor pins and attach speed washers.
   g. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.
5. Secure each layer of insulation with stainless-steel or aluminum bands. Select band material compatible with insulation materials.
6. Where insulation hangers on equipment and vessels are not permitted or practical and where insulation support rings are not provided, install a girdle network for securing insulation. Stretch prestressed aircraft cable around the diameter of vessel and make taut with clamps, turnbuckles, or breather springs. Place one circumferential girdle around equipment approximately 6 inches from each end. Install wire or cable between two circumferential girdles 12 inches o.c. Install a wire ring around each end and around outer periphery of center openings, and stretch prestressed aircraft cable radially from the wire ring to nearest circumferential girdle. Install additional circumferential girdles along the body of equipment or tank at a minimum spacing of 48 inches o.c. Use this network for securing insulation with tie wire or bands.
7. Stagger joints between insulation layers at least 3 inches.
8. Install insulation in removable segments on equipment access doors, manholes, handholes, and other elements that require frequent removal for service and inspection.
9. Bevel and seal insulation ends around manholes, handholes, ASME stamps, and nameplates.
10. For equipment with surface temperatures below ambient, apply mastic to open ends, joints, seams, breaks, and punctures in insulation.

B. Flexible Elastomeric Thermal Insulation Installation for Tanks and Vessels: Install insulation over entire surface of tanks and vessels.

1. Apply 100 percent coverage of adhesive to surface with manufacturer's recommended adhesive.
2. Seal longitudinal seams and end joints.

C. Insulation Installation on Pumps:

1. Fabricate metal boxes lined with insulation. Fit boxes around pumps and coincide box joints with splits in pump casings. Fabricate joints with outward bolted flanges. Bolt flanges on 6-inch centers, starting at corners. Install 3/8-inch- diameter fasteners with wing nuts. Alternatively, secure the box sections together using a latching mechanism.
2. Fabricate boxes from aluminum, at least 0.060 inch thick.
3. For below ambient services, install a vapor barrier at seams, joints, and penetrations. Seal between flanges with replaceable gasket material to form a vapor barrier.

3.5 INSTALLATION OF CALCIUM SILICATE INSULATION

A. Insulation Installation on Boiler Breechings:

1. Secure single-layer insulation with stainless-steel bands at 12-inch intervals and tighten bands without deforming insulation material.
2. Install two-layer insulation with joints tightly butted and staggered at least 3 inches. Secure inner layer with wire spaced at 12-inch intervals. Secure outer layer with stainless-steel bands at 12-inch intervals.
3. On exposed applications without metal jacket, finish insulation surface with a skim coat of mineral-fiber, hydraulic-setting cement. When cement is dry, apply flood coat of lagging adhesive and press on one layer of glass cloth. Overlap edges at least 1 inch. Apply finish coat of lagging adhesive over glass cloth. Thin finish coat to achieve smooth, uniform finish.

3.6 INSTALLATION OF PHENOLIC INSULATION

A. Secure single-layer insulation with stainless-steel bands at 12-inch intervals and tighten bands without deforming insulation materials.

B. Install two-layer insulation with joints tightly butted and staggered at least 3 inches. Secure inner layer with 0.062-inch wire spaced at 12-inch intervals. Secure outer layer with stainless-steel bands at 12-inch intervals.

3.7 MASS LOADED VINYL LAGGING INSTALLATION

A. Cut sound control lagging material to length, wrapped around the outside of the pipe or duct to which the material is to be applied

B. Fasten with mechanical fasteners or bands

C. Tapes or adhesives for FSK jacketing shall be used in addition to the mechanical fasteners

D. Install per manufacturer design guidelines.

3.8 FIELD-APPLIED JACKET INSTALLATION

A. Where glass-cloth jackets are indicated, install directly over bare insulation or insulation with factory-applied jackets.

1. Draw jacket smooth and tight to surface with 2-inch overlap at seams and joints.
2. Embed glass cloth between two 0.062-inch- thick coats of lagging adhesive.
3. Completely encapsulate insulation with coating, leaving no exposed insulation.

B. Where FSK jackets are indicated, install as follows:

1. Draw jacket material smooth and tight.
2. Install lap or joint strips with same material as jacket.
3. Secure jacket to insulation with manufacturer's recommended adhesive.
4. Install jacket with 1-1/2-inch 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-barrier mastic.

C. Where PVC jackets are indicated, install with 1-inch overlap at longitudinal seams and end joints; for horizontal applications, install with longitudinal seams along top and bottom of tanks and vessels. Seal with manufacturer's recommended adhesive.

1. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge.

D. Where metal jackets are indicated, install with 2-inch 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.

E. Where PVDC jackets are indicated, install as follows:

1. Jacket can be wrapped in cigarette fashion along length of roll for insulation systems with an outer circumference of 33-1/2 inches or less. 33-1/2-inch- circumference limit allows for 2-inch-overlap seal. Using the length of roll allows for longer sections of jacket to be installed at one time. Use adhesive on the lap seal. Visually inspect lap seal for "fishmouthing," and use PVDC tape along lap seal to secure joint.
2. Repair holes or tears in PVDC jacket by placing PVDC tape over the hole or tear and wrapping a minimum of 1-1/4 circumferences to avoid damage to tape edges.

3.9 FINISHES

A. Equipment Insulation with ASJ, Glass-Cloth, or Other Paintable Jacket Material: Paint jacket with paint system identified below and as specified in Section 099113 "Exterior Painting" and Section 099123 "Interior Painting.

B. Flexible Elastomeric Thermal Insulation: After adhesive has fully cured, apply two coats of insulation manufacturer's recommended protective coating.

C. Color: Final color as selected by Architect. Vary first and second coats to allow visual inspection of the completed Work.

D. Do not field paint aluminum or stainless-steel jackets.

3.10 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Tests and Inspections: Inspect field-insulated equipment, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to two location(s) for each type of equipment defined in the "Equipment Insulation Schedule" Article. For large equipment, remove only a portion adequate to determine compliance.

C. All insulation applications will be considered defective Work if sample inspection reveals noncompliance with requirements.

3.11 EQUIPMENT INSULATION SCHEDULE

A. Insulation materials and thicknesses are identified below. If more than one material is listed for a type of equipment, selection from materials listed is Contractor's option.

B. Insulate indoor and outdoor equipment that is not factory insulated.

C. Heat-exchanger (water-to-water for cooling service) insulation shall be one of the following:

1. Flexible Elastomeric: 1 inch thick.
2. Polyisocyanurate: 1 inch thick.

D. Heat-exchanger (water-to-water for heating service) insulation shall be one of the following:

1. Mineral-Fiber Pipe and Tank: 2 inches thick.

E. Chilled-water pump insulation shall be one of the following:

1. Flexible Elastomeric: 1 inch thick.
2. Polyolefin: 1 inch thick.

F. Chilled-water expansion/compression tank insulation shall be one of the following:

1. Flexible Elastomeric: 1 inch thick.
2. Polyisocyanurate: 1 inch thick.
3. Polyolefin: 1 inch thick.

G. Heating-hot-water expansion/compression tank insulation shall be one of the following:

1. Mineral-Fiber Board: 1 inch thick and 3 lb/cu. Ft. density
2. Mineral-Fiber Pipe and Tank: 1 inch thick.

H. Chilled-water air-separator insulation shall be one of the following:

1. Flexible Elastomeric: 1 inch thick.
2. Polyisocyanurate: 1 inch thick.
3. Polyolefin: 1 inch thick.

I. Heating-hot-water air-separator insulation shall be one of the following:

1. Mineral-Fiber Pipe and Tank: 2 inches thick.

J. Thermal storage tank (water) insulation shall be one of the following:

1. Polyolefin: 2 inches thick.

K. Piping system filter-housing insulation shall be one of the following:

1. Mineral-Fiber Pipe and Tank: 2 inches thick.

3.12 INDOOR, FIELD-APPLIED JACKET SCHEDULE

A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.

B. If more than one material is listed, selection from materials listed is Contractor's option.

C. Equipment, Concealed:

1. None.

D. Equipment, Exposed, up to 48 Inches in Diameter or with Flat Surfaces up to 72 Inches:

1. None.

E. Equipment, Exposed, Larger Than 48 Inches in Diameter or with Flat Surfaces Larger Than 72 Inches:

1. None.

3.13 OUTDOOR, FIELD-APPLIED JACKET SCHEDULE

A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.

B. If more than one material is listed, selection from materials listed is Contractor's option.

C. Equipment, Concealed:

1. None.

D. Equipment, Exposed, up to 48 Inches in Diameter or with Flat Surfaces up to 72 Inches:

1. Prefabricated, Self-Adhering, Sheet-Type Waterproofing Membrane.

E. Equipment, Exposed, Larger Than 48 Inches in Diameter or with Flat Surfaces Larger Than 72 Inches:

1. Prefabricated, Self-Adhering, Sheet-Type Waterproofing Membrane.

END OF SECTION

SECTION 230719
HVAC PIPING INSULATION

PART 1 GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes insulating the following HVAC piping systems:
   1. Condensate drain piping
   2. Chilled-water and brine piping
   3. Heating hot-water piping
   4. Steam and steam condensate piping

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include thermal conductivity, water-vapor permeance thickness, and jackets (both factory and field applied if any).

1.4 QUALITY ASSURANCE

A. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products according to ASTM E 84, by a testing and inspecting agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing agency.
   1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.
   2. Insulation Installed Outdoors: Flame-spread index of 75 or less, and smoke-developed index of 150 or less.

1.5 DELIVERY, STORAGE, AND HANDLING

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

1.6 COORDINATION

A. Coordinate sizes and locations of supports, hangers, and insulation shields specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

B. Coordinate clearance requirements with piping Installer for piping insulation application. Before preparing piping Shop Drawings establish and maintain clearance requirements for installation of insulation and field-applied jackets and finishes and for space required for maintenance.

C. Coordinate installation and testing of heat tracing.

1.7 SCHEDULING

A. Schedule insulation application after pressure testing systems and, where required, after installing and testing heat tracing. Insulation application may begin on segments that have satisfactory test results.

B. Complete installation and concealment of plastic materials as rapidly as possible in each area of construction.

PART 2 - PRODUCTS

2.1 INSULATION MATERIALS

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

B. Products shall not contain asbestos, lead, mercury, or mercury compounds.

C. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C 871.

D. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C 795.

E. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.

F. Calcium Silicate:

1. Products: Subject to compliance with requirements provide one of the following:
   a. Industrial Insulation Group (IIG); Thermo-12 Gold. (www.iig-llc.com)
2. Thermal conductivity (k-value) at 400 degrees F is 0.49 Btu x in. /h x sq. ft. x degrees F or less.
3. Preformed Pipe Sections: Flat-, curved-, and grooved-block sections of noncombustible, inorganic, hydrous calcium silicate with a non-asbestos fibrous reinforcement. Comply with ASTM C 533, Type I.
4. Flat-, curved-, and grooved-block sections of noncombustible, inorganic, hydrous calcium silicate with a non-asbestos fibrous reinforcement. Comply with ASTM C 533, Type I.
5. Prefabricated Fitting Covers: Comply with ASTM C 450 and ASTM C 585 for dimensions used in pre-forming insulation to cover valves, elbows, tees, and flanges.

G. Mineral-Fiber Blanket Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 553, Type II and ASTM C 1290, Type I, II with factory-applied vinyl jacket, III with factory-applied FSK jacket or III with factory-applied FSP jacket. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

1. Products: Subject to compliance with requirements provide one of the following:
   a. CertainTeed Corporation; (www.certainteed.com)
   b. Johns Manville; Microlite. (www.jm.com)
   c. Knauf Insulation; (www.knaufinsulation.us)
   d. Manson Insulation Inc.; Alley Wrap. (www.isolationmanson.com)
   e. Owens Corning; SOFTR All-Service Duct Wrap. (commercial.owenscorning.com)
2. Thermal conductivity (k-value) at 150 degrees F is 0.27 Btu x in. /h x sq. ft. x degrees F or less.

H. Mineral-Fiber, Preformed Pipe Insulation:

1. Products: Subject to compliance with requirements provide one of the following:
   a. Fibrex Insulations Inc.; Coreplus 1200. (www.fibrex.com)
   b. Johns Manville; Micro-Lok. (www.jm.com)
   c. Knauf Insulation; 1000-Degree Pipe Insulation. (www.knaufinsulation.us)
   d. Manson Insulation Inc.; Alley-K. (www.isolationmanson.com)
   e. Owens Corning; Fiberglas Pipe Insulation. (commercial.owenscorning.com)
2. Type I, 850 degrees F Materials: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 547, Type I, Grade A, with factory-applied ASJ-SSL. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
   a. Thermal conductivity (k-value) at 150 degrees F is 0.27 Btu x in. /h x sq. ft. x degrees F or less.

I. Mineral-Fiber, Pipe and Tank Insulation: Mineral or glass fibers bonded with a thermosetting resin. Semi-rigid board material with factory-applied ASJ complying with ASTM C 1393, Type II or Type IIIA Category 2, or with properties similar to ASTM C 612, Type IB. Nominal density is 2.5 lb/cu. ft. or more.

1. Products: Subject to compliance with requirements provide one of the following:

a. CertainTeed Corp.; CrimpWrap. (www.certainteed.com)
b. Johns Manville; MicroFlex. (www.jm.com)
c. Knauf Insulation; Pipe and Tank Insulation. (www.knaufinsulation.us)
d. Manson Insulation Inc.; AK Flex. (www.isolationmanson.com)
e. Owens Corning; Fiberglas Pipe and Tank Insulation. (commercial.owenscorning.com)
2. Thermal conductivity (k-value) at 150 deg F is 0.27 Btu x in. /h x sq. ft. x degrees F or less.
3. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

J. Phenolic:
1. Products: Subject to compliance with requirements provide one of the following:
a. ITW Insulation Systems; Trymer Green. (www.itwinsulation.com)
b. Kingspan Tarec Industrial Insulation NV; Koolphen K. (www.kingspantarec.com)
c. Resolco International BV; Insul-phen. (www.resolco.com)
2. Thermal conductivity (k-value) at 75 degrees F is 0.15 Btu x in. /h x sq. ft. x degrees F or less.
3. Preformed pipe insulation of rigid, expanded, closed-cell structure. Comply with ASTM C 1126, Type III, Grade 1.
4. Block insulation of rigid, expanded, closed-cell structure. Comply with ASTM C 1126, Type II, Grade 1.
5. Factory fabricate shapes according to ASTM C 450 and ASTM C 585.
6. Factory-Applied Jacket: Requirements are specified in "Factory-Applied Jackets" Article.
a. Preformed Pipe Insulation: ASJ.

2.2 ADHESIVES

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

B. Calcium Silicate Adhesive: Fibrous, sodium-silicate-based adhesive with a service temperature range of 50 to 800 degrees F.
1. Products: Subject to compliance with requirements provide one of the following:
a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-97. (www.idccorp.com)
b. Eagle Bridges - Marathon Industries; 290. (www.eaglebridges.com)
c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 81-27. (www.fosterproducts.com)
d. Mon-Eco Industries, Incorprated (www.mon-ecoindustries.com)
e. Vimasco Corporation; 760. (www.vimasco.com)
2. For indoor applications, adhesive shall have a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
3. Adhesive shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

C. Phenolic and Polyisocyanurate Adhesive: Solvent-based resin adhesive, with a service temperature range of minus 75 to plus 300 degrees F.
1. Products: Subject to compliance with requirements provide one of the following:
a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-96. (www.idccorp.com)
b. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 81-33. (www.fosterproducts.com)

D. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.
1. Products: Subject to compliance with requirements provide one of the following:
a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-127. (www.idccorp.com)
b. Eagle Bridges - Marathon Industries; 225. (www.eaglebridges.com)
c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 85-60/85-70. (www.fosterproducts.com)
d. Mon-Eco Industries, Incorporated; 22-25. (www.mon-ecoindustries.com)

E. ASJ Adhesive, and FSK and PVDC Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.

1. Products: Subject to compliance with requirements provide one of the following:
   a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-82. (www.idccorp.com)
   b. Eagle Bridges - Marathon Industries; 225. (www.eaglebridges.com)
   c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 85-50. (www.fosterproducts.com)
   d. Mon-Eco Industries, Incorporated; 22-25. (www.mon-ecoindustries.com)

F. PVC Jacket Adhesive: Compatible with PVC jacket.
1. Products: Subject to compliance with requirements provide one of the following:
   a. Dow Corning Corporation; 739, Dow Silicone. (www.dow.com)
   b. Johns Manville; Zeston Perma-Weld, CEEL-TITE Solvent Welding Adhesive. (www.jm.com)
   c. P.I.C. Plastics, Inc.; Welding Adhesive. (www.pic-plastics.com)
   d. Speedline Corporation; Polyco VP Adhesive. (www.speedlinepvc.com)

2.3 MASTICS

A. Vapor-Barrier Mastic: Water based; suitable for indoor use on below-ambient services.
1. Products: Subject to compliance with requirements provide one of the following:
   a. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 30-80/30-90. (www.fosterproducts.com)
   b. Vimasco Corporation; 749. (www.vimasco.com)
2. Water-Vapor Permeance: ASTM E 96/E 96M, Procedure B, 0.013 perm at 43-mil dry film thickness.
3. Service Temperature Range: Minus 20 to plus 180 degrees F.
4. Solids Content: ASTM D 1644, 58 percent by volume and 70 percent by weight.
5. Color: White.

B. Vapor-Barrier Mastic: Solvent based; suitable for indoor use on below-ambient services.
1. Products: Subject to compliance with requirements provide one of the following:
   a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-30. (www.idccorp.com)
   b. Eagle Bridges - Marathon Industries; 501. (www.eaglebridges.com)
   c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 30-35. (www.fosterproducts.com)
   d. Mon-Eco Industries, Inc.; 55-10. (www.mon-ecoindustries.com)
2. Water-Vapor Permeance: ASTM F 1249, 0.05 perm at 35-mil dry film thickness.
3. Service Temperature Range: 0 to 180 degrees F.
4. Solids Content: ASTM D 1644, 44 percent by volume and 62 percent by weight.
5. Color: White.

C. Vapor-Barrier Mastic: Solvent based; suitable for outdoor use on below-ambient services.
1. Products: Subject to compliance with requirements provide one of the following:
   a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; Encacel. (www.idccorp.com)
   b. Eagle Bridges - Marathon Industries; 570. (www.eaglebridges.com)
   c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 60-95/60-96. (www.fosterproducts.com)
2. Water-Vapor Permeance: ASTM F 1249, 0.05 perm at 30-mil dry film thickness.
3. Service Temperature Range: Minus 50 to plus 220 degrees F.
4. Solids Content: ASTM D 1644, 33 percent by volume and 46 percent by weight.
5. Color: White.

D. Breather Mastic: Water based; suitable for indoor and outdoor use on above-ambient services.
1. Products: Subject to compliance with requirements provide one of the following:
   a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-10. (www.idccorp.com)
   b. Eagle Bridges - Marathon Industries; 550. (www.eaglebridges.com)
   c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 46-50. (www.fosterproducts.com)

d. Mon-Eco Industries, Inc.; 55-50. (www.mon-ecoindustries.com)
e. Vimasco Corporation; WC-1/WC-5. (www.vimasco.com)
2. Water-Vapor Permeance: ASTM F 1249, 1.8 perms at 0.0625-inch dry film thickness.
3. Service Temperature Range: Minus 20 to plus 180 degrees F.
4. Solids Content: 60 percent by volume and 66 percent by weight.
5. Color: White.

2.4 SEALANTS

A. Joint Sealants:

1. Products: Subject to compliance with requirements provide one of the following:
   a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-76. (www.idccorp.com)
   b. Eagle Bridges - Marathon Industries; 405. (www.eaglebridges.com)
   c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 30-45. (www.fosterproducts.com)
   d. Mon-Eco Industries, Inc.; 44-05. (www.mon-ecoindustries.com)
   e. Pittsburgh Corning Corporation; Pittseal 444.
2. Products: Subject to compliance with requirements provide one of the following:
   a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-70. (www.idccorp.com)
   b. Eagle Bridges - Marathon Industries; 405. (www.eaglebridges.com)
   c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 30-45. (www.fosterproducts.com)
   d. Mon-Eco Industries, Inc.; 44-05. (www.mon-ecoindustries.com)
3. Materials shall be compatible with insulation materials, jackets, and substrates.
4. Permanently flexible, elastomeric sealant.
5. Service Temperature Range: Minus 100 to plus 300 degrees F.
6. Color: White or gray.

B. FSK and Metal Jacket Flashing Sealants:

1. Products: Subject to compliance with requirements provide one of the following:
   a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-76. (www.idccorp.com)
   b. Eagle Bridges - Marathon Industries; 405. (www.eaglebridges.com)
   c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 95-44. (www.fosterproducts.com)
   d. Mon-Eco Industries, Inc.; 44-05. (www.mon-ecoindustries.com)
2. Materials shall be compatible with insulation materials, jackets, and substrates.
3. Fire- and water-resistant, flexible, elastomeric sealant.
4. Service Temperature Range: Minus 40 to plus 250 degrees F.
5. Color: Aluminum.

C. ASJ Flashing Sealants, and Vinyl, PVDC, and PVC Jacket Flashing Sealants:

1. Products: Subject to compliance with requirements provide one of the following:
   a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-76. (www.idccorp.com)
2. Materials shall be compatible with insulation materials, jackets, and substrates.
3. Fire- and water-resistant, flexible, elastomeric sealant.
4. Service Temperature Range: Minus 40 to plus 250 degrees F.
5. Color: White.

2.5 FACTORY-APPLIED JACKETS

A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:

1. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C 1136, Type I.
2. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C 1136, Type I.

3. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C 1136, Type II.
4. FSP Jacket: Aluminum-foil, fiberglass-reinforced scrim with polyethylene backing; complying with ASTM C 1136, Type II.
5. PVDC Jacket for Indoor Applications: 4-mil- thick, white PVDC biaxially oriented barrier film with a permeance at 0.02 perm when tested according to ASTM E 96/E 96M and with a flame-spread index of 5 and a smoke-developed index of 20 when tested according to ASTM E 84.
6. Products: Subject to compliance with requirements provide one of the following:
    1) Dow Chemical Company (The); Saran 540 Vapor Retarder Film and Saran 560 Vapor Retarder Film. (www.dow.com)
7. PVDC Jacket for Outdoor Applications: 6-mil- thick, white PVDC biaxially oriented barrier film with a permeance at 0.01 perm when tested according to ASTM E 96/E 96M and with a flame-spread index of 5 and a smoke-developed index of 25 when tested according to ASTM E 84.
8. Products: Subject to compliance with requirements provide one of the following:
    1) Dow Chemical Company (The); Saran 540 Vapor Retarder Film and Saran 560 Vapor Retarder Film. (www.dow.com)
9. PVDC-SSL Jacket: PVDC jacket with a self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip.
10. Products: Subject to compliance with requirements provide one of the following:
    1) Dow Chemical Company (The); Saran 540 Vapor Retarder Film and Saran 560 Vapor Retarder Film. (www.dow.com)
11. Vinyl Jacket: White vinyl with a permeance of 1.3 perms when tested according to ASTM E 96/E 96M, Procedure A, and complying with NFPA 90A and NFPA 90B.

2.6 FIELD-APPLIED JACKETS

A. Field-applied jackets shall comply with ASTM C 921, Type I, unless otherwise indicated.

B. FSK Jacket: Aluminum-foil-face, fiberglass-reinforced scrim with kraft-paper backing.

C. PVC Jacket: High-impact-resistant, UV-resistant PVC complying with ASTM D 1784, Class 16354-C; thickness as scheduled; roll stock ready for shop or field cutting and forming. Thickness is indicated in field-applied jacket schedules.

1. Products: Subject to compliance with requirements provide one of the following:
    a. Johns Manville; Zeston. (www.jm.com)
    b. P.I.C. Plastics, Inc.; FG Series. (www.pic-plastics.com)
    c. Proto Corporation; LoSmoke. (www.protocorporation.com)
    d. Speedline Corporation; SmokeSafe. (www.speedlinepvc.com)
2. Adhesive: As recommended by jacket material manufacturer.
3. Color: White.
4. Factory-fabricated fitting covers to match jacket if available; otherwise, field fabricate.
    a. Shapes: 45- and 90-degrees, short- and long-radius elbows, tees, valves, flanges, unions, reducers, end caps, soil-pipe hubs, traps, mechanical joints, and P-trap and supply covers for lavatories.

2.7 TAPES

A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C 1136.

1. Products: Subject to compliance with requirements provide one of the following:
    a. ABI, Ideal Tape Division; 428 AWF ASJ. (www.abitape.com)
    b. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0836. (www.stus.averydennison.com)
    c. Venture Tape; 1540 CW Plus, 1542 CW Plus, and 1542 CW Plus/SQ. (www.venturetape.com)
2. Width: 3 inches.
3. Thickness: 11.5 mils.
4. Adhesion: 90 ounces force/inch in width.
5. Elongation: 2 percent.
6. Tensile Strength: 40 lbf/inch in width.
7. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.

B. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C 1136.

1. Products: Subject to compliance with requirements provide one of the following:
   a. ABI, Ideal Tape Division; 491 AWF FSK. (www.abitape.com)
   b. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0827. (www.stus.averydennison.com)
   c. Venture Tape; 1525 CW NT, 1528 CW, and 1528 CW/SQ. (www.venturetape.com)
2. Width: 3 inches.
3. Thickness: 6.5 mils.
4. Adhesion: 90 ounces force/inch in width.
5. Elongation: 2 percent.
6. Tensile Strength: 40 lbf/inch in width.
7. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.

C. PVC Tape: White vapor-retarder tape matching field-applied PVC jacket with acrylic adhesive; suitable for indoor and outdoor applications.

1. Products: Subject to compliance with requirements provide one of the following:
   a. ABI, Ideal Tape Division; 370 White PVC tape. (www.abitape.com)
   b. Venture Tape; 1506 CW NS. (www.venturetape.com)
2. Width: 2 inches.
3. Thickness: 6 mils.
4. Adhesion: 64 ounces force/inch in width.
5. Elongation: 500 percent.
6. Tensile Strength: 18 lbf/inch in width.

D. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive.

1. Products: Subject to compliance with requirements provide one of the following:
   a. ABI, Ideal Tape Division; 488 AWF. (www.abitape.com)
   b. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0800. (www.stus.averydennison.com)
   c. Venture Tape; 3520 CW. (www.venturetape.com)
2. Width: 2 inches.
3. Thickness: 3.7 mils.
4. Adhesion: 100 ounces force/inch in width.
5. Elongation: 5 percent.
6. Tensile Strength: 34 lbf/inch in width.

2.8 SECUREMENTS

A. Bands:

1. Products: Subject to compliance with requirements provide one of the following:
   a. ITW Insulation Systems; Gerrard Strapping and Seals. (www.itwinsulation.com)
   b. RPR Products, Inc.; Insul-Mate Strapping, Seals, and Springs. (www.rprhouston.com)
2. Stainless Steel: ASTM A 167 or ASTM A 240/A 240M, Type 304 or Type 316; 0.015 inch thick, 1/2 inch or 3/4 inch wide with wing seal or closed seal.
3. Springs: Twin spring set constructed of stainless steel with ends flat and slotted to accept metal bands. Spring size determined by manufacturer for application.

B. Staples: Outward-clinching insulation staples, nominal 3/4-inch- wide, stainless steel or Monel.

C. Wire: 0.062-inch soft-annealed, stainless steel.

1. Products: Subject to compliance with requirements provide one of the following:
   a. C & F Wire. (www.cfwireproducts.com)

PART 3 - EXECUTION

3.1 EXAMINATION

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

1. Verify that systems to be insulated have been tested and are free of defects.

2. Verify that surfaces to be insulated are clean and dry.
3. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.

3.3 GENERAL INSTALLATION REQUIREMENTS

A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of piping including fittings, valves, and specialties.

B. Install insulation materials, forms, vapor barriers or retarders, jackets, and thicknesses required for each item of pipe system as specified in insulation system schedules.

C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.

D. Install insulation with longitudinal seams at top and bottom of horizontal runs.

E. Install multiple layers of insulation with longitudinal and end seams staggered.

F. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.

G. Keep insulation materials dry during application and finishing.

H. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.

I. Install insulation with least number of joints practical.

J. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.
   1. Install insulation continuously through hangers and around anchor attachments.
   2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.
   3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.
   4. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.

K. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.

L. Install insulation with factory-applied jackets as follows:
   1. Draw jacket tight and smooth.
   2. Cover circumferential joints with 3-inch- wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches o.c.
   3. Overlap jacket longitudinal seams at least 1-1/2 inches. Install insulation with longitudinal seams at bottom of pipe. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 4 inches o.c.
      a. For below-ambient services, apply vapor-barrier mastic over staples.
   4. Cover joints and seams with tape, according to insulation material manufacturer's written instructions, to maintain vapor seal.
   5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to pipe flanges and fittings.

M. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.

N. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.

O. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.

P. For above-ambient services, do not install insulation to the following:

1. Vibration-control devices.
2. Testing agency labels and stamps.
3. Nameplates and data plates.
4. Manholes.
5. Handholes.
6. Cleanouts.

3.4 PENETRATIONS

A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.

1. Seal penetrations with flashing sealant.
2. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
3. Extend jacket of outdoor insulation outside roof flashing at least 2 inches below top of roof flashing.
4. Seal jacket to roof flashing with flashing sealant.

B. Insulation Installation at Underground Exterior Wall Penetrations: Terminate insulation flush with sleeve seal. Seal terminations with flashing sealant.

C. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.

1. Seal penetrations with flashing sealant.
2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches.
4. Seal jacket to wall flashing with flashing sealant.

D. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.

E. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Install insulation continuously through penetrations of fire-rated walls and partitions.

1. Comply with requirements in Section 078413 "Penetration Firestopping" for firestopping and fire-resistive joint sealers.

F. Insulation Installation at Floor Penetrations:

1. Pipe: Install insulation continuously through floor penetrations.
2. Seal penetrations through fire-rated assemblies. Comply with requirements in Section 078413 "Penetration Firestopping."

3.5 GENERAL PIPE INSULATION INSTALLATION

A. Requirements in this article generally apply to all insulation materials except where more specific requirements are specified in various pipe insulation material installation articles.

B. Insulation Installation on Fittings, Valves, Strainers, Flanges, and Unions:

1. Install insulation over fittings, valves, strainers, flanges, unions, and other specialties with continuous thermal and vapor-retarder integrity unless otherwise indicated.

2. Insulate pipe elbows using preformed fitting insulation or mitered fittings made from same material and density as adjacent pipe insulation. Each piece shall be butted tightly against adjoining piece and bonded with adhesive. Fill joints, seams, voids, and irregular surfaces with insulating cement finished to a smooth, hard, and uniform contour that is uniform with adjoining pipe insulation.
3. Insulate tee fittings with preformed fitting insulation or sectional pipe insulation of same material and thickness as used for adjacent pipe. Cut sectional pipe insulation to fit. Butt each section closely to the next and hold in place with tie wire. Bond pieces with adhesive.
4. Insulate valves using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. For valves, insulate up to and including the bonnets, valve stuffing-box studs, bolts, and nuts. Fill joints, seams, and irregular surfaces with insulating cement.
5. Insulate strainers using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Fill joints, seams, and irregular surfaces with insulating cement. Insulate strainers so strainer basket flange or plug can be easily removed and replaced without damaging the insulation and jacket. Provide a removable reusable insulation cover. For below-ambient services, provide a design that maintains vapor barrier.
6. Insulate flanges and unions using a section of oversized preformed pipe insulation. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker.
7. Cover segmented insulated surfaces with a layer of finishing cement and coat with a mastic. Install vapor-barrier mastic for below-ambient services and a breather mastic for above-ambient services. Reinforce the mastic with fabric-reinforcing mesh. Trowel the mastic to a smooth and well-shaped contour.
8. For services not specified to receive a field-applied jacket except for flexible elastomeric and polyolefin, install fitted PVC cover over elbows, tees, strainers, valves, flanges, and unions. Terminate ends with PVC end caps. Tape PVC covers to adjoining insulation facing using PVC tape.
9. Stencil or label the outside insulation jacket of each union with the word "union." Match size and color of pipe labels.

C. Insulate instrument connections for thermometers, pressure gages, pressure temperature taps, test connections, flow meters, sensors, switches, and transmitters on insulated pipes. Shape insulation at these connections by tapering it to and around the connection with insulating cement and finish with finishing cement, mastic, and flashing sealant.

D. Install removable insulation covers at locations indicated. Installation shall conform to the following:

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

3.6 INSTALLATION OF CALCIUM SILICATE INSULATION

A. Insulation Installation on Straight Pipes and Tubes:

1. Secure single-layer insulation with stainless-steel bands at 12-inch intervals and tighten bands without deforming insulation materials.
2. Install two-layer insulation with joints tightly butted and staggered at least 3 inches. Secure inner layer with 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 insulation surface. When cement is 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 finish coat to achieve smooth, uniform finish.

B. Insulation Installation on Pipe Flanges:

1. Install preformed pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of block insulation of same material and thickness as pipe insulation.
4. Finish flange insulation same as pipe insulation.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install preformed sections of same material as straight segments of pipe insulation when available. Secure according to manufacturer's written instructions.
2. When preformed insulation sections of insulation are not available, install mitered sections of calcium silicate insulation. Secure insulation materials with wire or bands.
3. Finish fittings insulation same as pipe insulation.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install mitered segments of calcium silicate insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
2. Install insulation to flanges as specified for flange insulation application.
3. Finish valve and specialty insulation same as pipe insulation.

3.7 INSTALLATION OF MINERAL-FIBER INSULATION

A. Insulation Installation on Straight Pipes and Tubes:

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

B. Insulation Installation on Pipe Flanges:

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

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install preformed sections of same material as straight segments of pipe insulation when available.
2. When preformed insulation elbows and fittings are not available, install mitered sections of pipe insulation, to a thickness equal to adjoining pipe insulation. Secure insulation materials with wire or bands.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed sections of same material as straight segments of pipe insulation when available.
2. When preformed sections are not available, install mitered sections of pipe insulation to valve body.
3. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
4. Install insulation to flanges as specified for flange insulation application.

3.8 INSTALLATION OF PHENOLIC INSULATION

A. General Installation Requirements:
   1. Secure single-layer insulation with stainless-steel bands at 12-inch intervals and tighten bands without deforming insulation materials.
   2. Install 2-layer insulation with joints tightly butted and staggered at least 3 inches. Secure inner layer with 0.062-inch wire spaced at 12-inch intervals. Secure outer layer with stainless-steel bands at 12-inch intervals.

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

C. Insulation Installation on Pipe Flanges:
   1. Install preformed pipe insulation to outer diameter of pipe flange.
   2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
   3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of block insulation of same material and thickness as pipe insulation.

D. Insulation Installation on Pipe Fittings and Elbows:
   1. Install preformed insulation sections of same material as straight segments of pipe insulation. Secure according to manufacturer's written instructions.

E. Insulation Installation on Valves and Pipe Specialties:
   1. Install preformed insulation sections of same material as straight segments of pipe insulation. Secure according to manufacturer's written instructions.
   2. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
   3. Install insulation to flanges as specified for flange insulation application.

3.9 FIELD-APPLIED JACKET INSTALLATION

A. Where FSK jackets are indicated, install as follows:
   1. Draw jacket material smooth and tight.
   2. Install lap or joint strips with same material as jacket.
   3. Secure jacket to insulation with manufacturer's recommended adhesive.
   4. Install jacket with 1-1/2-inch 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-barrier mastic.

B. Where PVC jackets are indicated, install with 1-inch overlap at longitudinal seams and end joints; for horizontal applications. Seal with manufacturer's recommended adhesive.
   1. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge.

3.10 PIPING INSULATION SCHEDULE, GENERAL

A. Acceptable preformed pipe and tubular insulation materials and thicknesses are identified for each piping system and pipe size range. If more than one material is listed for a piping system, selection from materials listed is Contractor's option.

B. Items Not Insulated: Unless otherwise indicated, do not install insulation on the following:

1. Underground piping.

3.11 INDOOR PIPING INSULATION SCHEDULE

A. Condensate and Equipment Drain Water below 60 Degrees F:

1. All Pipe Sizes: Insulation shall be one of the following:
    a. Flexible Elastomeric: 3/4 inch thick.
    b. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1/2 inch thick.

B. Chilled Water and Brine, 40 Degrees to 60 degrees F:

1. NPS: All sizes
    a. Phenolic: 1 inch thick.

C. Heating-Hot-Water Supply and Return, 105 degrees to 140 degrees F:

1. NPS 1.5 and Smaller: Insulation shall be the following:
    a. Mineral-Fiber, Preformed Pipe, Type I: 1.5-inches thick.
2. NPS 2 and Larger: Insulation shall be the following:
    a. Mineral-Fiber, Preformed Pipe, Type I, 2-inches thick.

D. Heating-Hot-Water Supply and Return, 141 degrees to 200 degrees F:

1. NPS 1.25 and Smaller: Insulation shall be the following:
    a. Mineral-Fiber, Preformed Pipe, Type I: 1.5-inches thick.
2. NPS 1.5 and Larger: Insulation shall be the following:
    a. Mineral-Fiber, Preformed Pipe, Type I, 2-inches thick.

E. Steam and Steam Condensate, 201 degrees to 250 degrees F:

1. NPS 1.5 and Smaller: Insulation shall be the following:
    a. Mineral-Fiber, Preformed Pipe, Type I: 2.5-inches thick.
2. NPS 2 through NPS 6: Insulation shall be the following:
    a. Mineral-Fiber, Preformed Pipe, Type I: 3-inches thick.
3. NPS 8 and Larger: Insulation shall be the following:
    a. Mineral-Fiber, Preformed Pipe, Type I, 3.5-inches thick.

F. Steam and Steam Condensate, 251 degrees to 350 degrees F:

1. NPS .75 and Smaller: Insulation shall be the following:
    a. Mineral-Fiber, Preformed Pipe, Type I: 3-inches thick.
2. NPS 1 and NPS 1.25: Insulation shall be the following:
    a. Mineral-Fiber, Preformed Pipe, Type I: 4-inches thick.
3. NPS 1.5 and Larger: Insulation shall be the following:
    a. Mineral-Fiber, Preformed Pipe, Type I, 4.5-inches thick.

3.12 INDOOR, FIELD-APPLIED JACKET SCHEDULE

A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.

B. If more than one material is listed, selection from materials listed is Contractor's option.

C. Piping, Concealed:

1. None.

D. Piping, Exposed:

1. PVC, Color-Coded by System: 20 mils thick.

END OF SECTION

SECTION 230900
INSTRUMENTATION AND CONTROLS 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. This Section includes control equipment for plumbing and HVAC systems and components, including control components for terminal heating and cooling units not supplied with factory-wired controls.

1. Refer to Division 21, 22, and 23 sections for required control and alarm points.
2. Integrate the new DDC systems into the existing Hennepin County system. The communications protocol used by the County is BAC/IP.
3. Interface with the digital addressable fire alarm system.
4. Interface with the safety and security system.

B. Related Sections include the following:

1. Division 23 Section "Meters and Gages for HVAC Piping" for additional details on measuring equipment that relates to this Section.
2. Division 23 Section "Sequence of Operations for HVAC Controls" for requirements that relate to this Section.
3. Division 23 Section "Control Standard for BACNET Integration" for requirements that relate to this Section.
4. Division 23 Section "Data and Control Points List" for requirements that relate to this Section.

C. Refer also to Division-26 Sections for the following work.

1. Power from the power source to the power connection on control panels.
2. Interlock wiring between electrically operated equipment units, and between equipment and field-installed control devices.

1.3 DEFINITIONS

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. BIBBs - BACnet Interoperability Building Blocks
6. BMA – BACnet Manufacturers Association
7. BTL – BACnet Testing Laboratories
8. CSV – Comma Separated Value
9. DDC - Direct Digital Controls
10. EIA - Electronic Industries Association
11. I/O: Input/output.
12. IP – Internet Protocol
13. ISO - International Standards Organization
14. LAN - Local Area Network
15. LON - Local Operating Network

16. LONTalk - Open, published protocol
17. LONWorks - A set of tools and components
18. NIST - National Institute of Standards and Technology
19. MS/TP: Master slave/token passing.
20. PC: Personal computer.
21. PIC - Protocol Implementation Conformance Statement
22. PID: Proportional plus integral plus derivative.
23. RTD: Resistance temperature detector.
24. VAV - Variable Air Volume
25. SOC – Security Operations Center
26. Acceptance Date: The date that the installer demonstrates, to the owner or the owner's representative, that all system components are functioning properly. Refer to demonstration article for demonstration requirements.

1.4 GENERAL

A. Refer Specification section 230950 "Control Standard for BACnet Integration".

B. Security Operations Center
   1. Hennepin County owns and operates a Securities Operation Center (SOC) which provides central monitoring of HVAC systems, fire, security and life safety systems, for approximately 70 County owned facilities. Each addition and/or alteration to a building control system shall work on the Hennepin County LAN utilizing BACnet/IP as the primary inter building protocol.
   2. The SOC is presently located at: Hennepin County Government Center

C. Hennepin County DDC Network
   1. Refer to Specification section 230950, "Control Standard for BACNET Integration".

D. Hennepin County Base DDC System Functions
   1. Refer to Specification section 230950, "Control Standard for BACNET Integration".

E. BACnet Integration:
   1.Refer to Specification section 230950, "Control Standard for BACNET Integration".

1.5 SYSTEM PERFORMANCE

A. Comply with the following performance requirements:
   1. Graphic Display: Display graphic with minimum 20 dynamic points with current data within 10 seconds.
   2. Graphic Refresh: Update graphic with minimum 20 dynamic points with current data within 8 seconds.
   3. Object Command: Reaction time of less than two seconds between operator command of a binary object and device reaction.
   4. Object Scan: Transmit change of state and change of analog values to control units or workstation within six seconds.
   5. Alarm Response Time: Annunciate alarm at workstation within 45 seconds. Multiple workstations must receive alarms within five seconds of each other.
   6. Program Execution Frequency: Run capability of applications as often as five seconds, but selected consistent with mechanical process under control.
   7. Performance: Programmable controllers shall execute DDC PID control loops, and scan and update process values and outputs at least once per second.
   8. Reporting Accuracy and Stability of Control: Report values and maintain measured variables within tolerances as follows:
      a. Water Temperature: Plus or minus 1 degrees F.
      b. Water Flow: Plus or minus 5 percent of full scale.
      c. Water Pressure: Plus or minus 2 percent of full scale.
      d. Space Temperature: Plus or minus 1 degrees F.
      e. Ducted Air Temperature: Plus or minus 1 degrees F.
      f. Outside Air Temperature: Plus or minus 2 degrees F.
      g. Dew Point Temperature: Plus or minus 3 degrees F.
      h. Temperature Differential: Plus or minus 0.25 degrees F.
      i. Relative Humidity: Plus or minus 5 percent.

j. Airflow (Pressurized Spaces): Plus or minus 3 percent of full scale.
k. Airflow (Measuring Stations): Plus or minus 5 percent of full scale.
l. Airflow (Terminal): Plus or minus 10 percent of full scale.
m. Air Pressure (Space): Plus or minus 0.01-inch water gage.
n. Air Pressure (Ducts): Plus or minus 0.1-inch water gage.
o. Carbon Monoxide: Plus or minus 5 percent of reading.
p. Carbon Dioxide: Plus or minus 50 ppm.
q. Electrical: Plus or minus 5 percent of reading.

1.6 SEQUENCE OF OPERATION

A. Refer to Specification Section 230993 “Sequence of Operation for HVAC Controls”.

1.7 SUBMITTALS

A. Refer to Specification Section 230950 ”Control standard for BACnet Integration”.

1.8 OWNERSHIP OF PROPRIETARY MATERIAL

A. Refer to Specification Section 230950 ”Control standard for BACnet Integration”.

1.9 QUALITY ASSURANCE

A. Installer Qualifications: Automatic control system manufacturer's authorized representative who is trained and approved for installation of system components 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.

C. Startup Personnel Qualifications: Specially trained personnel, in the direct employ of manufacturer or franchise of the primary automatic-control-system provider, who are experienced with the installation and startup of automatic control systems installations similar to those required for this Project.

D. Codes and Standards: Equipment, materials, and labor; provided as work of this section shall comply with federal, state, and local standards, codes, and ordinances.

E. Comply with ASHRAE 135 for DDC system components.

1.10 DELIVERY, STORAGE, AND HANDLING

A. Factory-Mounted Components: Where control devices specified in this Section are indicated to be factory mounted on equipment, arrange for shipping of control devices to equipment manufacturer.

B. System Software: Update to latest version of software at Project completion.

1.11 COORDINATION

A. Arrange and participate in pre-submittal meeting to coordinate scope of work. Pre-submittal meeting shall include necessary participants from contractor team, design team and owner team.

B. Coordinate location of thermostats, humidistats, and other exposed control sensors with plans and room details before installation.

C. Coordinate the location and installation of automatic control dampers, instruments, and air control accessories. Automatic control dampers, instruments, and air control accessories will be installed according to Division 23 Section Duct Accessories.

D. Coordinate the location and installation of automatic control valves, instrument wells, and hydronic accessories. Control valves, instrument wells, and hydronic control accessories will be installed according to Division 23 Section Hydronic Piping.

E. Coordinate the location and installation of automatic control valves, instrument wells, and steam accessories. Control valves, instrument wells, and steam control accessories will be installed according to Division 23 Section Steam and Condensate Piping.

F. Coordinate the location and installation of automatic control valves, instrument wells, and plumbing control devices. Control valves, instrument wells, and plumbing control devices will be installed according to Division 22.

G. Coordinate equipment with Division 26 Section "Network Lighting Controls" to achieve compatibility with equipment that interfaces with that system.

H. Coordinate equipment with Division 28 Section "Fire Detection and Alarm" to achieve compatibility with equipment that interfaces with that system.

I. Coordinate supply of conditioned electrical branch circuits for control units and operator workstation.

J. Coordinate equipment with Division 26 Section "Electrical Power Monitoring and Control" to achieve compatibility of communication interfaces.

K. Coordinate equipment with Division 26 Section "Panelboards" to achieve compatibility with starter coils and annunciation devices.

L. Coordinate equipment with Division 26 Section "Motor-Control Centers" to achieve compatibility with motor starters and annunciation devices.

1.12 WARRANTY

A. Components, system software, parts and assemblies will be guaranteed against defects in materials and workmanship for two years from the acceptance date.

B. Labor and material to troubleshoot, repair, reprogram, or replace system components will provide, at no charge to the owner during the warranty period.

C. Corrective software modifications made during warranty service periods will be updated on all user documentation and on user and manufacturer archived software disks. Provide the owner with a new compact disc whenever software changes are required.

D. The installer will be capable of doing any repairs with factory trained technicians operating out of a local service office.

E. The installer will furnish the Owner with a local telephone number where a factory-trained technician may be reached at all times.

F. The factory-trained technician will arrive at the job-site ready to service the system within two hours upon receiving a request for repairs and will prosecute the work continuously until the system is back in proper reliable operating condition.

G. The installer will keep a permanent maintenance record at the local service office of all repairs performed and all service calls responded to during the warranty period (including labor and material used); copy of record will be presented to Owner's representative at completion of each service call.

H. Permanent maintenance records will include all dial-up-type service calls made via the dial-up communications feature.

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. Refer Specification section 230950 “Control Standard for BACnet Integration”.

2.2 SYSTEM ARCHITECTURE

A. Refer Specification section 230950 “Control Standard for BACnet Integration”.

2.3 NETWORKING

A. Refer Specification section 230950 “Control Standard for BACnet Integration”.

2.4 BUILDING LEVEL CONTROLLERS (B-BC)

A. Refer Specification section 230950 “Control Standard for BACnet Integration”.

2.5 UNIT LEVEL CONTROLLERS

A. Refer Specification section 230950 “Control Standard for BACnet Integration”.

2.6 OPERATOR WORKSTATION (OWS)

A. Refer Specification section 230950 “Control Standard for BACnet Integration”.

B. Provide OWS at the following locations:

1. Location TBD.

2.7 OPERATOR WORKSTATION INTERFACE

A. Refer Specification section 230950 “Control Standard for BACnet Integration”.

2.8 DDC SYSTEM SOFTWARE

A. Refer Specification section 230950 “Control Standard for BACnet Integration”.

2.9 AIR TERMINAL CONTROLLER

A. Controller provides direct digital control for room temperature control in variable air volume systems. The controller will operate independently, stand-alone or networked to perform HVAC control, monitoring and energy management functions without relying on a higher level processor. The controller will include a pressure differential transducer and electronic controller.

B. Control algorithms will be preprogrammed; the operator’s terminal may be used to adjust air volume set points and other parameters. The controller will be designed for operation and modification without vendor assistance.

C. The controller will interface with the following external devices:

1. Averaging air velocity sensor.
2. Floating control valve and damper actuators.
3. Temperature sensors (including but not limited to space and discharge air).
4. Portable operators terminal
5. Building Automation System.
6. Digital input devices (alarm contacts)
7. Digital output devices.

D. Controller requirements:

1. Power requirements:
   a. Operating Range: 18 to 28 Vac.
   b. Power Consumption: 3.5 VA (Nominal) to 5.0 VA (Peak) at 24 Vac.
2. Analog Inputs:
   a. One room temperature sensor.
   b. One velocity sensor.
   c. One relative humidity sensor.
   d. One set point
   e. One auxiliary temperature sensor.
3. Digital Inputs: Two dry contacts.
4. Outputs: Six DO 24 Vac. optically isolated solid state switches @ 0.5 amps.
5. Controlled temperature accuracy: plus or minus 1.5^{o}F.
6. Controlled relative humidity accuracy: plus or minus 2.5% RH.
7. Communications
   a. Remote: LAN Truck
   b. Local: Portable Operators Terminal.
8. Ambient Conditions:
   a. Operating Temperature: 32^{o}F to 122^{o}F.
   b. Humidity Range: 10 to 95 percent.

E. Differential Pressure Transducer: The averaging air velocity sensor (provided by the VAV terminal unit manufacturer) sends an average air velocity measurement of the duct air velocity to the controller. The air velocity sensor connects to the differential pressure transducer and measures the average differential pressure. The air terminal controller converts this value to actual airflow in CFM. The controller will report CFM and set points.

F. Differential Pressure Transducer Requirements:
   1. Temperature range: 48^{o}F to 112^{o}F.
   2. Measurement Range: 0 to 4000 fpm.
   3. Measurement Resolution: Plus or minus 4 fpm.
   4. Measurement Accuracy
      a. 300 to 4000 fpm: Plus or minus 5-percent of actual reading
      b. 200 to 300 fpm: +12-percent to –15-percent of actual reading
   5. Repeatability: Plus or minus 8 fpm.

2.10 ELECTRONIC SENSORS AND THERMOSTATS

A. Description: Vibration and corrosion resistant; for wall, immersion, or duct mounting as required.

B. Thermistor Temperature Sensors and Transmitters:
   1. Manufacturers:
      a. BEC Controls Corporation.
      b. Ebtron, Incorporated
      c. Heat-Timer Corporation.
      d. I.T.M. Instruments Incorporated
      e. Kele Incorporated
      f. MAMAC Systems, Incorporated
      g. Precon; Division of Kele Incorporated.
      h. RDF Corporation.
      i. Veris Industries
   2. Accuracy: Plus or minus 0.36 degrees F at calibration point.
   3. Wire: Twisted, shielded-pair cable.
   4. Insertion Elements in Ducts: Single point, 8 inches long; use where not affected by temperature stratification or where ducts are smaller than 9 square feet.
   5. Averaging Elements in Ducts: 72 inches long, flexible; use where prone to temperature stratification or where ducts are larger than 10 sq. ft.
   6. Insertion Elements for Liquids: Brass or stainless-steel socket with minimum insertion length of 2-1/2-inches.
   7. Type (1) Room Sensor Construction: Standard Cover plate size, brushed stainless steel RTD sensor. (Example: Precon ST-S Series)
      a. Set-Point Adjustment: None.
      b. Set-Point Indication: None.
      c. Switched Override: None.
      d. Finish: Brushed Stainless Steel.
      e. Orientation: None.
      f. Locations used: As indicated on the drawings.
   8. Space Thermostat
      a. Power Requirements: Provide by connecting controller.
      b. Temperature Range: 55^{o}F to 95^{o}F.
      c. Accuracy: Plus or minus 1^{o}F.
      d. Cover Construction: Manufacturer’s standard covers.
      e. Set-Point Adjustment: Warmer/Cooler control.
      f. Set-Point Indication: Concealed
      g. Override Button: allows the occupant to change the occupied control schedule during the unoccupied cycle for a predetermined period of time.
      h. Port: Plug-in portable-operators terminal port; located on the bottom of the cover.
      i. Orientation: Vertical.
      j. Color: White.
      k. Locations used: As indicated on the drawings.
   9. Wireless Room Sensor
      a. Sensor Power: Two AA Lithium 1.5 V batteries

b. Temperature Range: $55^{o}F$ to $95^{o}F$.
c. Accuracy: Plus or minus $1^{o}F$.
d. Cover Construction: Manufacturer's standard covers.
e. Set-Point Adjustment: Warmer/Cooler control.
f. Set-Point Indication: Concealed
g. Override Button: allows the occupant to change the occupied control schedule during the unoccupied cycle for a predetermined period of time.
h. Port: Plug-in portable-operators terminal port; located on the bottom of the cover.
i. Orientation: Vertical.
j. Color: White.
k. Transmission time: Min 30 seconds; maximum 15 minutes.
l. Tamper proof / lockable housing for attachment to furniture or shelf systems.
m. Receiver
    1) Power: 24V
    2) Radio Channels: 16
    3) Useable Range: 200 feet
n. Locations Used: As indicated on the drawings.

10. Outside-Air Sensors: Watertight inlet fitting, shielded from direct sunlight.

C. Humidity Sensors: Bulk polymer sensor element.

1. Manufacturers:
    a. BEC Controls Corporation.
    b. General Eastern Instruments.
    c. MAMAC Systems, Incorporated
    d. Precon; Division of Kele Incorporated.
    e. ROTRONIC Instrument Corporation
    f. TCS/Basys Controls.
    g. Vaisala.
    h. Veris Industries
2. Accuracy: 2 percent full range with linear output.
3. Room Sensor Range: 0 to 100 percent relative humidity.
4. Room Sensor Cover Construction: Manufacturer's standard locking covers.
    a. Set-Point Adjustment: Concealed.
    b. Set-Point Indication: Concealed.
    c. Color: White.
5. Duct Sensor: 20 to 80 percent relative humidity range with element guard and mounting plate.
6. Outside-Air Sensor: 20 to 80 percent relative humidity range with mounting enclosure, suitable for operation at outdoor temperatures of minus 22 to plus 185 degrees F
7. Duct and Sensors: With element guard and mounting plate, range of 0 to 100 percent relative humidity.

D. Pressure Transmitters/Transducers:

1. Manufacturers:
    a. Air Monitor Corporation
    b. BEC Controls Corporation.
    c. General Eastern Instruments.
    d. MAMAC Systems, Incorporated
    e. ROTRONIC Instrument Corporation
    f. TCS/Basys Controls.
    g. Vaisala.
    h. Veris Industries
2. Static-Pressure Transmitter: Non-directional sensor with suitable range for expected input, and temperature compensated.
    a. Accuracy: 1 percent of full scale with repeatability of 0.5 percent.
    b. Output: 4 to 20 mA.
    c. Building Static-Pressure Range: 0- to 0.50-inch water gage.
        1) Indoor shielded static air probe: 316 stainless steel recessed probe with integral volume chamber capable of sensing room pressure within 1 percent of actual pressure. (Example: Air Monitor Corporation model S.A.P. /3)

2) Outside static air probe: 316 stainless steel round probe with parallel plates capable of sensing pressure within 1 percent of actual pressure. Sensing accuracy unaffected by rain or snow or wind velocities less than 40 MPH. (Example: Air Monitor Corporation model S.O.A.P.)

d. Duct Static-Pressure Range: 0- to 5-inch water gage.

3. Water Pressure Transducers: Stainless-steel diaphragm construction, suitable for service; minimum 150-psig operating pressure; linear output 4 to 20 mA.
4. Water Differential-Pressure Transducers: Stainless-steel diaphragm construction, suitable for service; minimum 150-psig operating pressure and tested to 300-psig; linear output 4 to 20 mA.
5. Differential-Pressure Switch (Air or Water): Snap acting, with pilot-duty rating and with suitable scale range and differential.
6. Pressure Transmitters: Direct acting for gas, liquid, or steam service; range suitable for system; linear output 4 to 20 mA.

2.11 STATUS SENSORS

A. Status Inputs for Fans: Differential-pressure switch with pilot-duty rating and with adjustable range of 0- to 5-inch water gage.

B. Status Inputs for Pumps: Differential-pressure switch with pilot-duty rating and with adjustable pressure-differential range of 8 to 60 psig, piped across pump.

C. Status Inputs for Electric Motors: Comply with ISA 50.00.01, current-sensing fixed- or split-core transformers with self-powered transmitter, adjustable and suitable for 175 percent of rated motor current.

D. Voltage Transmitter (100- to 600-V ac): Comply with ISA 50.00.01, single-loop, self-powered transmitter, adjustable, with suitable range and 1 percent full-scale accuracy.

E. Power Monitor: 3-phase type with disconnect/shorting switch assembly, listed voltage and current transformers, with pulse kilowatt hour output and 4- to 20-mA kW output, with maximum 2 percent error at 1.0 power factor and 2.5 percent error at 0.5 power factor.

F. Current Switches: Self-powered, solid-state with adjustable trip current, selected to match current and system output requirements.

G. Electronic Valve/Damper Position Indicator: Visual scale indicating percent of travel and 2- to 10-V dc, feedback signal.

H. Water-Flow Switches: Bellows-actuated mercury or snap-acting type with pilot-duty rating, stainless-steel or bronze paddle, with appropriate range and differential adjustment, in NEMA 250, Type 1 enclosure.

1. Manufacturers:
   a. BEC Controls Corporation.
   b. I.T.M. Instruments Incorporated

2.12 GAS DETECTION EQUIPMENT

A. Carbon Dioxide Sensor (CO2) for Demand Controlled Ventilation. Provide a general purpose indoor transmitter/sensor assembly with removable sensor, UL listed. 4-20 mA DC output representing 0-2000 ppm. Minimum (5) year sensor life, with field-replaceable sensor unit. Accuracy +/- 1 percent of reading at 77°F. Long term drift less than 1 percent of scale per year. For wall-mounted sensors, provide local readout display.

B. Occupancy Sensor: Passive infrared, with time delay, daylight sensor lockout, sensitivity control, and 180-degree field of view with vertical sensing adjustment; for flush mounting.

2.13 WATERFLOW MEASURING METERS

A. Manufacturers: Manufacturers: Subject to compliance with requirements, provide control system component products by one of the listed manufacturers:

1. Onicon Incorporated.

B. Insertion turbine flow meters made for insertion in hydronic piping fluid flow that measures flow in gallons per minute (GPM).

1. Pipe sizes 2-inces and smaller: single turbine.
2. Pipe sizes 2-1/2-incehs and larger: Dual turbine.

C. Output: Flow meters will provide an analog electronic output signal compatible with the building automation system.

D. Sensing Method: Impedance sensing; non-magnetic and non-photoelectric.

E. Accuracy: 2 percent of flow rate from 0.4 to 20 feet per second.

F. Materials:
   1. Rotor: Non-metallic.
   2. Housing 316 stainless steel.
   3. Shaft: Tungsten carbide.
   4. Wetted Parts: Bronze and carbon steel.
   5. External Parts: Bronze and carbon steel.

2.14 HUMIDISTATS

A. Manufacturers:
   1. MAMAC Systems, Incorporated
   2. ROTRONIC Instrument Corporation
   3. Veris
   4. Vaisala

B. Duct-Mounting Humidistat: Electric insertion, 2-position type with adjustable, 2 percent throttling range, 0 to 100 percent operating range, and single- or double-pole contacts.

2.15 ACTUATORS

A. Electric Motors: Size to operate with sufficient reserve power to provide smooth modulating action or two-position action.
   1. Comply with requirements in Division 23 Section "Common Motor Requirements for HVAC Equipment."
   2. Permanent Split-Capacitor or Shaded-Pole Type: Gear trains completely oil immersed and sealed. Equip spring-return motors with integral spiral-spring mechanism in housings designed for easy removal for service or adjustment of limit switches, auxiliary switches, or feedback potentiometer.
   3. Non-spring-Return Motors for Valves Larger than NPS 2-1/2: Size for running torque of 150 in. x lbf and breakaway torque of 300 in. x lbf.
   4. Spring-Return Motors for Valves Larger than NPS 2-1/2: Size for running and breakaway torque of 150 in. x lbf.
   5. Non-spring-Return Motors for Dampers Larger than 25 Sq. Ft.: Size for running torque of 150 in. x lbf and breakaway torque of 300 in. x lbf.
   6. Spring-Return Motors for Dampers Larger than 25 Sq. Ft.: Size for running and breakaway torque of 150 inches x lbf.

B. Electronic Actuators: Direct-coupled type designed for minimum 60,000 full-stroke cycles at rated torque.
   1. Manufacturers:
      a. Belimo Aircontrols (USA), Incorporated
      b. Bray International Incorporated.
      c. Delta Control Products.
      d. Honeywell, Incorporated; Home & Building Control.
      e. Siemens Building Technologies
      f. Johnson Controls, Incorporated; Controls Group.
   2. Valves: Size for torque required for valve close off at maximum pump differential pressure.
      a. Run Time: Hydronic terminal units 3-inches and smaller: 90 seconds open, 90 seconds closed.
   3. Dampers: Size for running torque calculated as follows:
      a. Parallel-Blade Damper with Edge Seals: 7 inch-lb/sq. ft. of damper.
      b. Opposed-Blade Damper with Edge Seals: 5 inch-lb/sq. ft. of damper.
      c. Parallel-Blade Damper without Edge Seals: 4 inch-lb/sq. ft of damper.

d. Opposed-Blade Damper without Edge Seals: 3 inch-lb/sq. ft. of damper.
e. Dampers with 2- to 3-Inch w.g of Pressure Drop or Face Velocities of 1000 to 2500 fpm: Increase running torque by 1.5.
f. Dampers with 3- to 4-Inch w.g of Pressure Drop or Face Velocities of 2500 to 3000 fpm: Increase running torque by 2.0.

4. Coupling: V-bolt and V-shaped, toothed cradle.
5. Overload Protection: Electronic overload or digital rotation-sensing circuitry.
6. Fail-Safe Operation: Mechanical, spring-return mechanism. Provide external, manual gear release on nonspring-return actuators.
7. Power Requirements (Two-Position Spring Return): 120-V ac.
8. Power Requirements (Modulating): Maximum 10 VA at 24-V ac or 8 W at 24-V dc.
9. Proportional Signal: 2- to 10-V dc or 4 to 20 mA, and 2- to 10-V dc position feedback signal.
10. Temperature Rating: Minus 22 to plus 122 degrees F.
11. Temperature Rating (Smoke Dampers): Minus 22 to plus 250 degrees F.
12. Run Time: 12 seconds open, 5 seconds closed.

2.16 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. Pressure Independent Hydronic Globe Valves

1. Manufacturers:
   a. Belimo Aircontrols (USA), Incorporated
   b. Delta-P (Flow Control Industries)
   c. Johnson Controls, Incorporated; Controls Group.

C. Pressure Independent Hydronic system globe valves shall have the following characteristics:

1. NPS 4 and Larger: Class 125 iron body, bronze trim, rising stem, plug-type disc, flanged ends, and renewable seat and disc.
2. Internal Construction: Replaceable plugs and stainless-steel or brass seats.
   a. Single-Seated Valves: Cage trim provides seating and guiding surfaces for plug on top and bottom.
3. Sizing 5-psig maximum pressure drop at design flow rate or the following:
   a. Two Position: Line size.
   b. Two-Way Modulating: Either the value specified above or twice the load pressure drop, whichever is more.
   c. Three-Way Modulating: Twice the load pressure drop, but not more than value specified above.
4. Flow Characteristics: Two-way valves shall have equal percentage characteristics; three-way valves shall have linear characteristics.
5. Close-Off (Differential) Pressure Rating: Combination of actuator and trim shall provide minimum close-off pressure rating of 150 percent of total system (pump) head for two-way valves and 100 percent of pressure differential across valve or 100 percent of total system (pump) head.

D. Pressure Independent Ball Pattern Control Valves

1. Manufacturers:
   a. Belimo Aircontrols (USA), Incorporated
   b. Delta-P (Flow Control Industries)
   c. Johnson Controls, Incorporated; Controls Group.
2. NPS 3 and Smaller: Class 150, 580-psig rated, ASTM B 584 bronze body and bonnet, two-piece construction; stainless steel ball, standard or modified port, blowout proof, stainless steel stem, RPTFE seats and seals, threaded or flanged end connections.
3. Sizing:
   a. Pressure drop; 2-psig greater than the controlled heating or cooling device pressure drop.
4. Flow Characteristics: Two-way valves shall have equal percentage characteristics; three-way valves shall have linear characteristics. Select operators to close valves against pump shutoff head plus system static pressure (but not less than 50-psig).
5. Torque: 45 in-lbs. maximum torque; open to close.

2.17 DAMPERS

A. Manufacturers: Manufacturers: Subject to compliance with requirements, provide control damper products by one of the listed manufacturers:
   1. Arrow United Industries
   2. Belimo Aircontrols (USA), Incorporated
   3. Cesco Products
   4. Johnson Controls, Incorporated; Controls Group.
   5. Ruskin Manufacturing Company
   6. Siemens Building Technologies
   7. Tamco
   8. Vent Products Co., Incorporated.

B. Pressure and Volume Control Dampers
   1. Construction:
      a. Frames: Extruded aluminum hat channels, 0.125-in. minimum thickness.
      b. Blades: Extruded aluminum airfoil type, 6-inch maximum blade width.
      c. Hardware: Molded synthetic bearings. Zinc plated steel axles, linkage brackets, connecting rods, and mounting bolts.
      d. Seals: Flexible extruded silicone side seals and blade gaskets.
      e. Edge Seals, Low-Leakage Applications: Use inflatable blade edging or replaceable rubber blade seals and spring-loaded stainless-steel side seals, rated for leakage at less than 8 cfm per sq. ft. of damper area, at differential pressure of 4-inch wg when damper is held by torque of 50 in. x lbf; when tested according to AMCA 500D.
   2. Operating Limits:
      a. Temperature: -20 to 200 degrees F.
      b. Pressure: 6 inches w.g. differential.
      c. Velocity: Up to 4000 FM.
   3. Select Parallel blade dampers for proportional service. Opposed blade dampers shall be used for two-position service.
   4. Damper sizes will be provided as indicated on the drawings. Damper sizes may be provided differently from those shown on the drawings, if improved performance can be demonstrated with calculations.

2.18 CONTROL CABLE

A. Electronic and fiber-optic cables for control wiring are specified in Division 27 Section "Communications Horizontal Cabling."

2.19 ENCLOSURES AND WEATHER SHIELDS

A. Enclosures will meet the following minimum requirements:
   1. Outdoors: Enclosures located outdoors will meet NEMA 250 Type 4 requirements.
   2. Mechanical and Electrical Rooms: Enclosures will meet NEMA 250 Type 12 requirements.
   3. Other Locations: Enclosures will meet NEMA 250 Type 1 requirements.
   4. Panels shall be self-supporting enclosures with keyed lock
   5. 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.

2.20 WIRE, CABLE, AND TRANSFORMERS

A. Refer to Division 26 for conduits and conductors, except as noted.

B. 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, single or multiple strand, twisted (minimum 50 mm lay of twist), 100% shielded pairs and shall have 300 volt insulation. Each pair shall have a 20 AWG tinned-copper drain wire and individual overall pair insulation.

G. IP Network cable shall meet or exceed 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.

I. Electronic and fiber-optic cables for control wiring are specified in Division 27 Section "Communications Horizontal Cabling."

2.21 OTHER EQUIPMENT REQUIREMENTS

A. 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. 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. 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 four-hour uninterruptible power supply (UPS) with full-load rectification and inversion (double conversion).

2.22 HVAC CONTROL HARDWARE IDENTIFICATION

A. Automatic Control Valve Tags: Include

1. Lubrication instructions.
2. Identifying number and system.

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. (Exclude space temperature sensors)
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 and tags will match the identification indicated on the as-built documents.

E. Refer to Division 23 Section Identification for HVAC Piping and Equipment for identification materials and additional requirements.

PART 3 EXECUTION

3.1 EXAMINATION

A. Verify that power supply is available to control units and operator workstation.

3.2 INSTALLATION

A. Temperature control panels and enclosures in equipment rooms will be located at readily accessible walkup locations approved by the owner.

B. Install equipment level and plumb. Conduits and raceways shall be parallel to walls and structural elements.

C. Install equipment in readily accessible locations as defined by Chapter 1, Article 100, and Part A of the Nations Electrical Code (NEC).

D. Install software in control units and operator workstations. Implement all features of programs to specified requirements and as appropriate to sequence of operation.

E. Connect and configure equipment and software to achieve sequence of operation specified.

F. Verify location of temperature sensors, humidity sensors, thermostats, humidistats, and other exposed control sensors with Drawings and room details before installation.

1. Where wall mounted sensors are mounted adjacent to light switches or occupancy sensors, match the mounting height of the lighting control devices.
2. Where wall mounted sensors are NOT mounted adjacent to lighting control devices, mount at 60 inches above the floor.
3. Install averaging elements in ducts and plenums in crossing or zigzag pattern.

G. Install type (1) room temperature sensors where sensors or thermostats are indicated on the drawings; and where required to control air terminals or heating devices.

H. Install low limit (freeze protection) thermostats on the upstream face of cooling coils in a crossing or zigzag pattern to provide freeze protection for each square foot of coil surface.

I. Provide a dedicated “unitary controller” for each air handling unit. The controller shall be mounted on the air handling unit or as indicated on the drawings.

J. Install a minimum of one “unitary controller” in each mechanical equipment room.

K. Connect manual reset limit controls, such as low limit thermostats, and high limit pressure controls, directly (hard-wired) to motor-starters (or variable speed drives). Connect limit controls to stop the fans or pumps in both the “Hand” and the “Auto” selector switch positions.

L. Install damper motors on outside of duct in warm areas, not in locations exposed to outdoor temperatures.

M. Install labels and nameplates to identify control components according to Division 23 Section "Identification for HVAC Piping and Equipment."

N. Install fan inlet air flow measuring stations according to the manufacturer’s instructions.

O. Install duct mounted air flow measuring stations according to the manufacturer’s instructions. Comply with manufactures mounting requirements to achieve specified instrument accuracy.

P. Install outside air static pressure probe according to the manufactures instructions.

Q. Connect end switches on smoke and combination fire/smoke dampers to BAS.

R. Install electronic and fiber-optic cables according to Division 27 Section "Communications Horizontal Cabling."

3.3 ACTUATORS

A. Mount control damper actuators according to manufacturer’s instructions.

B. When spring return actuators are used on normally closed dampers, the seals shall be compressed when the dampers have been closed by the actuator.

C. Damper/actuator combinations shall modulate smoothly from fully closed to fully open and return.

D. 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 (jack shafting) in lieu of blade-to-blade linkages or shaft coupling when driving axially aligned damper sections.

3.4 IDENTIFICATION

A. Install labels and nameplates to identify control components according to Division 23 Section "Identification for HVAC Piping and Equipment."

B. Enclosures: Building controllers and/or enclosures shall be clearly labeled with their device ID and IP address.

C. Unit level controllers and/or enclosures shall be clearly labeled with their Node address. Tag wiring on the DDC side of the interface panel identifying the associated point.

D. Mark DDC panels with circuit number and electrical panel number.

E. Identification of Hardware and Wiring
   1. Label 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.
   2. Label pneumatic tubing at each end within 2 inches of the end with a descriptive identifier.
   3. Label all control panels with minimum ½ inch letters on laminated plastic nameplates.
   4. Identify all other control components with permanent labels. 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.
   5. Label room sensors relating to terminal box or valves with nameplates.
   6. Manufacturer's nameplates and UL or CSA labels are to be visible and legible after equipment is installed.
   7. Identifiers shall match the as-built documents.

F. Warning Labels
   1. Affix permanent warning labels to equipment that can be automatically started by the DDC system.
      a. Labels shall use white lettering, 12 point type or larger, on a red background.
      b. 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."
   2. Affix permanent warning labels to motor starters and control panels that are connected to multiple power sources utilizing separate disconnects.
      a. Labels shall use white lettering, 12 point type or larger, on a red background.
      b. The labels shall read: "CAUTION: This equipment is fed from more than one power source with separate disconnects. Disconnect all power sources before servicing."

3.5 ELECTRICAL WIRING AND CONNECTION INSTALLATION

A. Instrumentation and control wiring will be exposed in mechanical equipment rooms. Instrument and control wiring, conduits, and raceways, in finished spaces shall be concealed.

B. Install raceways, boxes, and cabinets according to Division 26 Section "Raceway and Boxes for Electrical Systems."

C. Install building wire and cable according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

D. Install signal and communication cable according to Division 27 Section "Communications Horizontal Cabling."
   1. Wiring exposed to view, or concealed: Run wiring within electric metallic tubing.

2. Number-code or color-code conductors for future identification and service of control system, except local individual room control cables.
3. Install wire and cable with sufficient slack and flexible connections to allow for vibration of piping and equipment.
4. Provide enclosures for terminal strips and similar devices.

E. Connect manual-reset limit controls independent of manual-control switch positions. Automatic duct heater resets may be connected in interlock circuit of power controllers.

F. Connect hand-off-auto selector switches to override automatic interlock controls when switch is in hand position.

G. Install power supply wiring in addition to, or different from electrical power supply wiring specifically shown on the electrical drawings. Include disconnects, and required electrical devices. Power supply wiring for controls will extend from separate circuits on emergency power panels located as indicated on the electrical drawings.

H. Install control wiring between field-installed sensing and control devices controlled equipment and unit control panels. Include disconnects, and required electrical devices.

I. Install interlock wiring between electrically-operated equipment units, and between equipment and field installed control devices in addition to, or different from, interlock wiring specifically shown on the electrical drawings.

3.6 NETWORK COMMUNICATION TRUNK AND TERMINATIONS

A. A backbone communication tie in point will be provided and installed by Hennepin County IT. The controls contractor is responsible for all DDC network wiring within the building.

B. 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.

3.7 IP INTERFACE DEVICES

A. Install Building Controllers for each required connection to the dedicated DDC IP network.

B. The Building Controllers shall be configured and commissioned to ensure that the only data traffic on the IP is data that is essential for operation of the system.

3.8 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 Hennepin County 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 Hennepin County network.

3.9 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 Hennepin County network. BACnet integration must conform to Data Link Layer Option BACnet /IP shown in BACnet ANSI/ASHRAE 135-2004 publication Annex J.

B. All BACnet read property requests from any BACnet Operator Workstation must not take more then 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 that 10 seconds.

3.10 CRITICAL SYSTEM MONITORING

A. The system point list defines which alarm points are considered critical

B. In facilities where critical system monitoring is performed by DDC equipment, the controls contractor shall be responsible for all required material and labor to connect the Owner's critical equipment to the DDC system.

C. In buildings with emergency generators, all DDC devices and networking equipment that monitor and/or transmit critical system monitoring points shall be connected to emergency power.

D. The controls contractor shall provide UPS power supplies for all DDC and networking devices that monitor and/or transmit critical system monitoring points. UPS shall be capable of maintaining full operation for a period no less than 4 hours.

E. The DDC system shall monitor all UPS required under this section and report an alarm to SOC whenever the UPS senses a loss of primary power or indicates a fault of any kind.

F. Refer also to Appendix B – BAS Acceptable Critical Alarms for critical alarms ro be sent to SOC Center via the BAS network.

3.11 FIRE ALARM MONITORING

A. Fire alarm inputs shall be configured as normally closed (open contact indicates an alarm condition).

B. The DDC system shall accept up to four normally closed binary inputs (Alarm, Water Flow, Supervisory, and Trouble).

C. Provide (UPS) uninterruptible power supplies for DDC and networking devices that monitor and/or transmit fire alarm points. UPS shall maintain full operation for a period no less than 4 hours.

D. Monitor uninterruptible power supplies (UPS) required under this section and report an alarm to County whenever the UPS senses a loss of primary power or indicates a fault of any kind.

3.12 POINT NAMING/POINT LOGICAL GROUPING AND GRAPHICS

A. The programmer shall meet with Hennepin county 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 Hennepin personnel before deviating from Hennepin County Standards. Failure to work within Hennepin County 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 Hennepin County for questions regarding naming. Hennepin County 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 Hennepin County prior to the start of database generation.

3.13 WEB SERVER INTEGRATION REQUIREMENTS

A. Data Sharing

1. Ability to see the required properties (see Appendix A) of any BACnet object.
2. Ability to modify BACnet properties as shown in the Hennepin County required object table (see Appendix A). All objects listed must be writable by Web Server.

B. Alarm and Event Management

1. Ability to receive intrinsic or algorithmic alarms.
2. Ability to retrieve a list of unacknowledged alarms/events retrievable using standard BACnet Services.
3. Ability to retrieve a list of alarms/events retrievable using standard BACnet Services.
4. Ability to notify other recipients that the acknowledgement has been performed.
5. Ability to perform adjustment of alarm/event parameters.

C. Scheduling

1. Ability to schedule/modify exception schedule output actions, both in the local device and in other devices, both binary and analog, based on date and time.

D. Trending

1. Collection of (time, valve) pairs which include a complete "BACnet trend log buffer upload".

3.14 ALARM COMMISSIONING

A. Commissioning Agent shall review the BACnet alarm commissioning report summary and shall work with the Controls Contractor to correct BACnet alarm issues identified in the report. The BACnet Alarm Commissioning report identifies if alarms have been properly assigned and if alarm limits are enabled. The Alarm Commissioning report shall be generated by the Hennepin County controls consultant and a summary report shall be made available to the Commissioning Agent and Controls Contractor.

B. Commissioning Agent and Controls Contractor shall test two (2) alarms of every BACnet Object Type (9 potential BACnet Point Types) for each BACnet Notification Class.

C. Refer also to Appendix B – BAS Acceptable Critical Alarms for critical alarms ro be sent to SOC Center via the BAS network.

3.15 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections, and to assist in field testing. Report results in writing.

B. Perform the following field tests and inspections and prepare test reports:

1. Operational Test: After electrical circuitry has been energized, start units to confirm proper unit operation. Remove and replace malfunctioning units and retest.
2. Test and adjust controls and safeties.
3. Test calibration of electronic controllers by disconnecting input sensors and stimulating operation with compatible signal generator.
4. Test each point through its full operating range to verify that safety and operating control set points are as required.
5. Test each control loop to verify stable mode of operation and compliance with sequence of operation. Adjust PID actions.
6. Test each system for compliance with sequence of operation.
7. Test software and hardware interlocks.

C. DDC Verification:

1. Verify that instruments are installed before calibration, testing, and loop or leak checks.
2. Check instruments for proper location and accessibility.
3. Check instrument installation for direction of flow, elevation, orientation, insertion depth, and other applicable considerations.
4. Check temperature instruments and material and length of sensing elements.
5. Check control valves. Verify that they are in correct direction.
6. Check DDC system as follows:
    a. Verify that DDC controller power supply is from emergency power supply, if applicable.
    b. Verify that wires at control panels are tagged with their service designation and approved tagging system.
    c. Verify that spare I/O capacity has been provided.
    d. Verify that DDC controllers are protected from power supply surges.
7. Verify software including automatic restart, control sequences, scheduling, reset controls, and occupied/unoccupied cycles.
8. Verify operation of operator workstation.
9. Verify local control units including self-diagnostics.

D. De-activate all occupied / unoccupied settings, set-back etc. functions during start-up and testing activities. Re-activate these functions as directed by the owner's representative during owner training activities.

E. Replace damaged or malfunctioning controls and equipment and repeat testing procedures.

3.16 ADJUSTING

A. Calibrating and Adjusting:
   1. Calibrate instruments.
   2. Make three-point calibration test for both linearity and accuracy for each analog instrument.
   3. Calibrate equipment and procedures using manufacturer's written recommendations and instruction manuals. Use test equipment with accuracy at least double that of instrument being calibrated.
   4. Control System Inputs and Outputs:
      a. Check analog inputs at 0, 50, and 100 percent of span.
      b. Check analog outputs using milliampere meter at 0, 50, and 100 percent output.
      c. Check digital inputs using jumper wire.
      d. Check digital outputs using ohmmeter to test for contact making or breaking.
      e. Check resistance temperature inputs at 0, 50, and 100 percent of span using a precision-resistant source.
   5. Flow:
      a. Set differential pressure flow transmitters for 0 and 100 percent values with 3-point calibration accomplished at 50, 90, and 100 percent of span.
      b. Manually operate flow switches to verify that they make or break contact.
   6. Pressure:
      a. Calibrate pressure transmitters at 0, 50, and 100 percent of span.
      b. Calibrate pressure switches to make or break contacts, with adjustable differential set at minimum.
   7. Temperature:
      a. Calibrate resistance temperature transmitters at 0, 50, and 100 percent of span using a precision-resistance source.
      b. Calibrate temperature switches to make or break contacts.
   8. Stroke and adjust control valves and dampers without positioners, following the manufacturer's recommended procedure, so that valve or damper is 100 percent open and closed.
   9. Stroke and adjust control valves and dampers with positioners, following manufacturer's recommended procedure, so that valve and damper is 0, 50, and 100 percent closed.
   10. Provide diagnostic and test instruments for calibration and adjustment of system.
   11. Provide written description of procedures and equipment for calibrating each type of instrument. Submit procedures review and approval before initiating startup procedures.

B. Adjust initial temperature and humidity set points.

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 three visits to Project during other than normal occupancy hours for this purpose.

3.17 VALIDATION

A. The contractor shall furnish all labor and test apparatus required to execute a startup testing plan. Key tasks to be executed and documented in the startup 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.

B. Validation report: The validation report shall include all testing activities and test reports.

C. Entire automatic control system / building automation system including graphical user interface (GUI) shall be complete and fully functional prior to any inspections, demonstrations or acceptance testing including punch list activities.

3.18 DOCUMENTATION

A. 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. Include control equipment drawings. 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 will be “B” sized 11 inches x 17 inches. Include in the submittals a detailed point list for each integrated building. The point list will 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.

C. As-built drawings will each be stamped “As-Built” and have the as-built date on them. Copies of as-built drawings will include the following at a minimum: Detailed drawings for each piece of controlled and monitored equipment, point lists, sequence of operations, and hardware with part information, logic tables, room schedules, and O & M manuals. As part of the as-built drawings; 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.

D. Project Record Documents: Record actual locations of control components, including control units, thermostats, and sensors. Revise Shop Drawings to reflect actual installation and operating sequences.

E. Provide electronic copies of as-built documentation to the Owner. The electronic copies will be stored on CDs and will be saved in an editable format. Acceptable formats include Microsoft Office program formats (i.e. Word, Excel, Access, etc.), Visio, and AutoCAD.

3.19 DEMONSTRATION

A. Engage a factory service representative to demonstrate, to the owner and engineer, that all system components have been calibrated and adjusted and are functioning properly.

B. Engage a factory service representative to train Owner's maintenance personnel to adjust, operate, and maintain control systems and components.

1. Train Owner's maintenance personnel on procedures and schedules for starting and stopping, troubleshooting, servicing, and maintaining equipment and schedules.
2. Provide operator training on data display, alarm and status descriptors, requesting data, executing commands, calibrating and adjusting devices, resetting default values, and requesting logs. Include a minimum of 40 hours' dedicated instructor time on-site.
3. Review data in maintenance manuals. Refer to Division 1 Section "Closeout Submittals."
4. Schedule training with Owner, through Architect, with at least seven days' advance notice.

C. Refer also to Appendix B – BAS Acceptable Critical Alarms for critical alarms ro be sent to SOC Center via the BAS network.

3.20 TRAINING

A. The manufacturer will provide training for the Owner's building personnel in procedures for start-up, testing and operating the Automatic Control System.

B. During the startup phase of the installation, and when acceptable performance of the overall system's hardware and software has been established. The contractor will provide on-site operator instruction for the Owner's operating personnel.

C. Operator instruction about the automatic control system will include, but not be limited to the overall operational program, equipment functions (both individually and as part of the total integrated system), commands, system generation, advisories, and appropriate operator intervention required in responding to the automatic control system operation, a description of the chronological information flow from field sensors, contacts and devices and an overview of the automatic control system communication network explaining the interplay between initiating devices, field data-gathering panels, system communications and their importance within the operating system.

D. Provide on-site operator instruction during normal working hours. Instruction will be performed by experienced factory trained technical representatives familiar with the overall system's software, hardware and accessories. Provide a minimum of forty (40) hours of on-site training for three (3) of the Owner's designated operating personnel.

3.21 SERVICE AND SPARE PARTS

A. After the warranty period, the controls contractor shall provide service on hardware and software components with technical staff located in a local service office.

B. All service items and spare parts shall be available from the manufacturer or Contractor’s stock for a minimum of 7 years following the expiration of the warranty period.

SECTION 230950
CONTROL STANDARD FOR BACNET INTEGRATION

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 GENERAL

A. Furnish all labor, materials, equipment, 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 BSACnet protocol ANSI/ASHRAE 135-2004 at the IP level of the architecture. Conformance under ANSI/ASHRAE 135-2008, 135-2010 and 135-2012 is also acceptable. Web services at the supervisory controller or PC server level is also required.

B. Furnish all labor, materials, equipment, service, and training necessary to integrate the proposed DDC system into the existing Hennepin County Control Securities Operations Center BACnet alarm receiver. The primary communications protocol used by Hennepin County is BACne/IP at the Supervisory controller and Web services from the vendor specific PC web server. LON and BACnet MS/TP may be used at the inter building level only, provided that the supervisory controllers communicate using BACnet/IP on the existing Hennepin County LAN which is Ethernet based.

C. The controls contractor shall include all items, which are reasonably necessary to complete the installation even though not specifically mentioned in the Contract Documents.

D. Temperature control panels and/or enclosures in equipment rooms shall be located at readily accessible locations approved by Hennepin County's Owner Representative.

E. The control system "As-Built" drawings that show all devices and wiring and the sequence of operation shall be accessible through links on the Web Browser graphic page.

1. Hennepin County owns and operates a Securities Operation Center (SOC) which provides central monitoring of HVAC systems, fire, security and life safety systems, for approximately 70 County owned facilities. Each addition and/or alteration to a building control system shall work on the Hennepin County LAN utilizing BACnet/IP as the primary inter building protocol.
2. The SOC is presently located at: Hennepin County Government Center.

F. Hennepin County DDC Network:

1. Hennepin County owns and operates a dedicated mixed-mode network (fiber and copper) for building-to-building communications. This network is not dedicated to the fire, security and building control systems. Temperature Control Contractors must work directly with the County IT department to acquire access to the County LAN. It is the responsibility of the Controls Contractor to ensure that all County's IT requirements are met before any Ethernet based DDC system is bid.
2. All building level devices must communicate using BACnet/IP and must support the requirements listed in this specification. Hennepin County is committed to integration so that point status and automatic control and alarming can be channeled into a common protocol. Hennepin County has established BACnet/IP and LON or BACnet MS/TP as the common protocol.

G. Hennepin County Base DDC System Functions:

1. The general categories of the automated capabilities of Hennepin County DDC system are:
   a. Monitoring and Scheduling: Includes starting, stopping, observing, and reporting the operating status.
   b. Intervention: The ability to automatically or manually shift to an alternate operating mode when conditions warrant it from a remote location.
   c. Integration: The ability to coordinate the operation of several systems within a building, or several buildings, to ensure 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 DDC systems must be capable of functioning in the following modes:
    a. All life safety and building system objects shall be monitored and controlled, including equipment scheduling, via (BACnet/IP).
    b. System alarms shall be transmitted from each BACnet Supervisory controller to a BACnet recipient using intrinsic and algorithmic (event enrollments) alarming methods.
3. Hennepin County personnel shall have the ability to: control set point, alarm limit and time schedule program modifications from the vendor’s workstation or through any third party BACnet/IP workstation.

H. BACnet Integration:

1. Due to the complexity and size of Hennepin County BACnet system, integration requires stringent cooperation between Hennepin County Property Services and the selected Temperature Controls Contractor. Hennepin County 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. Hennepin County is committed to integrating different manufacturer’s temperature control systems on a common LAN for all existing and future temperature control systems that may be installed. Hennepin County BACnet required conformance is limited to B-Side or BACnet building controllers, only. The Temperature Controls Contractor must provide labor, software, materials, wiring, network coordination and expertise to install Web Based BACnet Building Controller or LON/BACnet MS/TP floor level controllers.
3. Bidding Controls Contractors must install control devices that have been pre-approved by Hennepin County. Refer to Appendix A for the listing of pre-approved controllers.
4. BACnet/Web Services communication shall be via the Hennepin County LAN directly from the building level controllers or vendor information PC server 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.
5. Building level network controllers shall have the same model/part number and major firmware revision as the pre-approved controllers listed in Appendix A.
6. Contractor shall provide current BACnet Interoperability Building Blocks (BIBBs) and PICs Statements with a written request to approve new BTL Listed BACnet controllers or major firmware revisions that are not currently preapproved and are not listed in Appendix A. Hennepin County will determine if the new controllers are acceptable for use on Hennepin County projects. Until such time that new controllers or firmware revisions are added to the preapproved controls list (Appendix A), they shall not be used on Hennepin County projects.
7. BACnet/LON conformance disputes that may arise in the Temperature Control Contractors installed BACnet Building Controller shall be resolved by the temperature controls Contractor working directly with the temperature controls manufacturer. 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 3.5.4 (VTS) program. Virtual Test Shell (VTS) is an application for testing the BACnet functionality of various devices used in building automation systems. Conformance issue fault will be agreed on and resolved using ANSI/ASHRAE Standards 135-2004 publication.

1.3 RELATED SECTIONS

A. Division 23 Section “Instrumentation and Control for HVAC” for requirements that relate to this Section.

B. Division 23 Section “Sequence of Operations for HVAC Controls” for requirements that relate to this Section.

1.4 RELATED DOCUMENTS

A. Drawings and general provisions of the contract, including General and Supplementary Conditions and Division 1 Specification sections, apply to this section.

1.5 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. BIBBs - BACnet Interoperability Building Blocks.
6. BMA – BACnet Manufacturers Association.
7. BTL – BACnet Testing Laboratories.
8. CSV – Comma Separated Value.
9. DDC - Direct Digital Controls.
10. EIA - Electronic Industries Association.
11. IP – Internet Protocol.
12. ISO - International Standards Organization.
13. LAN - Local Area Network.
14. LON - Local Operating Network.
15. LONTalk - Open, published protocol.
16. LONWorks - A set of tools and components.
17. NIST - National Institute of Standards and Technology.
18. PIC - Protocol Implementation Conformance Statement.
19. VAV - Variable Air Volume.
20. SOC – Security Operations Center.

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)
4. ASHRAE 135-2004 BACnet Standard 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)

1.7 PRODUCTS FURNISHED, BUT NOT INSTALLED UNDER THIS SECTION

1.8 PRODUCTS INSTALLED, BUT NOT FURNISHED UNDER THIS SECTION

1.9 PRODUCTS INTEGRATED WITH THE WORK OF THIS SECTION

1.10 PROJECT DESCRIPTION

1.11 SUBMITTALS

A. Upon acceptance of a proposal, the controls Contractor will provide submittal drawings for approval prior to ordering 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. Software includes all software needed to program all system components including PC applications, supervisory and sub controllers.

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 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 Engineer and Owner and request clarification. The Engineer and 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. 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) Riser Diagram shall show the IP layer and all of the Building Level Net layers.
         2) Riser Diagram shall show each computer, printer, router, repeater, controller, and protocol translator (for existing equipment only) that is connected to either the IP layer or any of the Building Level Net sub controllers.
         3) Where applicable, the Riser 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) Riser 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 sub controller wiring diagram shall clearly show the use of the daisy chain wiring concept, the order in which the devices are connected to the building 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 shall 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, Hennepin County requires the following:
                (i) Optional properties that are supported by the device
                (ii) A list of properties that can be written using BACnet services
                (iii) Any object that can be dynamically created or deleted using BACnet services
                (iv) 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 (to ensure distributed processing)
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 four 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.

(i) 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) Objects list

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 building 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 Engineer and Hennepin County 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 Hennepin County 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 Hennepin County 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.

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.

1.12 OWNERSHIP OF PROPRIETARY MATERIAL

A. Hennepin County shall retain all rights to software for this project.

B. Hennepin County shall sign a copy of the manufacturer's standard software and firmware licensing agreement as a condition off this contractor. 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. Hennepin County conducted control system prequalification testing for BACnet integration and has published a list of approved control devices in Appendix A. Only pre-approved control devices listed in Appendix A shall be proposed and installed on Hennepin County projects.
2. Building level network controllers shall have the same model/part number and firmware revision as the pre-approved controllers listed in Appendix A.
3. Control Contractors shall provide all of the "Requirements for use at Hennepin County Buildings" from Appendix A for their approved controllers.

4. Approved Manufacturers that don't currently have virtualized Web Server supervisor software on the Hennepin County network must include the cost of furnishing and installing Web Server supervisor software in their proposed cost. All Hennepin County network security, software license and installation requirements shall apply to the Web Server software.

B. Acceptable Installation Contractors:

1. 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. It is fully expected that companies that install DDC systems licensed by the manufacturer, but not owned by the manufacturer have direct technical access to the product manufacturer.
2. Contractors shall have a minimum of five (5) years experience installing and servicing controls for the control manufacturer's products being proposed.
3. Contractor's primary place of business shall be within 60 miles of the project site location.
4. Contractor shall demonstrate experience on similar size and type of control projects upon request.
5. Branch offices and independent representatives for the approved 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.

2.2 SYSTEM ARCHITECTURE

A. The DDC system architecture shall consist of three layers: the IP layer devices, the Building Level Net devices and Web services devices.

B. All new building controllers, PCs and IP devices will be connected to the Hennepin County LAN. The LAN connection shall be coordinated with Hennepin County IT personal. The Temperature Control Contractor shall be responsible for all inner building wiring. Hennepin County IT dept will provide a single RJ-45 Ethernet connection point in the building. All internal building communications wire shall be supplied and installed by Temperature Control Contractor.

C. BACnet Building Controllers (B-BC) shall be used to connect each Building Level Net to the IP layer.

2.3 NETWORKING

A. IP Network: All devices that connect to the County LAN shall be capable of operating at 100 megabits per second.

B. IP-to-Building Level Net Routing Devices:

1. BACnet Building Controller (Supervisory Controller) shall be used to provide this functionality.
2. These devices shall be configurable locally with EIA-232, IP connection or USB communications.
3. The routing configuration shall be such that only data packets from the Building Level Net devices that need to travel over the IP level of the architecture are forwarded. Additionally, data packets from the IP level that need to travel to the sub LAN devices will be forwarded. BACnet 'Who is' and 'Who has' global and local broadcast messages should be answered by the supervisory controller as a proxy whenever possible. It is the intention of the County to minimize network traffic between supervisory controllers and Building Level Net devices using BACnet MS/TP protocol.

C. Building Level Net

1. The wiring of components shall use a bus or daisy chain concept with no tees, stubs, or free topology. Building Level Net device programming must be accessible via pass through from supervisory controller. Disconnecting Building Level Net for the purpose of programming sub controllers is prohibited.

D. Repeaters

1. Where repeaters are required to connect two segments, repeaters shall be installed in an enclosure mounted in an accessible location.

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 other BACnet building controllers or BACnet operator workstations.

B. Building level DDC controllers shall utilize BACnet open standard communication protocol. All Supervisory controllers shall communicate using BACnet/IP. If the proposed Temperature Controls Contractor doesn't include a web based communications server, the supervisory controller shall allow complete web based user access via industry standard web browsers. If multiple supervisory controllers are used in a single building installation then one of them must be dedicated as the main web server so users do not have to access more than one Uniform Resource Locator (URL) to monitor, program and control the building.

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. The BACnet Building Controller 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.
2. Alarm and Event Management:
   a. Generation of alarms / events notifications and the ability to direct them to recipients using the BACnet intrinsic or algorithmic 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/modify weekly and exception 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 which includes a complete 'BACnet trend log buffer upload'.
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.
   e. Ability to perform re-initialize upon request.
   f. Ability to upload its configuration and allow it to be subsequently restored.
   g. Ability to command half routers to establish and terminate connections.

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. All ANSI/ASHRAE 135-2004 BACnet objects and object properties shall be supported so that alarms are sent from the Temperature Control Contractor's BACnet device without having to be solicited from any Hennepin County BACnet Operators Workstation (BOWS)

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 including the site IP LAN. Derogation includes router, switch, or hub lockups, BACnet building controller lockups, excessive site network slowdowns, broadcast storms, unnecessary and repeated network broadcasts including BACnet 'who is', 'who has', I am, I have, and 'who is router' messages. Who is, I am messages should be limited to initially determine BACnet MAC addresses, segmentation support and maximum APDU length. Other reasons include when a device moves. BACnet MS/TP devices may not exceed 60 on a single BACnet MS/TP network.

G. 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. Acceptable methods of connection are USB, Ethernet, and EIA-485.

H. Memory: Each DDC controller shall have sufficient memory to support its own operating system and data bases including continuous trending on all analog points for that controller (AV, AI, AO) based on 300 sample intervals.

I. 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.

1. The system is to report the alarm at the workstations. In addition, the alarm will go to the building engineer, and building manager.

J. 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.

K. 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 majorly interrupt the execution of control strategies at other operational devices. All bound objects between controllers must maintain the last value or go to a pre specified default.

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, BACnet arcnet or LON open standard communication protocol.

C. 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.

D. 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.

E. 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.

F. Unit level controllers shall not be dependent upon any other controller (unit or building level) to maintain safe operation of the controlled equipment.

G. 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.

H. PROHIBITED: The combination of master/slave panels or point expansion for PID control loops without prior approval from Owner.

I. 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 shall 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 BAS 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. On project where an OWS is specified, Hennepin County will furnish and install any required PC's for the OWS at the project location. Contractor shall furnish and install all software and tools:

2.7 DDC SYSTEM SOFTWARE

A. Web-based BAS Server Software:

1. Utilize the existing web based BAS server software for user access via industry standard web browsers. Contractor shall furnish controllers that are compatible with the current version of BAS server software.
2. Contractor shall furnish and install a temporary server-workstation with BAS server software in the building until virtual server software is accessible on the Hennepin County network.
3. Contractor shall provide all materials and labor required to connect to the BAS server software and to provide user access via industry standard web browsers.

B. Software Upgrades

1. Contractor shall furnish and install the most current version of all BAS software available throughout the warranty period.
2. It is Hennepin County Property Services desire to install the most current hardware and software available without jeopardizing control integration conformance or Hennepin County Standards.
   a. Contractor shall provide current BACnet Interoperability Building Blocks (BIBBs) and PICs Statements with a written request to approve new BTL Listed BACnet controllers or firmware revisions that are not currently preapproved and are not listed in Appendix A. Hennepin County will determine if the new controllers are acceptable for use on Hennepin County projects. Until such time that new controllers or firmware revisions are added to the preapproved controls list (Appendix A), they shall not be used on Hennepin County projects.

C. 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.

PART 3 EXECUTION

3.1 NETWORK COMMUNICATION TRUNK AND TERMINATIONS

A. A backbone communication tie in point will be provided and installed by Hennepin County IT. The Temperature Controls Contractor is responsible for all DDC network wiring within the building.

B. The Temperature 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.

3.2 IP INTERFACE DEVICES

A. Install Building Controllers for each required connection to the dedicated DDC IP network.

B. The Building Controllers shall be configured and commissioned to ensure that the only data traffic on the IP is data that is essential for operation of the system.

3.3 SYSTEMS INTEGRATION

A. The Temperature Controls Contractor shall be fully responsible for the installation and commissioning of the integrated system.

B. Temperature 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 Hennepin County Property Services. If the Contractor deems changes to the Contract Documents necessary, submit details in writing, to the Owner for approval.

C. The Temperature 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 Hennepin County network.

3.4 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 Hennepin County network. BACnet integration must conform to Data Link Layer Option BACnet /IP shown in BACnet ANSI/ASHRAE 135-2004 publication Annex J.

B. All BACnet read property requests from any BACnet Operator Workstation must not take more than 20 ms 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 50 ms 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.

3.5 BUILDING ALARMS AND CRITICAL SYSTEM MONITORING

A. The control specifications and/or point lists shall identify building alarm requirements.

B. The Temperature Control Contractor shall provide an alarm matrix with the Control Submittal that lists all building alarm points. The matrix shall identify an alarm class for each alarm point. Alarm Classes shall include:

1. Critical Alarms: Refer to Appendix B.
2. Page/Text Alarms: Building alarms that need immediate attention, but are not critical. Alarm notification to the Building Engineer by page, text or by a means of communication defined by the Building Manager.
3. General Alarms: All building alarms. Alarm notification to BAS.

C. The Temperature Control Contractor shall use the Hennepin County Critical Alarm Standard in Appendix B as a guide for defining critical alarms.

D. The Hennepin County Building Manager, Building Engineer and Automation Technician shall review the building alarm matrix and make corrections as needed. The Approved Alarm Matrix will be returned to the Temperature Control Contractor and shall be used for programming building alarms.

E. The Temperature Control Contractor shall follow the BACnet Alarm Recipient Standard in Appendix D.

F. In facilities where critical system monitoring is performed by DDC equipment, the controls contractor shall be responsible for all required material and labor to connect the Owner's critical equipment to the DDC system.

G. In buildings with emergency generators, all DDC devices and networking equipment that monitor and/or transmit critical system monitoring points shall be connected to emergency power.

H. The controls contractor shall provide UPS power supplies for all DDC and networking devices that monitor and/or transmit critical system monitoring points. UPS shall be capable of maintaining full operation for a period no less than 4 hours.

I. The DDC system shall monitor all UPS required under this section and report an alarm to SOC whenever the UPS senses a loss of primary power or indicates a fault of any kind.

3.6 POINT NAMING/POINT LOGICAL GROUPING AND GRAPHICS

A. The programmer shall meet with Hennepin County Property Services 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 Hennepin Property Services before deviating from Hennepin County Standards. Failure to work within Hennepin County Standards may result in the Contractor being required to redo their work without compensation.

B. Supervisory controllers must be named with their corresponding building number & panel number. Before database generation is started, controls contractors are advised to contact Hennepin County for questions regarding naming. Hennepin County 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 Device IDs & IP address information with Hennepin County prior to the start of database generation.

D. The Temperature Control Contractor shall follow the BACnet Device and Network Number Standards in Appendix C for all Hennepin County controls projects.

3.7 PROGRAMMING METHODS USING THE GRAPHIC INTERFACE

A. Provide the capability to copy objects from the supplied libraries, or from a user-defined library to the user’s application. Objects shall be linked by a graphical linking scheme by dragging a link from one object to another. Object links will support one-to-one, many-to-one, or one-to-many relationships. Linked objects shall maintain their connections to other objects regardless of where they are positioned on the page and shall show link identification for links to other objects on other pages for easy identification. Links will vary in color depending on the type of link; i.e., internal, external, hardware, etc.

B. Configuration of each object will be done through the object’s property sheet using fill-in the blank fields, list boxes, and selection buttons. Use of custom programming, scripting language, or a manufacturer-specific procedural language for configuration will not be accepted.

C. The software shall provide the ability to view the logic in a monitor mode. When on-line, the monitor mode shall provide the ability to view the logic in real time for easy diagnosis of the logic execution. When Off-line (debug), the monitor mode shall allow the user to set values to inputs and monitor the logic for diagnosing execution before it is applied to the system.

D. Control system logic shall be viewable in real time from the Web Browser. Linking real time control system logic from the server to the Web Browser in a “view only” mode is acceptable.

E. Control PIDs shall be accessible in real time for tuning and diagnosing from the Web Browser. Exposing adjustable PID’s in Web Browser graphics is acceptable.

F. All programming shall be done in real-time. Systems requiring the uploading, editing, and downloading of database objects shall not be allowed.

G. The system shall support object duplication within a customer’s database. An application, once configured, can be copied and pasted for easy re-use and duplication. All links, other than to the hardware, shall be maintained during duplication.

H. The O&M Documents and sequence of operation shall be viewable from the control system.

3.8 CRITICAL ALARM COMMISSIONING

A. Complete the Critical Alarm Commissioning Checklist defined in Appendix E and include it with close-out documentation.

B. Schedule a critical alarm commissioning test with the Owner to test critical BACnet intrinsic and algorithmic alarms going to the Hennepin County Security Operations Center (SOC) BACnet to ANSI/SIA DC-09-2013: Security Industry Association Manitou Interface. The Control Contractor shall test each critical BACnet alarm to confirm that they are properly transmitted to the SOC interface as outlined in the control and integration specification.

3.9 COMMISSIONING

A. Temperature controls contactor shall perform services and activities to participate in the commissioning. Provide web-based access to the commissioning agent as required to facilitate commissioning. Fill out forms and provide information as required to participate in the project commissioning. This may include operation of ventilation systems, valves, and other equipment as directed by and in the presence of the Commissioning Agent. Commissioning Agent shall review the performance reports, forms, and controls submitted by the temperature controls contactor. The temperature controls contactor shall work with the Commissioning Agent to rectify issues identified in the reports and in the project commissioning.

B. Complete the commissioning checklist defined in Appendix F. The Commissioning Agent in coordination with the Controls Contractor shall complete and sign off on all checklist tasks prior to the start of system warranty. The Commissioning Agent and Controls Contractor shall arrange a review meeting with the Owner to demonstrate that all of the commissioning checklist tasks have been completed to the satisfaction of the Owner. The completed commissioning checklist form containing sign-off from all parties shall be included in the close-out documentation submitted by the Contractor.

END OF SECTION

APPENDIX A: HENNEPIN COUNTY PREQUALIFIED CONTROLS

Control Manufacturer	Controller Type	Part Number	Pass/ Fail/ Review	Requirements for Use at Hennepin County
Automated Logic	Supervisory	ME-812U-LGR	Pass	
Automated Logic	Supervisory	LGR25	Pass	
Automated Logic	Supervisory	LGR250	Pass	
Automated Logic	Supervisory	LGR1000	Pass	
Automated Logic	Supervisory	ME-LGR25	Pass	
Automated Logic	Supervisory	ME-LGR200	Pass	
Automated Logic	Supervisory	ME-912U-E	Pass	
Automated Logic	Field	SE6104a	Pass	
Automated Logic	Field	ME812U	Pass	
Automated Logic	Field	MEX816U	Pass	
Automated Logic	Field	MEX48U	Pass	
Automated Logic	Field	MEX88U	Pass	
Automated Logic	Field	MEX016U	Pass	
Automated Logic	Field	RC642	Pass	
Automated Logic	Field	RC642D	Pass	
Automated Logic	Field	ZN220	Pass	
Automated Logic	Field	ZN341V	Pass	
Automated Logic	Field	ZN551	Pass	
Automated Logic	Field	ZN253	Pass	
Automated Logic	Field	ZN141V	Pass	

Control Manufacturer	Controller Type	Part Number	Requirements for Use at Hennepin County
Alerton	Supervisory	A-x A2	AX must be set-up to use BACnet conformance from Alerton field controllers.
Alerton	Supervisory	A-x A6	
Alerton	Supervisory	A-x A7	
Alerton	Supervisory	BCM-MS/TP	Control vendor must add SOC as a recipient using native software.
Alerton	Field	VLC-853	
Alerton	Field	VLC-444	
Alerton	Field	VLC-550	
Alerton	Field	VLC-1688	
Alerton	Field	VLC-1188	
Alerton	Field	VLC-16160	
Alerton	Field	VLC-1600	
Alerton	Field	VAV-SD	
Alerton	Field	VAViH-SD	
Alerton	Field	VAV-SD2A	
Alerton	Field	VAV-DD	
Alerton	Field	VAV-DD7	
Alerton	Field	VLX	

Control Manufacturer	Controller Type	Part Number	Requirements for Use at Hennepin County
American Auto-Matrix	Supervisory	BBC-SSB	Control vendor must add SOC as a recipient using native software.
American Auto-Matrix	Field	NB-GPC1	
American Auto-Matrix	Field	NB-GPC2	
American Auto-Matrix	Field	NB-GPC3	
American Auto-Matrix	Field	NB-GPC4	
American Auto-Matrix	Field	NB-ASCE	
American Auto-Matrix	Field	NB-VAV	
American Auto-Matrix	Field	NB-V3T	

Control Manufacturer	Controller Type	Part Number	Requirements for Use at Hennepin County
Johnson Controls	Supervisory	MS-NAE3510-2	
Johnson Controls	Supervisory	NAE-3510-2	
Johnson Controls	Supervisory	NAE-3510-2U	
Johnson Controls	Supervisory	NAE3511-2	
Johnson Controls	Supervisory	MS-NAE3514-2	
Johnson Controls	Supervisory	MS-NAE3515-2	
Johnson Controls	Supervisory	MS-NAE3520-2	
Johnson Controls	Supervisory	MS-NAE3521-2	
Johnson Controls	Supervisory	MS-NAE3524-2	
Johnson Controls	Supervisory	MS-NAE3525-2	
Johnson Controls	Supervisory	MS-NAE4510-1	
Johnson Controls	Supervisory	MS-NAE4510-2U	
Johnson Controls	Supervisory	MS-NAE4511-2	
Johnson Controls	Supervisory	MS-NAE4520-2	
Johnson Controls	Supervisory	MS-NAE4521-2	
Johnson Controls	Supervisory	MS-NAE5510-1	
Johnson Controls	Supervisory	MS-NAE5510-1U	
Johnson Controls	Supervisory	MS-NAE5510-2	
Johnson Controls	Supervisory	MS-NAE5511-1	
Johnson Controls	Supervisory	MS-NAE5511-2	
Johnson Controls	Supervisory	MS-NAE5520-1	
Johnson Controls	Supervisory	MS-NAE5520-2	
Johnson Controls	Supervisory	MS-NAE5521-1	
Johnson Controls	Supervisory	MS-NAE5521-2	
Johnson Controls	Field	MS-FEC2611-0	
Johnson Controls	Field	MS-FEC-1621-0	
Johnson Controls	Field	MS-FEC-2611-0	
Johnson Controls	Field	MS-FEC-2621-0	
Johnson Controls	Field	MS-IOM-1711-0	
Johnson Controls	Field	MS-IOM-2711-0	
Johnson Controls	Field	MS-IOM-2721-0	
Johnson Controls	Field	MS-IOM-3711-0	
Johnson Controls	Field	MS-IOM-3721-0	
Johnson Controls	Field	MS-IOM-3731-0A	
Johnson Controls	Field	MS-IOM-4711-0	
Johnson Controls	Field	MS-VMA1620-0	

Control Manufacturer	Controller Type	Part Number	Requirements for Use at Hennepin County
Johnson Controls	Field	TEC2601-4+PIR	
Johnson Controls	Field	TEC2601-4	
Johnson Controls	Field	TEC2602-4	
Johnson Controls	Field	TEC2602-4+PIR	
Johnson Controls	Field	TEC2603-4	
Johnson Controls	Field	TEC2603-4+PIR	
Johnson Controls	Field	TEC2604-4	
Johnson Controls	Field	TEC2604-4+PIR	
Johnson Controls	Field	TEC2613-4	
Johnson Controls	Field	TEC2613-4+PIR	
Johnson Controls	Field	TEC2645-2	
Johnson Controls	Field	TEC2616-2	
Johnson Controls	Field	TEC2616H-2	
Johnson Controls	Field	TEC2626-2	
Johnson Controls	Field	TEC2626H-2	
Johnson Controls	Field	TEC2636-2	
Johnson Controls	Field	TEC2636H-2	
Johnson Controls	Field	TEC2646-2	
Johnson Controls	Field	TEC2646-2ME	
Johnson Controls	Field	TEC2646H-2	
Johnson Controls	Field	TEC2656-2	
Johnson Controls	Field	TEC2656H-2	
Johnson Controls	Field	TEC2627-2	
Johnson Controls	Field	TEC2627VVT-2	
Johnson Controls	Field	TEC2647-2	
Johnson Controls	Field	TEC2647VVT-2	

New Control Devices:

A. Minor revision changes or build number updates to controllers from the approved devices listed above are acceptable.

B. The BTL listing mark must be present on all supervisory controllers and BACnet MS/TP sub controllers.

End of Appendix A

APPENDIX B – HENNEPIN COUNTY CRITICAL ALARM STANDARD

The intent of this list is to provide a guide for those types of facility alarms considered "critical" which can be communicated to the Security Operations Center via the BAS network. The total number of alarm points transmitted should be limited to only those that are necessary to protect the facility from damage. Multiple alarm points that indicate the same potential condition should be avoided.

Proper instructions for the SOC Operator should be given and the instructions checked annually for accuracy. Other operational failure alarms can be transmitted via blackberry, phone text message, email, or other sources of notification to the proper staff.

FIRE ALARMS

- Fire alarms received by the BAS can be transmitted to SOC, but are to be considered as redundant alarms. The BAS should not be the primary transmission method for fire alarms.

ALARM TEST

- A routinely scheduled test of the BAS communications network, that ensures alarms are being received by SOC, should be programmed

BOILER FAILURE / LOW HEATING WATER SUPPLY TEMPERATURE / HOT WATER CIRC PUMP FAIL

- The proper alarm(s) should be used to alert SOC that the facility's main heating system (or component) has or is failing. Limit the number of alarms while making sure your facility is protected.

LOSS OF POWER / EMERGENCY GENERATOR

- An alarm to indicate a facility power failure, generator running, or generator under load. Make sure the alarm instructions indicate the actual condition. This alarm can sometimes be wired so that the discontinuation/restoration of the alarm point indicates a restoration of normal power.

LOW SPACE TEMPERATURE

- This alarm should be used to protect an area vulnerable to low temperature damage. It can be physically located in an area known to be first to cool down during a heating failure, being a supplement to the boiler/heating failure alarm above.

SEWAGE EJECTOR HIGH LEVEL

- Indicates a system failure or potential failure.

LOW CONTROL AIR PRESSURE

- Indicates a potential failure of the air source controlling pneumatic controls.

CHILLER FAILURE / HIGH CHILLED WATER TEMP

- The proper alarm(s) should be used to alert SOC that the facility main facility air conditioning system (or component) has or is failing. Limit the number of alarm points while making sure your facility is protected. Extra thought should be given as to whether this situation is critical to the facility.

AIR HANDLING UNIT FAIL OR LOW TEMP/FREEZE ALARM

- The proper alarm(s) can be used to alert SOC that an air handling unit (or component) critical to the safety of the facility has or is failing. Limit the number of alarm points while making sure your facility is protected.

EXHAUST FAN FAIL

- The proper alarm(s) can be used to alert SOC that an exhaust unit (or component) critical to the safety of the facility has or is failing. Limit the number of alarm points while making sure your facility is protected. Extra thought should be given as to whether this situation is critical to the facility.

OTHERS

- Other alarms that do not fall into these categories may be needed to protect certain facilities. It is the responsibility of each Building Operations Manager to make sure that the necessary alarm points are transmitted, and to be able to justify the need. It is our intent to limit the alarm activity transmitted to SOC to those alarms that are truly critical.

End of Appendix B

APPENDIX C: BACnet DEVICE AND NETWORK NUMBER STANDARDS

BACnet Device and Network Number Standards
All point names must start with the building number. The point name should also include a reference to the system the point is associated with. Defined by Hennepin County.

BACnet Device Assignment Range 0-4194302
Hennepin County Standard BACnet device assignment
Digits 1,234,567
X,XXX,XXX
1st digit should normally be 1

2nd, 3rd, and 4th digit will equal the building number. In the case where the building number repeats itself with a letter or decimal such as 18 and 18n or 18.1 then the 1st digit (which is normally 1) can be changed to 2 or 3 to differentiate between buildings with the same number. The first digit can only be 1, 2 or 3. Do not use 4.

5th 6th and 7th digit will be assigned as follows:

1,XXX,001 to 1,XXX,099 reserved for building supervisory controllers or BACnet routers. These 3 digits should be sequentially assigned starting from the lowest level in the building to the highest level. Floors with multiple supervisory controllers or routers can be assigned by the temperature control contractors own discretion.

BACnet Field level device (MAC) assignment: 5th 6th and 7th digit will be assigned as follows:

X,XXX,100 to X,XXX,999 reserved for SubLAN devices such as VAV controllers. Can be assigned by the temperature control contractors own discretion. Hennepin County suggests the 5th digit correspond with the building floor number.

Temperature Control Contractor shall set Max Master in each MS/TP Device. Do not leave the default setting (typically 127). This setting defines the address that is searched for on a BACnet LAN (last address). Each search involves sending a message and waiting for a response or a timeout (if the devices are not there). Hennepin County restricts the maximum number of BACnet subLAN devices on each loop to 60 or less.

Device packing practice must be followed. All SubLAN devices must be "packed" so there are no unused addresses between devices.

BACnet Network Number Range 0 to 65,535

Hennepin County Standard BACnet network number assignment

Digits 12,345
XX,XXX

1st and 2nd digit will range from 11 to 64. Each SubLAN must be assigned to a unique number. All Supervisory controllers that are not BACnet routers or do not originate a BACnet subLAN shall be assigned to 10 in the 1st and 2nd digit.

3rd, 4th and 5th digits will be set to the building number. In cases where the building number repeats it's self with a letter or decimal such as 18 and 18n or 18.1 than Hennepin county contracting coordinator will coordinate and assign these 3 digits.

BACnet User Datagram Protocol (UDP) port assignment must always be set to a UDP that is issued by the Owner. All BACnet IP devices must be set to that UDP. The supervisory controller must act as a BBMD accepting foreign device registrations. The number of simultaneously foreign device registrations will be set to 10.

End of Appendix C

APPENDIX D: BACnet ALARM RECIPIENT AND COMMAND PRIORITY STANDARDS

All BACnet alarms shall be directed to the Hennepin County primary SOC BACnet alarm receiver via notification class object 01-03. The BACnet Notification object is a BACnet Object that is used to send event notifications within a BACnet System. BACnet notification class object 01 shall be used for the highest priority alarms such as building freeze stat alarms, loss of control air, loss main heating system, sump pump failures etc. Priority alarms shall be determined by Hennepin County Property Services (see “Appendix B” for details). Notification class object 02 shall be used for medium priority alarms that will be called out to the building engineer, but only requires a message be left with the building engineer. Notification class object 03 is for all priority alarms that will not be sent to the Hennepin County’s SOC BACnet alarm receiver. This alarm shall be sent to the building engineer’s web station or laptop/desktop client.

Notification object 01 and 02 shall contain device recipient 1000 (SOC alarm receiver). This recipient shall be setup for confirmed alarm transmission, handling type alarm, all days and times 24/7/365. Notification object 03 shall contain device recipient 1001 (building engineer alarm receiver). This recipient shall be setup for unconfirmed alarm transmission, handling type alarm, all days and times 24/7/365.

All intrinsic alarm and event enrollment object names that are to be sent to Device 1000 (SOC Interface) must contain the prefix “SOC”.

BACnet alarm priorities for notification class 01 (Critical Priority SOC calls out immediately):
To: Off Normal Priority 50
To: Fault Priority 100
To: Normal Priority 150

BACnet alarm priorities for notification class 02 (High Priority Leave Message):
To: Off Normal Priority 50
To: Fault Priority 100
To: Normal Priority 150

BACnet alarm priorities notification class 03 (To building engineer only):
To: Off Normal Priority 50
To: Fault Priority 100
To: Normal Priority 150

BACnet Device Command Priorities Standards

BACnet Command Priority
1 Manual Life-Safety
2 Automatic Life-Safety
3 Available
4 Available
5 Critical Equipment Control
6 Minimum On/Off
7 Available
8 Manual Operator Override
9 Available
10 Available
11 Available
12 Available
13 Available
14 Available
15 Time Schedule
16 Operator Command

End of Appendix D

APPENDIX E: CRITICAL ALARM COMMISSIONING TEST

The Owner or Owners Representative must complete and sign off on the critical alarm test before the control system warranty period can start. The test is not intended to replace the Contractor's normal and accepted procedures for installing and pre-testing equipment or relieve the Contractor of standard checkout and start-up responsibilities, but to verify that critical alarms properly transmit to the SOC interface.

General:

Temperature Control Contractor must expose points as BACnet alarms (intrinsic or algorithmic) and assign them to BACnet device 1000 (SOC interface)

Expose all existing alarming points to BACnet/IP on the Hennepin County LAN at subnet and UDP agreed on by Owner. Build notifications classes as described below and assign one recipient (SOC BACnet alarm translator) at device address 1000. Assign and setup point objects as required.

A complete list of Intrinsic and algorithmic alarms showing the supervisory controllers BACnet UDP port and all object instance numbers must submitted to the Owner in a PDF format 5 days before test is conducted.

The BACnet Building Controller that is located in every building must send a properly formatted BACnet intrinsic or event enrollment alarm message (not COV) to the SOC BACnet to SIA translator. The BACnet alarm (not event) message must include the BACnet destination object ID of 1000, process ID of 3 (set by BACnet to SIA translator), and a confirmed notification message type. Set points assigned to SOC Notification class event enable To Off Normal, To Fault, To Normal

The temperature controls contractor shall setup alarms in each building based on Hennepin County Alarming Standards as intrinsic or event enrollment. The “base load” of critical alarms should be configured with intrinsic reporting. The remaining complex situations should be configured using algorithmic reporting by creating individual event enrollment objects for each alarm. Hennepin County will use the algorithmic reporting method when necessary to reduce the number of false alarms, specifically during normal equipment cycles and floating set point changes. The Controls Contractor shall make every effort to eliminate false alarms during 'normal' periods.

Notification Class Test:

Ensure each previously agreed upon alarm object is assigned to the newly created 'Critical Points To SOC' notification class.

☐	Notification class object (alarm handlers) on all controllers transmitting alarms to SOC have been created
☐	Object name and/or descriptor of notification class object is set to 'Critical Points To SOC'
☐	Notification class is assigned to instance number 01. If already used on existing, indicate notification class number.____________
☐	Notification recipient 1000 (SOC Alarm Receiver) is present in the recipient list using Object ID entry method
☐	Recipient process ID has been set to 3

☐	Time and day is setup to transmit alarms to device 1000 for all dates and all times
☐	All 3 transition notifications are turned on. To Off Normal, To Fault, To Normal.
☐	Notification messages are set to 'Confirmed'
☐	All alarm priorities are set to 'Off Normal 50', To 'Fault 100', To 'Normal 150'
☐	Alarm type is set to 'Alarm' and not 'Event'
☐	Each agreed upon alarm object is assigned to the newly created 'Critical Points To SOC' notification class object

Notification Class Test	Pass:	Fail:
Notes / Exceptions:		

Network Settings:

BACnet User Datagram Protocol (UDP) port assignment is set to the agreed upon UDP port for all BACnet devices. Enter UDP port number here.____________________

Hennepin County BACnet Device Number Standards Setup for New Installations:

BACnet Device Assignment Range 0-4194302

Hennepin County Standard BACnet device assignment

Digits 1,234,567

Ensure the 1st digit is a 1

Ensure 2nd, 3rd, and 4th digit is the building number. In the case where the building number repeats itself with a letter or decimal such as 18 and 18n or 18.1 then the 1st digit (which is normally 1) can be changed to 2 or 3 to differentiate between buildings with the same number.

Ensure the 5th 6th and 7th digit is assigned as follows:

1,XXX,001 to 1,XXX,099 reserved for building supervisory controllers or BACnet routers. These 3 digits should be sequentially assigned starting from the lowest level in the building to the highest level. Floors with multiple supervisory controllers or routers can be assigned by the temperature control contractors own discretion.

Ensure that BACnet Field level device (MAC) assignment: 5th 6th and 7th digit is assigned as follows:

X,XXX,100 to X,XXX,999 reserved for SubLAN devices such as VAV controllers. Can be assigned by the temperature control contractors own discretion. Hennepin County suggests the 5th digit correspond with the building floor number if possible.

Device Number Standards Setup	Pass:	Fail:
Notes / Exceptions:		

BBMD Test Support:

One supervisory controller on each separate Hennepin County subnet is enabled with foreign device registration and setup for 10 users. The SOC interface will register to this. Contractor shall send IP address of BBMD that will allow foreign device registration and any other detailed information to Owner 5 days before test. IP Address of BBMD________________________

BBMD Test	Pass:	Fail:
Notes / Exceptions:		

Alarm and Event Services Test:

All alarms must be properly formatted and sent to SOC interface and observed by Owner in real time during SOC interface critical alarm test.

Each alarm object type listed below displays the alarm to the SOC interface as follows: 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 to the SOC interface for the following standard BACnet objects:

☐	All Binary Input s if applicable successfully received at alarm region of SOC interface
☐	All Binary Values if applicable successfully received at alarm region of SOC interface
☐	All Multi-state Inputs if applicable successfully received at alarm region of SOC interface
☐	All Multi-values Inputs if applicable successfully received at alarm region of SOC interface

BI, BV, MSI, MSV Intrinsic Alarm Test	Pass:	Fail:
Notes / Exceptions:		

Each alarm object type listed below displays the alarm on the SOC interface as follows: 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 to the SOC interface for the following standard BACnet objects:

☐	All Analog Input s if applicable successfully received at alarm region of SOC interface
☐	All Analog Outputs if applicable successfully received at alarm region of SOC interface
☐	All Analog Values if applicable successfully received at alarm region of SOC interface

AI, AO, AV Intrinsic Alarm Test	Pass:	Fail:
Notes / Exceptions:		

Each alarm object type listed below displays the normal to the SOC interface as follows: 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 to the SOC interface for the following standard BACnet objects:

☐	All Analog Input s if applicable successfully received a return to normal at alarm region of SOC interface
☐	All Analog Outputs if applicable successfully received a return to normal at alarm region of SOC interface
☐	All Analog Values if applicable successfully received a return to normal at alarm region of SOC interface

AI, AO, AV Intrinsic Normal Test	Pass:	Fail:
Notes / Exceptions:		

Each alarm object type listed below displays the normal to the SOC interface as follows: 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 sent to the SOC interface for the following standard BACnet objects:

☐	All Binary Outputs if applicable successfully received a return to normal at alarm region of SOC interface
☐	All Multistate Outputs if applicable successfully received a return to normal at alarm region of SOC interface

BO, MSO Intrinsic Alarm Test	Pass:	Fail:
Notes / Exceptions:		

Algorithmic Alarm Test:

Change of state:

Each event enrollment change of state type displays the alarm to the SOC interface as follows: If Present_Value changes to a new state for longer that Time_Delay AND the new transition is enabled in Event_Enable. An algorithmic alarm shall be sent to the SOC interface alarm region

Algorithmic COS	Pass:	Fail:
Notes / Exceptions:		

Command failure:

Each event enrollment command failure type displays the alarm to the SOC interface as follows: If Present_Value differs from Feedback_Value for longer than Time_Delay AND the new transition is enabled in Event_Enable. An algorithmic alarm shall be sent to the SOC interface alarm region

Algorithmic Command Failure	Pass:	Fail:
Notes / Exceptions:		

Floating limit:

Each event enrollment floating limit type displays the alarm to the SOC interface as follows: If Setpoint_reference returns or leaves from within the High_Differential_Limit or Low_Differential_Limit - Deadband to High Differential Limit or Low Differential Limit + Deadband range for longer than Time_Delay

AND the new transition is enabled in Event_Enable and Limit_Enable. An algorithmic alarm or return to normal shall be sent to the SOC interface alarm region

Algorithmic Floating Limit	Pass:	Fail:
Notes / Exceptions:		

Out of range

Each event enrollment out of range type displays the alarm to the SOC interface as follows: If Present_Value returns or leaves from within the High_Limit or Low_Limit - Deadband to High_Limit or Low_Limit + Deadband range for longer than Time_Delay AND the new transition is enabled in Event_Enable and Limit_Enable. An algorithmic alarm or return to normal shall be sent to the SOC interface alarm region

Algorithmic Out of Range	Pass:	Fail:
Notes / Exceptions:		

Alarm Services Test:

Owner shall restart SOC interface and run alarm summary service after alarm is sent.

☐	Get Event Info. Coordinate and conduct test with owners rep
☐	Get Alarm Summary. Coordinate and conduct test with owners rep

Alarm Services Test	Pass:	Fail:
Notes / Exceptions:		

End of Appendix E

APPENDIX F: COMMISSIONING CHECKLIST

The Commissioning Agent in coordination with the Controls Contractor shall complete and sign off on all checklist tasks prior to the start of control system warranty. In addition, the Commissioning Agent and Controls Contractor shall arrange a review meeting with the Owner, after all the checklist tasks are completed, to demonstrate that all of the commissioning checklist tasks are done to the satisfaction of the Owner.

COMMISSIONING CHECKLIST FOR CONTROLS

Task #	Description of Task	Cx Agent Sign-Off Initials	Control Contractor Sign-Off Initials	Owner Sign-Off Initials
1	O&M Documents have been submitted to the Owner and are complete and accurate.			
2	The Sequence of Operation is complete and accurate.			
3	The O&M Documents and Sequence of Operation are viewable from the control system.			
4	As-Built Drawings have been submitted to the Owner and are complete and accurate.			
5	The As-Built Drawings show all devices and wiring.			
6	All adjustable points are displayed on the graphics.			
7	All adjustable points have been tested and function per design.			
8	Control system "As-Built" drawings and the sequence of operation can be accessed by link on the control system graphics page.			
9	The control logic is viewable in real time from the Web Browser. Linking real time control logic from the server to the Web Browser in a "view only" format is acceptable.			
10	The control PID's are accessible to the user to set values for tuning PID's and diagnosing logic execution. Exposing adjustable PID's in Web Browser graphics is acceptable.			
11	Control system software and tools have been furnished.			
12	Final Test & Balance report has been provided (if TAB is subcontractor to Controls Contractor)			
13	Control system training per specifications has been provided.			
14	Control system software and tools have been furnished.			

End of Appendix F

SECTION 230993
SEQUENCE OF OPERATION FOR HVAC CONTROLS

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 sample control sequences for HVAC and plumbing systems, subsystems, and equipment on Hennepin County projects. Provide other control sequences as necessary to suite the specific project's needs.

1. Temperature and pressure set points listed shall be adjustable.
2. Provide the building automation system operator with manual over-ride for automatic control valves and dampers. The over-ride shall allow the operator to command open or close valves and dampers.

B. Related Sections include the following:

1. Division 23 Section "Instrumentation and Control for HVAC" for control equipment and devices and for submittal requirements.

1.3 DEFINITIONS

A. Air terminal damper open: The damper will open to the scheduled maximum air flow.

B. Damper or valve full open: Damper or valve will be 100 percent open.

C. DDC: Direct digital control.

D. Modulate: Proportionally position.

E. Set points: Set points will be operator adjustable unless noted as fixed.

F. Temperature: Air and liquid temperatures are in degrees F.

G. VAV: Variable air volume.

1.4 TIME SCHEDULE

A. HVAC and designated plumbing equipment will be scheduled for occupied and unoccupied status.

B. The daily scheduler will allow the system operator to switch between occupied and unoccupied status a minimum of five times per day. Holidays and weekends will be scheduled separately.

C. The initial schedule will incorporate HVAC and designated plumbing equipment. Coordinate the initial scheduled occupied/unoccupied hours with the owner and incorporate the schedules before substantial completion.

1.5 DUAL DUCT CONSTANT VOLUME TERMINAL OPERATING SEQUENCE

A. General:

1. This control sequence applies to the dual duct constant volume terminal units.
2. Air terminal units shall be controlled automatically through local electronic (DDC) velocity controllers.
3. The DDC damper actuators shall be provided by this temperature control contractor for field mounting and calibration by this contractor (or for factory mounting at contractor's option).
4. Pressure Independent Control. Airflow measuring sensors at the air terminal inlet shall provide a signal to control the unit airflow proportionally between the minimum and maximum CFM setpoints regardless of upstream duct pressure.
5. The temperature control contractor shall provide direct digital thermostats and mount/wire as shown on the drawings. Thermostats shall have a 10 F. (adjustable) setpoint range.

B. The dual duct constant volume units have separate hot and cold air duct connections. In this sequence cooling and heating maximum airflow rates are the same and minimum mix flow rates are the same as the maximums. The result is a constant volume of airflow over the entire heating and cooling range.

C. Dual Duct VAV Blending Sequence:

1. A digital space thermostat shall provide a signal to proportionally position the unit dampers to provide a constant volume of airflow to maintain the space temperature setpoint.
2. Upon a call for cooling the cold air damper modulates to maximum, fully open position while the heating air damper modulates to the fully closed position.
3. As the space temperature drops below setpoint the cold air damper modulates towards closed as the hot air damper modulates open. The dampers modulate together to provide a constant volume of airflow throughout this sequence.
4. As the space temperature continues to drop the cold air damper modulates to fully closed position and the hot air damper is fully open.
5. Initial set points:
   a. Winter: 69^{o}F (adjustable)
   b. Summer: 75^{o}F (adjustable)
6. Display:
   a. Room/area served.
   b. Room occupied/unoccupied.
   c. Room temperature indication.
   d. Room temperature set point, heating.
   e. Room temperature set point, cooling.
   f. Room temperature set point, occupied.
   g. Room temperature set point, unoccupied.
   h. Air terminal discharge air temperature.

1.6 DUAL DUCT VARIABLE VOLUME TERMINAL OPERATING SEQUENCE

A. General:

1. This control sequence applies to dual duct variable volume terminal units.
2. Air terminal units shall be controlled automatically through local electronic (DDC) velocity controllers.
3. The DDC damper actuators shall be provided by this temperature control contractor for field mounting and calibration by this contractor (or for factory mounting at contractor's option).
4. Pressure Independent Control. Airflow measuring sensors at the air terminal inlet shall provide a signal to control the unit airflow proportionally between the minimum and maximum CFM setpoints regardless of upstream duct pressure.
5. The temperature control contractor shall provide direct digital thermostats and mount/wire as shown on the drawings. Thermostats shall have a 10 F. (adjustable) setpoint range.

B. The dual duct variable volume units have separate hot and cold air duct connections. The dual duct VAV units vary the airflow individually between the hot and cold inlets.

C. Dual Duct VAV Blending Sequence:

1. A digital space thermostat shall provide a signal to proportionally position the unit dampers to provide cooling or heating airflow to maintain the space temperature setpoint.
2. Upon a call for cooling the cold air damper modulates to maximum, fully open position. Once the space reaches setpoint the cold air damper modulates from the maximum to the minimum flow rate. When the temperature continues to drop with the cooling damper at its minimum position thedual duct VAV goes into heating mode. The hot duct damper opens. The damper continues to open, increasing the heating airflow from the minimum to the maximum until the room setpoint is met.
3. Initial set points:
   a. Winter: 69^{o}F (adjustable)
   b. Summer: 75^{o}F (adjustable)
4. Display:
   a. Room/area served.
   b. Room occupied/unoccupied.
   c. Room temperature indication.

d. Room temperature set point, heating.
e. Room temperature set point, cooling.
f. Room temperature set point, occupied.
g. Room temperature set point, unoccupied.
h. Air terminal discharge air temperature.

1.7 VARIABLE AIR VOLUME TERMINAL UNIT OPERATING SEQUENCE

A. General

1. This control type is for shut-off type VAV boxes with or without reheat coils.
2. Air terminal units shall be controlled automatically through local electronic (DDC) velocity controllers.
3. The DDC damper actuators shall be provided by this temperature control contractor for field mouinting and calibration by this contractor (or for factory mounting at contractors option).
4. Pressure Independent Control. Airflow measuring sensors at the air terminal inlet shall provide a signal to control the unit airflow proportionally between the minimum and maximum CFM setpoints regardless of upstream duct pressure.
5. Heating water control valves shall be fully modulating digital two-way throttling valves, normally open, unless otherwise indicated. The temperature control contractor shall provide the valves for field installation by the mechanical contractor.
6. The temperature control contractor shall provide direct digital thermostats and mount/wire as shown on the drawings. Thermostats shall have a 10 F. (adjustable) setpoint range.

B. Control Sequence for Variable Air Volume Boxes without reheat coils:

1. A digital space thermostat shall provide a signal to position the unit damper to modulate from minimum position up to maximum position to maintain the space temperature setpoint. When the thermostat is satisfied, the unit damper shall close to minimum position.

C. Control Sequence for Variable Air Volume Boxes with reheat coils:

1. A digital space thermostat shall provide a signal to proportionally position the unit damper and the hot water heating coil in sequence to provide cooling or heating to maintain the space temperature setpoint.
2. On a call for cooling the unit damper shall modulate from minimum position to maintain the space temperature setpoint.
3. For units with heating CFM same as minimum CFM, on a call for heating with the unit damper in the minimum position, the heating water control valve shall be proportionally positioned from fully closed to maintain the space temperature setpoint.
4. For VAV boxes with heating CFM same as maximum CFM provided with dual maximum controllers, on a call for heating the unit damper shall modulate to maximum CFM and the heating water control valve shall be proportionally positioned from fully closed to maintain the space temperature setpoint
5. All VAV boxes shall have temperature sensors at discharge of box, monitored at the DDC.

D. Control sequence for Variable Air Volume Boxes with reheat coils and perimeter radiation:

1. A digital space thermostat shall provide a signal to proportionally position the unit damper and the hot water heating coil in sequence to provide cooling or heating to maintain the space temperature setpoint.
2. On a call for cooling the unit damper shall modulate from minimum position to maintain the space temperature setpoint.
3. On a call for heating with the unit damper in the minimum (heating) position, the heating water control valve shall be proportionally positioned from fully closed to maintain the space temperature setpoint. If, after a predetermined period of time the zone is not achieving the desired temperature, the area finned tube radiation valve shall open. See Fin Tube Radiation Sequence.

E. Minimum CO_2 Occupant Ventilation Box Controls:

1. This control contractor shall provide carbon dioxide sensors in the rooms (or areas) noted on the plans and as noted below, for control of the VAV box (or boxes) serving that room/zone, to maintain minimum outdoor air ventilation requirements for room occupants. The sensors shall be mounted on wall locations within at the same height as the thermostats.

2. Provide carbon dioxide sensor in each of the spaces identified on the drawings (typically large conference rooms, training rooms, etc.). Wire from the room sensor to control the respective VAV box(es) serving that zone. Upon sensing levels above setpoint (1000 ppm or higher adjustable), open the VAV box(es) in the room or area served to increase primary air flow until CO2 levels have reduced below setpoint. Energize the reheat coil as required to prevent the room from overcooling.

F. Initial Set points:
1. Winter: 69°F (adjustable)
2. Summer: 75°F (adjustable)

G. Operator Station Display: Indicate (as a minimum) the following on operator workstation display terminal:
1. DDC system graphic.
2. Damper position
3. Discharge temperature
4. Thermostat setpoint
5. Actual room temperature
6. High and low room temperature alarms at DDC
7. Reheat coil – on/off
8. Electric coil alarms
9. Provide 30-day summary/history logs of space temperatures and VAV operation
10. CO2 control as applicable:
    a. Carbon dioxide high limit setpoint
    b. Carbon dioxide setpoint
    c. Carbon dioxide indication

1.8 FAN POWERED AIR VOLUME TERMINAL UNIT OPERATING SEQUENCE – SERIES BOXES

A. General
1. This control type applies to all series fan-powered VAV boxes with reheat coils.
2. Fan-powered terminal units shall be controlled automatically through local electronic (DDC) velocity controllers
3. The DDC damper actuators shall be provided by this temperature control contractor for field mouinting and calibration by this contractor.
4. Pressure Independent Control. Airflow measuring sensors at the air terminal inlet shall provide a signal to control the unit airflow proportionally between the minimum and maximum CFM setpoints regardless of upstream duct pressure.
5. Heating water control valves shall be fully modulating digital two-way throttling valves, normally open, unless otherwise indicated. The temperature control contractor shall provide the valves and actuators for field installation by the mechanical contractor.
6. The temperature control contractor shall provide direct digital thermostats and mount/wire as shown on the drawings. Thermostats shall have a 10 F. (adjustable) setpoint range.

B. Fan-Powered Variable Air Volume Terminal Air Units with Hot Water Heating Coil Control:
1. The fan runs continuously in occupied mode of operation. The damper shall be at minimum position. A digital space thermostat shall provide a signal to proportionally position the unit damper and the hot water heating coil in sequence to provide cooling or heating to maintain the space temperature setpoint. On a call for cooling, the damper shall modulate to fully open to the primary air, the heating valve shall be fully closed. When thermostat is satisfied, the damper returns to minimum position. On a call for heating the primary air damper shall be at minimum position. The heating valve shall modulate open to provide heat to the space. When thermostat is satisfied, the fan continues to run, the motorized damper returns to minimum position and the heating valve shall be fully closed.

C. Minimum CO_2 Occupant Ventilation Box Controls:
1. This control contractor shall provide carbon dioxide sensors in the rooms (or areas) noted on the plans, for control of the series powered fan-powered VAV box (or boxes) serving that room/zone, to maintain minimum outdoor air ventilation requirements for room occupants.

2. Provide carbon dioxide sensor in each of the spaces identified on the drawings for the series fan powered boxes. Wire from the room sensor to control the respective fan-powered VAV box(es) serving that zone. Upon sensing levels above setpoint (1000 ppm or higher adjustable), open the VAV box(es) primary air damper in the room or area served to increase primary air flow until CO2 levels have reduced below setpoint. Energize the reheat coil as required to prevent the room from overcooling.

D. Initial Set points:
   1. Winter: 69°F (adjustable)
   2. Summer: 75°F (adjustable)

E. Operator Station Display: Indicate (as a minimum) the following on operator workstation display terminal:
   1. DDC system graphic.
   2. Fan status – on/off
   3. Fan failure
   4. Damper position
   5. Thermostat setpoint
   6. Discharge temperature
   7. Actual room temperature
   8. High and low room temperature alarms
   9. Reheat coil – valve position
   10. Provide 30-day history/summary logs of space temperatures and VAV operation
   11. CO2 control as applicable:
       a. Carbon dioxide high limit setpoint
       b. Carbon dioxide setpoint
       c. Carbon dioxide indication

1.9 FAN POWERED VARIABLE AIR VOLUME TERMINAL UNIT OPERATING SEQUENCE – PARALLEL BOXES

A. General
   1. This control type applies to parallel fan-powered VAV boxes with reheat coils.
   2. Fan-powered terminal units shall be controlled automatically through local electronic (DDC) velocity controllers
   3. The DDC damper actuators shall be provided by this temperature control contractor for field mounting and calibration by this contractor (or for factory mounting by VAV manufacturer at contractors option).
   4. Pressure Independent Control. Airflow measuring sensors at the air terminal inlet shall provide a signal to control the unit airflow proportionally between the minimum and maximum CFM setpoints regardless of upstream duct pressure.
   5. Heating water control valves shall be fully modulating digital two-way throttling valves, normally open, unless otherwise indicated. The temperature control contractor shall provide the valves and actuators for field installation by the mechanical contractor.
   6. The temperature control contractor shall provide direct digital thermostats and mount/wire as shown on the drawings. Thermostats shall have a 10 F. (adjustable) setpoint range.
   7. All VAV boxes shall have temperature sensors at discharge of box, monitored at the DDC.

B. Fan-Powered Variable Air Volume Terminal Air Units with Hot Water Heating Coil Control:
   1. A digital space thermostat shall provide a signal to proportionally position the unit damper and the hot water heating coil in sequence to provide cooling or heating to maintain the space temperature setpoint. On a call for heating, the fan shall energize. The primary air damper shall be at minimum position. When thermostat is satisfied, the fan shall be off.
   2. On a call for cooling the unit primary air damper shall modulate from minimum position to fully open to maintain the space temperature setpoint. The fan shall be off.

C. Minimum CO_2 Occupant Ventilation Box Controls:
   1. This control contractor shall provide carbon dioxide sensors in the rooms (or areas) noted on the plans and as noted below, for control of the fan-powered VAV box (or boxes) serving that room/zone, to maintain minimum outdoor air ventilation requirements for room occupants.

2. Provide carbon dioxide sensor in each of the spaces identified on the drawings (typically large conference rooms, training rooms, etc.). Wire from the room sensor to control the respective fan-powered VAV box(es) serving that zone. Upon sensing levels above setpoint (1000 ppm or higher adjustable), open the VAV box(es) primary air damper in the room or area served to increase primary air flow until CO2 levels have reduced below setpoint. Energize the reheat coil and fan as required to prevent the room from overcooling.

D. Initial Set points:
   1. Winter: 69°F (adjustable)
   2. Summer: 75°F (adjustable)

E. Operator Station Display: Indicate (as a minimum) the following on operator workstation display terminal:
   1. DDC system graphic.
   2. Fan status – on/off
   3. Fan failure
   4. Damper position
   5. Thermostat setpoint
   6. Discharge temperature
   7. Actual room temperature
   8. High and low room temperature alarms
   9. Reheat coil – valve position
   10. Provide 30-day history/summary logs of space temperatures and VAV operation
   11. CO2 control as applicable:
       a. Carbon dioxide high limit setpoint
       b. Carbon dioxide setpoint
       c. Carbon dioxide indication

1.10 HEAT PUMP CONTROL SEQUENCE

A. General
   1. The control sequence is for water to air heat pumps.
   2. Units include supply fans, compressor, reversing valve, air filters.
   3. Units are constant volume, heating and cooling type which provides space conditioning.
   4. Factory installed hardware and software shall enable building management system to control, monitor, control, display water-to-air status and alarms. Refer to Division 23 Section "Electric Boilers." All associated interlock wiring, relays, and other components required connect factory installed hardware to building management system shall be provided by Division 23.
   5. Unit shall be interlocked via DDC to start and stop.

B. Supply Temperature and Fan Control
   1. The unit shall run according to a user definable time schedule in the following modes:
      a. Occupied mode: The unit shall maintain:
         1) A 73 deg F cooling zone setpoint
         2) A 70 deg F heating zone setpoint
      b. Unoccupied Mode:
         1) A 78 deg F cooling zone setpoint
         2) A 66 deg F heating zone setpoint
   2. Combined/dual heat pump arrangements shall have a 2nd set of occupied and unoccupied temperature set points run according to a user definable time schedule in the following modes:
      a. Occupied mode: The second unit shall maintain:
         1) A 75 deg F cooling zone setpoint
         2) A 68 deg F heating zone setpoint
      b. Unoccupied Mode:
         1) An 80 deg F cooling zone setpoint
         2) A 64 deg F heating zone setpoint
   3. Zone temperature warnings shall be provided as follows for each fan coil unit:
      a. High Zone temperature: If the zone is above setpoint by an adjustable, user defined margin. Initial margin setting: 4 deg F.
      b. Low Zone Temperature: If the zone is below setpoint by an adjustable, user defined margin. Initial margin setting: 5 deg F.

4. Zone overrides
   a. A timed local override control shall allow an occupant to override the schedule and place the unit into an occupied mode for an adjustable period of time. Initial override time 2 hours. At the expiration of this time, the control of the unit shall automatically return to the schedule.
   b. Fan on-auto switch.

C. Heating and Cooling Control
1. The compressor and reversing valve shall be staged to maintain the zone temperature setpoint.
   a. Heating shall be enabled when fan is on and reversing valve is in heating mode.
   b. Cooling shall be enabled when fan is on and reversing valve is in cooling mode.
   c. To prevent cycling, provide 60 second delay when transitioning between heating and cooling modes.

D. Carbon Dioxide Control
1. See plans for CO2 sensor locations.
2. Heat pump units serving spaces with carbon dioxide sensors shall run the fan whenever space carbon dioxide setpoint is exceeded. Initial setpoint 1250 ppm. Heat pump coil shall modulate to maintain space temperature setpoint.
3. Outdoor Air Duct Motorized Damper Control: motorized damper shall modulate to maintain space carbon dioxide setpoint. Initial setpoint 800 ppm. Associated room exhaust air motorized damper shall modulate to match outdoor air damper position.
4. Alarm condition shall occur whenever space carbon dioxide setpoint is exceeded for more than 60 minutes (adj.)

E. Operator Station Display: Indicate the following on operator workstation display terminal for each fan coil unit:
1. DDC system graphic
2. DDC system on-off indication
3. DDC system occupied/unoccupied mode
4. Room temperature indication
5. Room temperature set point
6. Zone occupied status
7. Zone occupied time
8. Zone override status (on/off)
9. Occupancy sensor control mode (on/off)
10. Fan schedule control mode (on/off)
11. Reversing-valve mode (cooling/heating)
12. Supply air temperature
13. Fan on-off indication
14. Fan runtime.
15. Carbon dioxide high limit setpoint
16. Carbon dioxide setpoint
17. Carbon dioxide indication
18. Additional unit Alarms shall include:
    a. Controller fault
    b. Compressor run-time exceeded (One per compressor)
    c. Unit in manual override
    d. Carbon dioxide high limit

3.1 HEATING WATER SYSTEM

A. General.
1. The heating water system includes the hot water boilers, the heating water system pumps, air separator, expansion tank, glycol make-up unit, and miscellaneous control instrumentation.
2. The heating water system is intended to operate with 33% ethylene glycol solution.
3. The boilers are high efficiency units.
4. The heating water system shall be controlled automatically through the local direct digital control panels and the packaged boiler controls using PI and PID control methods. Sensing elements shall be electronic types; damper and valve operators shall be electric or electronic types. Safety and limit controls shall utilize local electric or electronic control loops.

B. Boiler Control:

1. The hot water boilers are packaged units with master and dedicated operating and safety controls. The boilers are sized and intended to operate with N+1 redundancy capability.
2. The BAS shall communicate with the boiler control package for start/stop, setpoint, and alarm capability. Other operating parameters shall be able to be transmitted to the BAS via network mapping.
3. The BAS contractor shall have overall responsibility for all interface and coordination efforts required for a fully functional system based on this design intent.
4. When signaled to operate, the packaged boiler controls shall open the dedicated isolation valves and modulate the boiler-burner from minimum to maximum to maintain the boiler water leaving temperature setpoint.
5. The setpoint temperature for the boiler (and system) supply water temperature: 140 deg F (adj).
6. The coordinated controls shall start and stop the packaged boilers based on the heating water supply temperature as follows:
   a. When the HWS falls 3 deg F (adj) below setpoint, start the lead boiler (or next boiler in the stage-on sequence) and modulate the burners to maintain supply water setpoint. Delay the boiler start for an adjustable time period, initially 5 minutes (adj), to assure the HWS temperature is consistently 3 deg F below setpoint.
   b. When the HWS falls 6 deg F (adj) below setpoint, send a signal to start the next boiler in sequence and abandon the start of the previously attempted boiler. Also send an alarm to BAS (Investigate Potential Boiler Failure).
   c. When the HWS rises to 2 deg F above setpoint for 10 minutes and the boiler-burner(s) at minimum fire, stop the lag/next boiler in the stage-off sequence.
   d. If after all lag boilers have sequenced off, the HWS continues to exceed 2 deg F above setpoint for 10 minutes, stop the lead boiler.
7. The lead and lag designation of the boilers shall be automatically rotated on a monthly (adj) basis.
8. Emergency shut off:
   a. A wall switch located near the boiler room exit will be hard wired to the boiler control panel to shutdown the boiler(s) and provide a DDC system alarm. Provide a manual reset at the boiler control panel.

C. Heating Water Temperature Control.

1. A temperature sensor in the heating water supply piping shall provide a signal to sequence and to modulate the hot water boilers to maintain a setpoint temperature. The setpoint temperature shall be reset with the outside air temperature as follows:

HWS Temperature	OA Temperature
120 deg F.	Above 40 deg F.
120 deg F to 140 deg F.	40 deg F to 0 deg F.
140 deg F.	Below 0 deg F.

D. Pump and Flow Control:

1. Description: The pumps are sized in an N+1, 100%-100% configuration to provide 100% of the anticipated system demand, and redundancy. During normal operation, the LEAD pump maintains discharge water pressure and flow while the BACKUP pump is available in case of emergency or maintenance.
2. Start LEAD pump manually or from occupancy schedule. Proof of flow via DP switch.
3. The pump(s) will be modulated from a local DPT near the pumps, whose setpoint will be reset by a remote DPT located out near the far end of the pipe network. Reset the local DPT setpoint as required to maintain 5 psig (adj.) differential between supply and return mains at the location noted on the piping plans.
4. If differential pressure drops below setpoint for 5 minutes continuous (adj.) and VFD is at 100% speed or on lack of proof-of-flow, start BACKUP pump, modulate pump speeds in unison and send an alarm to BAS (lead pump failure).
   a. Stage off: When LEAD and BACKUP pumps speeds both drop below 45 percent for 5 continuous minutes (adj.), disable BACKUP pump and related speed control.
5. Alarm when LEAD pump has been signaled to run and fails to do so for more than 10 seconds after start command has been given. Start BACKUP pump.

6. Provide program to alternate LEAD/BACKUP pumps to equalize run times. Initially set program to switch LEAD pump designation every month (adj.). Operator shall also have the capability to select the LEAD pump from the operator's workstation. Run time shall be monitored on an hourly basis.
7. Calculate the overall minimum flow needed based on the number of operating boilers and the manufacturer recommended minimums for each. If the system meter flow signal drops below manufacturer recommend flow minimums for the number of boilers operating, open the modulating bypass valve to accommodate.

E. Heating water system pressure: Monitor and display system pressure. Alarm if system pressure falls below setpoint of 7 psig (adj), and activate the glycol fill pumping unit until system pressure returns to 12 psig (adj). Alarm shall not be allowed to be fully reset until appropriate maintenance personnel has investigated and satisfactorily determined the cause of the pressure loss, and logged a full description, date, time and identification into the BAS.

F. Display:
   a. Boiler(s) status: enabled/disabled
   b. Boiler(s) Operation: On/Off
   c. Boiler(s) firing rate.
   d. Boiler(s) supply temperature
   e. Boiler(s) supply temperature setpoint
   f. Boiler(s) return temperature.
   g. Boiler(s) alarm.
   h. Emergency Shutoff status: Enable/Disable
   i. Outdoor-air temperature.
   j. Heating-water return temperature.
   k. Heating-water return system pressure.
   l. Heating-water supply temperature.
   m. Heating-water supply temperature set point.
   n. System Flow: GPM.
   o. System energy use, BTUH.
   p. Pump(s) enabled/disabled.
   q. Pumps(s) Operating status: on/off
   r. System local differential pressure
   s. System local differential pressure setpoint
   t. System remote differential pressure
   u. System remote differential pressure setpoint
   v. Pump(s) VSD speed: Hz
   w. Pump(s) VSD Full load amps
   x. Pump(s) VSD alarm.

3.2 CHILLED WATER SYSTEM

A. The chilled water system shall be enabled by the following: 1) Automatically by the BAS, when the outside air temperature is greater than 50^{o}F, 2) Upon activation of a manual software "switch" at the Operator's workstation(s). Upon system start-up, the chilled water pump(s) will start and establish flow through chiller. The chiller manufacturer's internal controls will verify proof of flow, and then start and stage and/or modulate to maintain 42°F (adj) chiller leaving water temperature.

B. Chilled Water Pump Control:
   1. The chilled water pumps will be modulated from a local DPT near the pumps, whose setpoint will be reset by the remote (master) DPT located near the far end of the pipe network.
      a. Start lead pump from BAS and modulate to meet the remote differential pressure set point of 10 psig (adj).
      b. When setpoint differential pressure is not maintained for more than 5 minutes (adj) and VFD is at 100% speed, start second pump and alarm the BAS. Lag pump start sequence shall be to start pump at 30% speed and ramp pump up over 30 seconds until it matches the speed of the lead pump. Once speeds have matched, operate pumps in unison.
      c. If pump speeds drop below 70% (adj.) for more than 5 minutes (adj) with both pumps running, stop the lag pump.
      d. If an operating pump fails, send an alarm to BAS and start backup pump.

e. Send an alarm to BAS if backup/lag pump is to run and fails to do so within 10 seconds of when start command has been given.
f. Lead/lag alternating will be based on calendar schedule and the default lead pump selection will be programmed to change weekly (adj). Operator shall also have the capability to select LEAD/LAG assignments from the operator's workstation. Runtime shall be monitored on an hourly basis.

2. Monitor system pressure at the chilled water system expansion tank and signal an alarm to the operator's work station if pressure drops below 12 psig (adj). Stop pumps and signal alarm if pressure drops below 5 psig (adj).

C. Chilled Water Bypass Valve Control:

1. The chilled water system flows shall be measured by the flow meter. The chilled water bypass valve shall start to slowly open as the metered flowrate approaches (within 50 gpm, adj) the manufacturer's recommended minimum flow rating of the operating chiller(s). The bypass valve shall modulate to maintain the minimum flowrates to the operating chiller(s). Verify minimum chiller flow setpoints with the chiller manufacturer.

D. Display

1. DDC system graphic.
2. DDC system status: Manual on/off button
3. Chilled water system status: (enabled/disabled)
4. Outdoor-air temperature.
5. Time and time schedule.
6. Chilled-water pump(s) on-off status.
7. Chilled-water pump(s) on-off indication.
8. Pump(s) VSD speed: Hz
9. Pump(s) VSD Full load amps
10. Pump(s) VSD alarm.
11. Chilled-water flow indication: gpm
12. Refrigeration machine on-off indication.
13. Leaving water temperature.
14. Leaving water temperature: Set point
15. Entering water temperature.
16. Entering water temperature: Set point
17. Chiller(s) on-off status.
18. Chiller(s) on-off indication.
19. Chiller "failure-to-start" indication.
20. Chilled-water pressure drop through chiller.
21. System capacity in tons.

1.11 FIN TUBE RADIATION OPERATING SEQUENCE

A. Radiators, Hydronic:

1. This control contractor shall provide DDC control valves as shown on the plans and electronic space temperature sensors. Electronic space temperature sensors may control both the finned tube radiation and a perimeter VAV box.
2. Room Temperature: An electronic sensor will sense and indicate space temperature; the thermostat will control both the finned tube radiation and the perimeter VAV box(es) with reheat coils serving the same area. The sequence shall first close the box to minimum. Upon a call for heating, with the VAV box at it's minimum air position, the VAV box reheat coil normally open valve opens first to provide heat to the perimeter zone. If, after a predetermined period of time the zone is not achieving desired temperature, the area finned tube radiation normally open valve shall open and provide supplemental heat to the zone. When temperature reaches and satisfies thermostat setpoint, both control valves shall modulate closed. This temperature control contractor shall provide the normally open 2-way modulating motorized control valves.
3. Initial set point 69°F (adjustable).
4. Display:
   a. Room temperature indication.
   b. Room temperature set point.
   c. Control-valve position.

1.12 UNIT HEATER OPERATING SEQUENCE

A. This control sequence consists of the unit heaters, motorized valves and thermostats.

B. Provide the hot water motorized control valves with DDC actuators.

C. Provide and mount the thermostat(s) on the wall of the space to be heated. Temperature setpoint shall be set from the DDC system.

D. Upon signal from space temperature sensor, energize the fan and modulate the valve to maintain space temperature.

E. Unit heaters shall be shut off when outdoor temperature exceeds space heating setpoint as referenced from the building DDC system outdoor temperature sensor.

F. Shut off the fan and close the valve when thermostat is satisfied.

G. Display:
   1. Temperature setpoint at room thermostat
   2. Valve position – open/closed
   3. Fan status – on/off

1.13 CABINET UNIT HEATER OPERATING SEQUENCE

A. This control sequence consists of the cabinet unit heaters, motorized valves and thermostats.

B. Provide the hot water motorized control valves with DDC actuators. The mechanical contractor installs the thermostats.

C. Provide and mount the thermostat on the wall of the space to be heated. Temperature setpoint shall be set from the DDC system.

D. Upon signal from space temperature sensor, energize the fan and modulate the valve to maintain space temperature.

E. Cabinet unit heaters shall be shut off when outdoor temperature exceeds space heating setpoint as referenced from the building DDC system outdoor temperature sensor.

F. Display:
   1. Temperature setpoint at room thermostat
   2. Valve position
   3. Fan status

1.14 FIRE/SMOKE DAMPER CONTROL

A. Smoke and Smoke/Fire Damper Control.
   1. Smoke and Smoke/Fire dampers are provided as work of Division 233300 Section "Duct Accessories." The manufacturer of the dampers shall provide 120 volt damper actuators. The electrical contractor shall provide local smoke detectors for activation of the smoke/fire damper actuators. The electrical contractor shall wire from the smoke detector(s) to the respective damper operators.
   2. Fire/Smoke Damper Operation: Upon detection of smoke via space smoke detectors in areas or ducts served (via signal from the fire alarm system) the dampers shall close and air handling unit and related fans shall stop. The temperature control contractor shall provide control wiring/interface with the BAS to enable these functions.
   3. The damper position, open/closed shall be monitored on the BAS.
   4. The end switch shall allow the BAS to command the damper closed for testing.
   5. Electrical wiring, smoke detectors, and fire alarm signal wiring are provided as work of Division 26.
   6. Operator Station Display: Indicate the following on operator workstation display terminal:
      a. DDC system graphic
      b. Damper position

1.15 VENTILATION SEQUENCES

A. Exhaust Fan: The exhaust fan will be started and stopped by the DDC system time schedule. The DDC system operator may start or stop the fan manually.

1. Display
    a. Manual on/off
    b. Fan status

B. Exhaust Fan: A pressure differential sensors will modulate fan motor speed to maintain a constant exhaust duct pressure relative to space pressure.
    1. Exhaust air terminal will modulate to maintain a constant air flow through the terminal.

3.1 MISC SPACE, SPLIT SYSTEM CONTROL

A. General: The fan coil unit is a constant air volume indoor unit equipped with the following:
    1. Supply fan.
    2. Direct expansion refrigerant cooling coil furnished with fan coil.
    3. Matching air cooled condensing unit.

B. Space Cooling Control:
    1. The BAS controller will energize unit fan and air cooled condensing unit to maintain space temperature set-point of 75º F (adj.).
    2. Provide 5º F (adj.) dead band to prevent unit fan and compressor short cycling.

3.2 MISCELLANEOUS CONTROL

A. Humidifier Control:
    1. Prove airflow with airflow switch.
    2. Energize and modulate humidifier steam production using a BAS input signal, originating from a humidistat located in the related space.
    3. Provide high humidity safety via sensor to disable electric humidifier steam production and send alarm to BAS if duct downstream humidity level rises above 90% rh (adj).

B. Domestic Water Heating System:
    1. The domestic water heating system includes the gas-fired water heaters, the hot water recirculating pump, and thermostatic mixing valve. The domestic water heating system provides domestic hot water for the Addition.
    2. The domestic water heating water heaters shall be controlled automatically through the manufacturer's local packaged controls.
    3. The recirc pump shall be started and stopped by the BAS system time schedule. It shall run continuously during occupied periods. The recirc pump shall shutdown during unoccupied periods. Provide manual shutdown from BAS workstation and through local HOA switch.
    4. Provide a temperature sensor on the main system water supply. Monitor and display the system supply water temperature to the building distribution. Provide an alarm if the temperature exceeds 120°F (adj).
    5. Provide a temperature sensor on the main system recirculation line back into the water room. Monitor and display the recirculation line temperature reading.

C. Elevator and Stormwater Sump Pump Operation:
    1. Utilize the sump pump control panel to send a high level alarm signal to the BAS operator workstation.

D. Lighting controls shall be integrated into the building control system through BACnet integration. Coordinate with Division 26 lighting contractor.

E. Coordinate and provide alarm notification for the following hard-wired input points available from other trades and/or contractors:
    1. Sump pump(s) high level alarm.

2. Sump pump(s) general alarm.
3. Water Softener package general alarm.
4. Fire alarm panel general alarm.
5. Generator start/run status.
6. Generator general alarm.
7. Generator fuel low level alarm.
8. Elevator controller general alarms.

PART 2 PRODUCTS

PART 3 EXECUTION

END OF SECTION

SECTION 230995
DATA AND CONTROL POINTS LIST

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 building automation and temperature control partial points list. Additional points maybe required to properly execute a sequence of operation.

B. Related Sections include the following:
1. Division 23 Section "Instrumentation and Control for HVAC" for control equipment and devices and for submittal requirements.
2. Division 23 Section "Sequence of Operations for HVAC Controls" for requirements that relate to this Section.
3. Division 23 Section "Control Standard for BACNET Integration" for requirements that relate to this Section.

1.3 DEFINITIONS

A. The following are common industry abbreviations for control points:
1. ASD: Adjustable speed drive.
2. CC: Cooling Coil
3. CFM: Cubic feet per minute
4. FTR: Finned Tube Radiation
5. GPM: Gallons per minute
6. HC: Heating coil.
7. M.A.: Mixed Air
8. O.A.: Outside Air
9. R.A.: Return air
10. RH: Relative humidity
11. S.P.: Static pressure.
12. VSD: Variable Speed Drive

1.4 PERFORMANCE REQUIREMENTS

A. The following table is a minimum points list developed to assist the building automation system provider. The BAS manufacturer and installer shall provide any additional points necessary to perform the sequences of control identified in other Division-23 sections.

	Hardware Points				Software Points					
Point Name	AI	AO	BI	BO	AV	BV	Sched	Trend	Alarm	Show on Graphic
(Example) AHU-1										
Supply air static pressure	X							X		X
Supply air S.P. set point					X					X
High supply air static pressure									X	X
Low supply air static pressure									X	X

	Hardware Points				Software Points					
Point Name	AI	AO	BI	BO	AV	BV	Sched	Trend	Alarm	Show on Graphic
Return plenum static pressure	X							X		X
Return Plenum S.P. set point					X					X
High return plenum static press.									X	X
Low return plenum static press.									X	X
Building static pressure	X							X		X
Building static pressure set point					X					X
High building static pressure									X	X
Low building static pressure									X	X
Outside air flow	X							X		X
Outside air flow set point					X					X
Low outside air flow									X	X
Supply air humidity	X							X		X
High supply air humidity									X	
Prefilter differential pressure	X							X		X
High differential pressure									X	
Mixed air temperature	X							X		X
Econ mixed air temp set point					X					X
Humidifier		X								X
Humidifier enable				X						X
Return air humidity	X							X		X
Humidifier set point					X					X
Supply air humidity	X							X		X
High supply air humidity									X	X
Return air temperature	X							X		X
Supply air temperature	X							X		X
Chilled water valve		X						X		X
Heating valve		X						X		X
Supply air temperature set point					X					X
Heating coil pump status			X					X		X
Heating coil pump start/stop				X				X		X

	Hardware Points				Software Points					
Point Name	AI	AO	BI	BO	AV	BV	Sched	Trend	Alarm	Show on Graphic
Relief air damper		X								X
Mixed air dampers		X								X
Freezestat			X					X	X	X
Emergency shutdown						X			X	X
Supply fan status			X					X		X
Supply fan start/stop				X				X		X
Supply fan VSD speed		X						X		X
Supply fan VSD fault			X						X	X
Supply air smoke detector			X					X	X	X
Return fan status			X					X		X
Return fan start/stop				X				X		X
Return fan VSD speed		X						X		X
Return fan VSD fault			X						X	X
Return air smoke detector			X					X	X	X
Example: Air Terminal Unit										
Space Temperature	X							X		X
Space Temperature Setpoint	X									X
Air Flow	X							X		X
Discharge Air Temperature	X							X		X
Zone Damper		X								X
Reheat Valve		X								X
Perimeter Heating Valve		X								X
Zone Override			X							X
Maximum Air Flow Set Point					X					X
Minimum Air Flow set Point					X					X
Heating Air Flow Set Point					X					X
Schedule							X			X
Heating Temperature Set Point										X
Cooling Temperature Set Point										X

	Hardware Points				Software Points					
Point Name	AI	AO	BI	BO	AV	BV	Sched	Trend	Alarm	Show on Graphic
High Zone Temperature									X	X
Low Zone Temperature									X	X

<u>Notes</u>

1. High Pressure Limit (positive). Hard-wired to VSD.
2. High Pressure Limit (negative). Hard-wired to VSD.
3. Duct Static Pressure Sensor located toward the end of supply air duct.
4. Coordinate connection requirements with equipment provided.
5. Return air sensors located upstream of minimum outside air duct connection.
6. Global Point. Used for more than one system.
7. Low Temperature Limit. Hard-wired to VSD.
8. Local temperature controls. Hard-wired to equipment.

PART 2 – PRODUCTS (NONE)

PART 3 – EXECUTION (NONE)

END OF SECTION

SECTION 232113
HYDRONIC 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. Section includes pipe and fitting materials and joining methods for the following:
   1. Hot-water heating piping.
   2. Chilled-water piping.
   3. Condenser-water piping.
   4. Makeup-water piping.
   5. Condensate-drain piping.
   6. Blowdown-drain piping.
   7. Air-vent piping.
   8. Safety-valve-inlet and -outlet piping.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of the following:
   1. Plastic pipe and fittings with solvent cement.
   2. RTRP and RTRF with adhesive.
   3. Chemical treatment.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Piping layout, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
   1. Suspended ceiling components.
   2. Other building services.
   3. Structural members.

B. Field quality-control reports.

C. Water Analysis: Submit a copy of the water analysis to illustrate water quality available at Project site.

1.5 QUALITY ASSURANCE

A. Installer Qualifications:
   1. Installers of Pressure-Sealed Joints: Installers shall be certified by pressure-seal joint manufacturer as having been trained and qualified to join piping with pressure-seal pipe couplings and fittings.

B. Steel Support Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

C. Pipe Welding: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code: Section IX.
   1. Comply with ASME B31.9, "Building Services Piping," for materials, products, and installation.
   2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.

D. 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 ASME Boiler and Pressure Vessel Code: Section VIII, Division 01.

1.6 COORDINATION

A. Coordinate layout and installation of hydronic piping and suspension system components with other construction, including light fixtures, HVAC equipment, fire-suppression-system components, and partition assemblies.

B. Coordinate pipe sleeve installations for foundation and exterior wall penetrations. Coordinate with requirements specified in Division 7 Sections for sealing pipe penetrations through exterior and foundation walls.

C. Coordinate piping installation with roof curbs, equipment supports, and roof penetrations. Roof specialties are specified in Division 7 Sections.

D. Coordinate pipe fitting pressure classes with products specified in related Sections.

E. Coordinate power requirements for hydronic specialties with Division 26 installer.

F. Coordinate the installation of hydronic control devices with Section 230900 "Instrumentation and Controls for HVAC".

PART 2 PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Hydronic piping components and installation shall be capable of withstanding the following minimum working pressure and temperature unless otherwise indicated:

1. Hot-Water Heating Piping: 125 psig at 200 degrees F.
2. Chilled-Water Piping: 125 psig at 200 degrees F.
3. Condenser-Water Piping: 125 psig at 150 degrees F.
4. Makeup-Water Piping: 80 psig at 150 degrees F.
5. Condensate-Drain Piping: 150 degrees F.
6. Blowdown-Drain Piping: 200 degrees F.
7. Air-Vent Piping: 200 degrees F.
8. Safety-Valve-Inlet and -Outlet Piping: Equal to the pressure of the piping system to which it is attached.

2.2 COPPER TUBE AND FITTINGS

A. Manufacturers: Subject to compliance with requirements, provide copper tubing and fittings manufactured by one of the following:

a. Cambridge-Lee Industries Incorporated.
b. Cerro Flow Products Incorporated.
c. Mueller Industries Incorporated.
d. Nibco Incorporated

B. Drawn-Temper Copper Tubing: ASTM B 88, Type L

C. Annealed-Temper Copper Tubing: ASTM B 88, Type K.

D. DWV Copper Tubing: ASTM B 306, Type DWV.

E. Wrought-Copper Unions: ASME B16.22.

F. Prohibited: ProPress

2.3 STEEL PIPE AND FITTINGS

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

1. American Steel Pipe; Division of American Cast Iron Pipe Company.
2. Central Steel and Wire Company.
3. LaBarge Pipe and Steel Company.

B. Steel Pipe: ASTM A 53/A 53M, black steel with plain ends; welded and seamless, Grade B, and wall thickness as indicated in "Piping Applications" Article.

C. Cast-Iron Threaded Fittings: ASME B16.4; Classes 125 and 250 as indicated in "Piping Applications" Article.

D. Malleable-Iron Threaded Fittings: ASME B16.3, Classes 150 and 300 as indicated in "Piping Applications" Article.

E. Malleable-Iron Unions: ASME B16.39; Classes 150, 250, and 300 as indicated in "Piping Applications" Article.

F. Cast-Iron Pipe Flanges and Flanged Fittings: ASME B16.1, Classes 25, 125, and 250; raised ground face, and bolt holes spot faced as indicated in "Piping Applications" Article.

G. Wrought-Steel Fittings: ASTM A 234/A 234M, wall thickness to match adjoining pipe.

H. 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.

I. Grooved Mechanical-Joint Fittings and Couplings:

1. Manufacturers: Subject to compliance with requirements, provide products by the following:
   a. Anvil International, Inc.
   b. Central Sprinkler Company; a division of Tyco Fire & Building Products.
   c. National Fittings, Inc.
   d. Victaulic Company.
2. Joint Fittings: ASTM A 536, Grade 65-45-12 ductile iron; ASTM A 47/A 47M, Grade 32510 malleable iron; ASTM A 53/A 53M, Type F, E, or S, Grade B fabricated steel; or ASTM A 106/A 106M, Grade B steel fittings with grooves or shoulders constructed to accept grooved-end couplings; with nuts, bolts, locking pin, locking toggle, or lugs to secure grooved pipe and fittings.
3. Couplings: Ductile- or malleable-iron housing and EPDM or nitrile gasket of central cavity pressure-responsive design; with nuts, bolts, locking pin, locking toggle, or lugs to secure grooved pipe and fittings.

J. Steel Pipe Nipples: ASTM A 733, made of same materials and wall thicknesses as pipe in which they are installed.

2.4 PLASTIC PIPE AND FITTINGS

A. CPVC Plastic Pipe: ASTM F 441/F 441M, with wall thickness as indicated in "Piping Applications" Article.

1. CPVC Plastic Pipe Fittings: Socket-type pipe fittings, ASTM F 438 for Schedule 40 pipe; ASTM F 439 for Schedule 80 pipe.

B. PVC Plastic Pipe: ASTM D 1785, with wall thickness as indicated in "Piping Applications" Article.

1. PVC Plastic Pipe Fittings: Socket-type pipe fittings, ASTM D 2466 for Schedule 40 pipe; ASTM D 2467 for Schedule 80 pipe.

2.5 JOINING MATERIALS

A. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.

1. ASME B16.21, nonmetallic, flat, asbestos free, 1/8-inch maximum thickness unless otherwise indicated.
   a. Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.
   b. Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.

B. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.

C. Plastic, Pipe-Flange Gasket, Bolts, and Nuts: Type and material recommended by piping system manufacturer unless otherwise indicated.

D. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.

E. Brazing Filler Metals: AWS A5.8/A5.8M, BCuP Series, copper-phosphorus alloys for joining copper with copper; or BAg-1, silver alloy for joining copper with bronze or steel.

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

G. Solvent Cements for Joining Plastic Piping:
  1. CPVC Piping: ASTM F 493.
    a. CPVC solvent cement shall have a VOC content of 490 g/L or less.
    b. Adhesive primer shall have a VOC content of 550 g/L or less.
    c. Solvent cement and adhesive primer shall comply with the testing and product requirements of the California Department of Public Health's (formerly, the California Health Services') "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
  2. PVC Piping: ASTM D 2564. Include primer according to ASTM F 656.
    a. PVC solvent cement shall have a VOC content of 510 g/L or less.
    b. Adhesive primer shall have a VOC content of 550 g/L or less.
    c. Solvent cement and adhesive primer shall comply with the testing and product requirements of the California Department of Public Health's (formerly, the California Health Services') "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

H. Gasket Material: Thickness, material, and type suitable for fluid to be handled and working temperatures and pressures.

2.6 TRANSITION FITTINGS

A. Plastic-to-Metal Transition Fittings:
  1. Manufacturers: Subject to compliance with requirements, provide products by the following:
    a. Charlotte Pipe and Foundry Company.
    b. IPEX Inc.
    c. KBI Company.
  2. One-piece fitting with one threaded brass or copper insert and one solvent-cement-joint end of material and wall thickness to match plastic pipe material.

B. Plastic-to-Metal Transition Unions:
  1. Manufacturers: Subject to compliance with requirements, provide products by the following:
    a. Charlotte Pipe and Foundry Company.
    b. IPEX Inc.
    c. KBI Company.
    d. NIBCO INC.
  2. Brass or copper end, solvent-cement-joint end of material and wall thickness to match plastic pipe material, rubber gasket, and threaded union.

2.7 BYPASS CHEMICAL FEEDER

A. Description: Welded steel construction; 125-psig working pressure; 5-gal. capacity; with fill funnel and inlet, outlet, and drain valves.
  1. Chemicals: Specially formulated, based on analysis of makeup water, to prevent accumulation of scale and corrosion in piping and connected equipment.

PART 3 EXECUTION

3.1 PIPING APPLICATIONS

A. Hot-water heating piping, aboveground, NPS 2 and smaller, shall be any of the following:
  1. Type L, drawn-temper copper tubing, wrought-copper fittings, and soldered joints.
  2. Type L, drawn-temper copper tubing, wrought-copper fittings, and pressure-seal joints.
  3. Schedule 40, Grade B, Type 96 steel pipe; Class 125, cast-iron fittings; cast-iron flanges and flange fittings; and threaded joints.

B. Hot-water heating piping, aboveground, NPS 2.5 and 3, shall be any of the following:

1. Type L, drawn-temper copper tubing, wrought-copper fittings, and soldered joints.
2. Type L, drawn-temper copper tubing, wrought-copper fittings, and pressure-seal joints.
3. Schedule 40 steel pipe, wrought-steel fittings, wrought-cast or forged-steel flanges, flange fittings, and welded and flanged joints.

C. Hot-water heating piping, aboveground, NPS 4 and larger shall be the following:

1. Schedule 40 steel pipe, wrought-steel fittings, wrought-cast or forged-steel flanges, flange fittings, and welded and flanged joints.

D. Hot-water heating piping installed below ground and within slabs shall be the following:

1. Type K annealed-temper copper tubing:
   a. Install underground tubing without joints.

E. Chilled-water piping, aboveground, NPS 2 and smaller shall be the following:

1. Type L drawn-temper copper tubing, wrought-copper fittings, and soldered joints.
2. Type L, drawn-temper copper tubing, wrought-copper fittings, and pressure-seal joints.
3. Schedule 40, Grade B, Type 96 steel pipe; Class 125, cast-iron fittings; cast-iron flanges and flange fittings; and threaded joints.

F. Chilled-water piping, aboveground, NPS 2.5 and 3 shall be the following:

1. Type L drawn-temper copper tubing, wrought-copper fittings, and soldered joints.
2. Type L, drawn-temper copper tubing, wrought-copper fittings, and pressure-seal joints.
3. Schedule 40 steel pipe; grooved, mechanical joint coupling and fittings; and grooved, mechanical joints.

G. Chilled-water piping, aboveground, NPS 4 and larger shall be the following:

1. Schedule 40 steel pipe, wrought-steel fittings and wrought-cast or forged-steel flanges and flange fittings, and welded and flanged joints.
2. Schedule 40 steel pipe; grooved, mechanical joint coupling and fittings; and grooved, mechanical joints.

H. Condenser-water piping, aboveground, NPS 3 and smaller, shall be any of the following:

1. Type L drawn-temper copper tubing, wrought-copper fittings, and soldered joints.
2. Type L, drawn-temper copper tubing, wrought-copper fittings, and pressure-seal joints.
3. Schedule 40 steel pipe; grooved, mechanical joint coupling and fittings; and grooved, mechanical joints.
4. Schedule 40 steel pipe, wrought-steel fittings, wrought-cast or forged-steel flanges, flange fittings, and welded and flanged joints.

I. Condenser-water piping, aboveground, NPS 4 and larger, shall be any of the following:

1. Schedule 40 steel pipe; grooved, mechanical joint coupling and fittings; and grooved, mechanical joints.
2. Schedule 40 steel pipe, wrought-steel fittings, wrought-cast or forged-steel flanges, flange fittings, and welded and flanged joints.
3. Schedule 10 stainless steel pipe, grooved, mechanical joint coupling and fittings; and grooved, mechanical joints.

J. Condenser-water piping installed below ground and within slabs shall be the following:

1. Schedule 80 CPVC plastic pipe and fittings and solvent-welded joints.Makeup-water piping installed aboveground shall be the following:

1. Type L, drawn-temper copper tubing, wrought-copper fittings, and soldered joints.
2. Type L, drawn-temper copper tubing, wrought-copper fittings, and pressure-seal joints.

L. Makeup-Water Piping Installed Belowground and within Slabs: Type K, annealed-temper copper tubing, wrought-copper fittings, and soldered joints. Use the fewest possible joints.

M. Condensate-Drain Piping: Type DWV, drawn-temper copper tubing, wrought-copper fittings, and soldered joints.

N. Blow-down-Drain Piping: Same materials and joining methods as for piping specified for the service in which blow-down drain is installed.

O. Air-Vent Piping:

1. Inlet: Same as service where installed with metal-to-plastic transition fittings for plastic piping systems according to the piping manufacturer's written instructions.
2. Outlet: Type K, annealed-temper copper tubing with soldered or flared joints.

P. Safety-Valve-Inlet and -Outlet Piping for Hot-Water Piping: Same materials and joining methods as for piping specified for the service in which safety valve is installed with metal-to-plastic transition fittings for plastic piping systems according to the piping manufacturer's written instructions.

3.2 PIPING INSTALLATIONS

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicate piping locations and arrangements if such were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

B. Install exterior underground piping and fittings according to the manufacturer's published instructions. Provide a minimum of two feet of cover.

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 groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves.

M. 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.

N. Install piping at a uniform grade of 0.2 percent upward in direction of flow.

O. Reduce pipe sizes using eccentric reducer fitting installed with level side up.

P. Install branch connections to mains using tee fittings in main pipe, with the branch connected to the bottom of the main pipe. For up-feed risers, connect the branch to the top of the main pipe.

Q. Install valves according to Section 230523 "General-Duty Valves for HVAC Piping."

R. Install unions in steel piping, adjacent to valves, at final connections of equipment, and elsewhere as indicated.

S. Install flanges in piping, NPS 2-1/2 and larger, at final connections of equipment and elsewhere as indicated.

T. Install shutoff valve immediately upstream of each dielectric fitting.

U. Comply with requirements in Section 230516 "Expansion Fittings and Loops for HVAC Piping" for installation of expansion loops, expansion joints, anchors, and pipe alignment guides.

V. Comply with requirements in Section 230553 "Identification for HVAC Piping and Equipment" for identifying piping.

W. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 230517 "Sleeves and Sleeve Seals for HVAC Piping."

X. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 230517 "Sleeves and Sleeve Seals for HVAC Piping."

Y. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 230518 "Escutcheons for HVAC Piping."

Z. Install drain traps for each condensate drain pan for cooling coils in air handling units and fan-coil units. Provide vented water seal and terminate with a turned-down elbow at a floor drain.

1. For roof-mounted equipment, provide drain traps with vented water seal and a turned-down elbow to discharge on the roof.

AA. Install drain piping for outside air and relief/exhaust air plenums, and as indicated. Provide a waste fitting on the sheet metal plenum, and extend a turned-down elbow at a floor drain. Do not trap. Do not use plastic pipe.

3.3 DIELECTRIC FITTING INSTALLATION

A. Install dielectric fittings in piping at connections of dissimilar metal piping and tubing.

B. Dielectric Fittings for NPS 2 and Smaller: Use dielectric nipples or flanges.

C. Dielectric Fittings for NPS 2-1/2 to NPS 4: Use dielectric flanges.

D. Dielectric Fittings for NPS 5 and Larger: Use dielectric flange kits.

3.4 HANGERS AND SUPPORTS

A. Comply with requirements in Section 230529 "Hangers and Supports for HVAC Piping and Equipment" for hanger, support, and anchor devices. Comply with the following requirements for maximum spacing of supports.

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.
5. Provide copper-clad hangers and supports for hangers and supports in direct contact with copper pipe.
6. On plastic pipe, install pads or cushions on bearing surfaces to prevent hanger from scratching pipe.

C. Install hangers for steel piping with the following maximum spacing and minimum rod sizes:

1. NPS 3/4: Maximum span, 7 feet.
2. NPS 1: Maximum span, 7 feet.
3. NPS 1-1/2: Maximum span, 9 feet.
4. NPS 2: Maximum span, 10 feet.
5. NPS 2-1/2: Maximum span, 11 feet.
6. NPS 3 and Larger: Maximum span, 12 feet.

D. Install hangers for drawn-temper copper piping with the following maximum spacing and minimum rod sizes:

1. NPS 3/4: Maximum span, 5 feet; minimum rod size, 1/4 inch.
2. NPS 1: Maximum span, 6 feet; minimum rod size, 1/4 inch.
3. NPS 1-1/4: Maximum span, 7 feet; minimum rod size, 3/8 inch.
4. NPS 1-1/2: Maximum span, 8 feet; minimum rod size, 3/8 inch.
5. NPS 2: Maximum span, 8 feet; minimum rod size, 3/8 inch.
6. NPS 2-1/2: Maximum span, 9 feet; minimum rod size, 3/8 inch.
7. NPS 3 and Larger: Maximum span, 10 feet; minimum rod size, 3/8 inch.

E. Plastic Piping Hanger Spacing: Space hangers according to pipe manufacturer's written instructions for service conditions. Avoid point loading. Space and install hangers with the fewest practical rigid anchor points.

F. Support vertical runs at roof, at each floor, and at 10-foot intervals between floors.

3.5 PIPE JOINT CONSTRUCTION

A. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.

B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

C. 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.

D. 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/A5.8M.

E. 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.

F. Welded Joints: Construct joints according to AWS D10.12M/D10.12, using qualified processes and welding operators according to "Quality Assurance" Article.

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

H. Plastic Piping Solvent-Cemented Joints: Clean and dry joining surfaces. Join pipe and fittings 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 ASTM D 1785 schedule number, 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 Non-pressure Piping: Join according to ASTM D 2855.

I. Grooved Joints: Assemble joints with coupling and gasket, lubricant, and bolts. Cut or roll grooves in ends of pipe based on pipe and coupling manufacturer's written instructions for pipe wall thickness. Use grooved-end fittings and rigid, grooved-end-pipe couplings.

3.6 TERMINAL EQUIPMENT CONNECTIONS

A. Sizes for supply and return piping connections shall be the same as or larger than equipment connections.

B. Install control valves in accessible locations close to connected equipment.

C. Install ports for pressure gages and thermometers at coil inlet and outlet connections. Comply with requirements in Section 230519 "Meters and Gages for HVAC Piping."

3.7 CHEMICAL TREATMENT

A. Perform an analysis of makeup water to determine type and quantities of chemical treatment needed to keep system free of scale, corrosion, and fouling, and to sustain the following water characteristics:

1. pH: 7.0 to 9.
1. "P" Alkalinity: 100 to 500 ppm.
2. Boron: 100 to 200 ppm.
3. Chemical Oxygen Demand: Maximum 100 ppm. Modify this value if closed system contains glycol.
4. Corrosion Inhibitor:
   a. Sodium Nitrate: 1000 to 1500 ppm.
   b. Molybdate: 200 to 300 ppm.
   c. Chromate: 200 to 300 ppm.
   d. Sodium Nitrate Plus Molybdate: 100 to 200 ppm each.
   e. Chromate Plus Molybdate: 50 to 100 ppm each.

5. Soluble Copper: Maximum 0.20 ppm.
6. Tolyiriazole Copper and Yellow Metal Corrosion Inhibitor: Minimum 10 ppm.
7. Total Suspended Solids: Maximum 10 ppm.
8. Ammonia: Maximum 20 ppm.
9. Free Caustic Alkalinity: Maximum 20 ppm.
10. Microbiological Limits:
    a. Total Aerobic Plate Count: Maximum 1000 organisms/ml.
    b. Total Anaerobic Plate Count: Maximum 100 organisms/ml.
    c. Nitrate Reducers: 100 organisms/ml.
    d. Sulfate Reducers: Maximum zero organisms/ml.
    e. Iron Bacteria: Maximum zero organisms/ml.

B. Install bypass chemical feeders in each hydronic system where indicated.
1. Install in upright position with top of funnel not more than 48 inches above the floor.
2. Install feeder in minimum NPS 3/4 bypass line, from main with full-size, full-port, ball valve in the main between bypass connections.
3. Install NPS 3/4 pipe from chemical feeder drain to nearest equipment drain and include a full-size, full-port, ball valve.

C. Fill system with fresh water and add liquid alkaline compound with emulsifying agents and detergents to remove grease and petroleum products from piping. Circulate solution for a minimum of 24 hours, drain, clean strainer screens, and refill with fresh water.

D. Add initial chemical treatment and maintain water quality in ranges noted above for the first year of operation.

E. Fill systems indicated to have antifreeze or glycol solutions with deionized water and the following concentrations:
1. Hot-Water Heating Piping: See drawings for glycol percentage.
2. Chilled-Water Piping: See drawings for glycol percentage.

3.8 FIELD QUALITY CONTROL

A. Prepare hydronic 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 hydronic piping systems with clean water; then remove and clean or replace strainer screens.
4. Isolate equipment from piping. If a valve is used to isolate equipment, its closure 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 hydronic piping:
1. Use ambient temperature water as a testing medium unless there is risk of damage due to freezing. Another liquid that is safe for workers and compatible with piping may be used.
2. While filling system, use vents installed at high points of system to release air. Use drains installed at low points for complete draining of test liquid.
3. Isolate expansion tanks and determine that hydronic system is full of water.
4. Subject piping system to hydrostatic test pressure that is not less than 1.5 times the system's working pressure. Test pressure 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 or 1.7 times the "SE" value in Appendix A in 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.

C. Perform the following before operating the system:

1. Open manual valves fully.
2. Inspect pumps for proper rotation.
3. Clean all strainers.
4. Set makeup pressure-reducing valves for required system pressure.
5. Inspect air vents at high points of system and determine if all are installed and operating freely (automatic type), or bleed air completely (manual type).
6. Set temperature controls so all coils are calling for full flow.
7. Inspect and set operating temperatures of hydronic equipment, such as boilers, chillers, cooling towers, to specified values.
8. Verify proper chemical treatment for each system.
9. Verify lubrication of motors and bearings.

END OF SECTION

SECTION 233113
METAL DUCTS

PART 1 – GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 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-inces to plus 10-inches wg. Metal ducts include the following:
   1. Rectangular ducts and fittings.
   2. Single-wall round longitudinal-seam ducts and formed fittings.
   3. Single-wall, round and flat oval spiral-seam ducts and formed fittings.
   4. Double-wall, round and flat oval spiral-seam ducts and formed fittings.
   5. Duct liner.

B. Related Sections include the following:
   1. Refer to Division 7 Section "Joint Sealants" for fire-resistant sealants for use around duct penetrations and fire-smoke damper installations in fire-smoke rated floors, partitions, and walls.
   2. Refer to Division 8 Section "Access Doors" for wall and ceiling-mounted access doors for access to concealed ducts.
   3. Refer to Division 10 Sections “Louvers and Vents” for intake air, exhaust air, and relief air louvers connected to ducts and installed in exterior walls.
   4. 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. Exposed Duct: Ducts that are visible; except in mechanical equipment rooms.

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 Architect. Accompany requests for layout modifications with calculations showing that proposed layout would provide original design results without increasing system total pressure.

1.5 SUBMITTALS

A. Product Data: Include details of construction, materials, and dimensions of individual components, profiles, and finishes for the following items:
   1. Fire Stopping Materials.
   2. Duct Transverse Joints.
   3. Liners and adhesives.
   4. Sealants and gaskets.
   5. Seismic-restraint devices.
   6. Duct Connection Systems

B. Shop Drawings: Drawn to scale not smaller than 1/4 inch equals 1 foot. Show fabrication and installation details for the size and types of metal ducts in the Project.
   1. Duct fabrication, assembly, and installation details.
   2. Duct sizes and materials thickness for the various systems and duct pressure classes.
   3. Sealing class.
   4. Fittings.
   5. Reinforcement and spacing.

6. Seam and joint construction.
7. Penetrations through fire-rated and other partitions.
8. Hangers and supports.
9. Methods for duct and building attachment.
10. Vibration isolation.
11. Plenums.

C. Coordination Drawings: Floor plans, or reflected ceiling plans, drawn to scale, on which the following items are shown and coordinated with each other and with the Work of other trades.

1. Duct layout plans indicating size and pressure class. Include elevations and sections, as may be necessary to demonstrate coordination.
2. Dimensions of main duct run from building grid lines.
3. Elevations of top and bottom of ducts.
4. Duct cross-over/under details.
5. Equipment installation based on equipment being used on Project.
6. Ceiling suspension assembly members.
7. Other systems installed in the same space as ducts.
8. Ceiling and wall-mounted access doors and panels required to provide access to dampers and other operating devices.
9. Ceiling-mounted lighting fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special details or moldings.

D. Welding certificates.

E. Field quality-control test reports.

1.6 QUALITY ASSURANCE

A. Welding: Qualify procedures and personnel according to:

1. AWS D1.1, "Structural Welding Code-Steel," for hangers and supports.
2. AWS D1.2, "Structural Welding Code-Aluminum," for aluminum supporting members.
3. 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 thickness, 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 and having G90 coating designation.

1. Ducts shall have mill-phosphatized "Paint-Grip" finish for surfaces of ducts exposed to view that are scheduled for field painting.

C. Carbon-Steel Sheets: ASTM A1008/A1008M, cold-rolled sheets; commercial quality; with oiled, matte finish for exposed ducts.

D. Stainless Steel: ASTM A 480, Type 316, and having a No. 2D finish for concealed ducts and No. 4 finish for exposed ducts.

E. Aluminum Sheets: ASTM B 209, alloy 3003, temper H14; with mill finish for concealed ducts and standard, 1-side bright finish (mechanically polished) for exposed ducts.

F. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts.

1. Black steel reinforcement may be used on galvanized sheet metal ducts and on aluminum or stainless steel ducts if painted with zinc-chromate primer prior to fabrication.
2. Use aluminum or stainless steel reinforcement on aluminum or stainless steel ducts exposed to view.

G. Tie Rods: Galvanized steel, 3/8-inch minimum diameter. Rigid conduit, minimum 3 /4-inch, can be used in accordance with referenced standards.

2.3 SEALANT MATERIALS

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

1. Ductmate Industries, Incorporated (PROseal & FIBERseal)

B. Water-Based Joint and Seam Sealant: Flexible, adhesive sealant, resistant to UV light when cured, UL 723 listed, and complying with NFPA requirements for Class 1 ducts.

C. Flanged Joint Mastic: One-part, acid-curing, silicone, elastomeric joint sealant complying with ASTM C 920, Type S, Grade NS, Class 25, use O.

D. Flange Gaskets: Butyl rubber or EPDM polymer with polyisobutylene plasticizer.

2.4 FIRESTOPPING

A. Refer to Division 7 for fire-resistant sealants and fire-stopping materials for use around duct penetrations and fire damper installations in fire rated floors, partitions, and walls.

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 concrete's or for slabs more than 4 inches thick.
2. Exception: Do not use powder-actuated concrete fasteners for lightweight-aggregate concrete's or for slabs less than 4 inches thick.
3. Exception: Do not use powder-actuated concrete fasteners in post-tensioned concrete slabs where the cable locations are not known. Fasteners shall not exceed 3/ 4-inch embedment.

B. Hanger Materials: Galvanized sheet steel or threaded steel rod.

1. Hanger's installed in Corrosive Atmospheres: Electro-galvanized, all-thread rods or galvanized rods with threads painted with zinc-chromate primer prior to 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.
3. Use stainless steel straps or rods for stainless steel ducts exposed to view. Steel materials may be used for concealed ducts if painted with zinc-chromate primer prior to installation.
4. Use aluminum straps or rods for aluminum steel ducts exposed to view. Steel materials may be used for concealed ducts if painted with zinc-chromate primer prior to installation.

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. Black steel shapes and plates may be used if painted with zinc-chromate primer prior to installation.
2. Supports for Stainless-Steel Ducts: Stainless-steel support materials if ducts are exposed to view. Steel materials may be used for concealed ducts if painted with zinc-chromate primer prior to installation.

3. Supports for Aluminum Ducts: Aluminum supports materials if ducts are exposed to view. Steel materials may be used for concealed ducts if contact surfaces are painted with zinc-chromate primer prior to installation.

2.6 DUCT FABRICATION-GENERAL

A. Comply with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible," and with the requirements of this Section.

B. Comply with SMACNA's "Rectangular Industrial Duct Construction Standards" for acceptable materials, material thickness, and duct construction methods outside the scope of SMACNA's "HVAC Duct Construction Standards-Metal and Flexible."

C. Duct Pressure Classification: Construct duct systems for the following pressure classifications:
   1. Supply Air Ducts:
      a. Supply air ducts on variable-volume air systems between fan outlet and air terminal units: 4-inches water gage positive pressure.
      b. Supply air ducts on all constant volume air systems, and all supply ducts downstream of air terminal units on variable volume air systems: 2 inches water gage, positive pressure.
   2. Return and Relief Air Ducts: 2 inches water gage, negative pressure.
   3. Exhaust Air Ducts: 2 inches water gage, negative pressure.
   4. Laboratory Fume Hood Exhaust Air Ducts: 3 inches water gage, negative pressure.
   5. Other Ducts: 2 inches water gage positive or negative pressure.

D. Duct Sealing Classification: Provide SMACNA "Seal Class A" for all duct pressure classifications.
   1. Seal all transverse joints, longitudinal seams, and duct penetrations.
   2. Seal to achieve no visible or audible leaks.

E. Materials: All ducts shall be galvanized steel, except as noted below or specifically noted on the drawings.
   1. Kitchen Grease Hood Exhaust Ducts.
   2. Dishwasher Exhaust Ducts.
   3. Ducts at Duct-Mounted Humidifiers.

2.7 RECTANGULAR DUCT FABRICATION

A. General: Fabricate ducts, elbows, transitions, offsets, branch connections, and other construction according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible." Comply with requirements for metal thickness, reinforcing types and intervals, tie-rod applications, and joint types and intervals, and with the requirements of this Section.
   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."
   3. Calculations: When duct construction is outside the scope of SMACNA's "HVAC Duct Construction Standards--Metal and Flexible," provide calculations to demonstrate compliance with Duct Pressure Classification.

B. Transverse Joints:
   1. Prefabricated Slide-On Joints and Components:
      a. Manufacturers:
         1) Ductmate Industries, Inc.
         2) Elgen Manufacturing
         3) Nexus Inc.
         4) Ward Industries, Inc.
      b. Apply joints using manufacturer's "Duct Construction Standards" for material thickness, reinforcement size and spacing, and joint reinforcement. "Duct Construction Standards" must be based on the referenced SMACNA Standards. "Duct Construction Standards" shall be submitted as shop drawings, and must be available upon request at the Project Site.
      c. Slide-on joints must include the use of corners, bolts, cleats, and gaskets.
      d. Gaskets must be suitable for application at temperatures experienced at the Project Site.

2. Formed-On Flanges:
    a. Manufacturers:
        1) Ductmate Industries Incorporated
        2) Elgen Manufacturing
        3) T.D.C.
        4) T.D.F.
    b. Construct according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible," Table 1-12. Formed-on flanges shall be constructed as T-25A (T.D.C.) and T-25B (T.D.F.) joints.
    c. Formed-on flanges must include the use of corners, bolts, cleats, and gaskets.
    d. Gaskets must be suitable for application at temperatures experienced at the Project Site.
    e. Duct Size: Maximum 42-inches wide and up to 4-inches wg pressure class.
    f. Duct Size: Maximum 60-inches wide and up to 2-inches wg pressure class.
3. Slips and Drives (Traditional):
    a. Construct according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible," Tables 1-11 or 1-12s.

C. Longitudinal Seams: Pittsburgh-lock sealed with non-curing polymer sealant.

D. Internal Tie Rod Reinforcements: Do not use a transverse or intermediate reinforcement that requires the use of internal tie rods on ducts less than 96-inches wide.

E. 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 non-braced panel area unless ducts are lined.

F. All-Welded Construction: Provide continuously welded longitudinal and transverse duct joints and seams on ducts as indicated.

G. Kitchen Grease Hood Exhaust Ducts: Fabricate exhaust ducts (rectangular and round) with 16-gage carbon steel sheets for concealed ducts and 18-gage stainless steel sheets for exposed ducts. Provide all-welded construction. Flanged joints may be used at equipment connections. Ducts shall be liquid-tight over their entire length.

H. Dishwasher Exhaust Ducts: Fabricate exhaust ducts (rectangular and round) with 18-gage stainless steel sheets. Provide all-welded construction. Flanged joints may be used at equipment connections. Ducts shall be liquid-tight over their entire length.

I. Ducts at Duct-Mounted Humidifiers: Fabricate ducts 12-inches upstream and 42-inches downstream of humidifiers with 18-gage stainless steel sheets. Provide all-welded construction. Ducts shall be liquid-tight over their entire length. Provide threaded waste fittings with caps at low points. Refer to Drawings and Details for additional requirements. Ducts shall be liquid-tight over their entire length.

J. Fabricate ductwork with accessories installed during fabrication to the greatest extent possible. Refer to Division 23 section "Ductwork Accessories" for accessory requirements.

K. Fabricate ductwork so as to be free from vibration, rattling, or "oil-canning" under all operating conditions.

L. Unless otherwise indicated, the net free area of the duct dimensions given on the Drawings shall be maintained. The duct dimensions shall be increased as necessary to compensate for liner thickness.

2.8 RECTANGULAR DUCT FITTINGS

A. General: Fabricate elbows, transitions, offsets, branch connections, and other duct construction in accordance with SMACNA "HVAC Metal Duct Construction Standards-Metal and Flexible," Figures 2-1 through 2-10.

B. Elbows and Divided Flow Fittings: Fabricate fittings with a centerline radius equal to 1.5 times the associated duct widths up to 28 inches wide, and 1.0 times the duct width for ducts 30 inches wide and wider. Figure 2-2; Type RE 1 radius elbow.
    1. Where elbows with a shorter radius are necessary, fabricate elbows with a 4-inch throat radius, full radius heel, and with short radius vanes. Figure 2-2, Type RE-3. Fabricate short radius vanes according to Appendix pages A.41, A.42 and A.43.

2. Do not use square elbows, except where indicated on the Drawings. Where used, fabricate square elbow with single-wall turning vanes.

C. Transitions and Offsets: Limit concentric transitions to 45 degrees for diverging, and 60 degrees for converging; limit single-sided transitions to 22.5 degrees for diverging and 30 degrees for converging. Limit angled offsets to a maximum of 30 degrees.

D. Branch Connections: Fabricate branch connections according to Figure 2-6 using clinch lock joints and 45-degree entry.

2.9 ROUND AND FLAT-OVAL DUCT FABRICATION

A. Fabricate ducts according to SMACNA's "HVAC Duct Construction Standards-Metal and Flexible," Tables 3-2 and 3-3.

B. Duct Pressure Classification and Duct Sealing Classification: As indicated in previous Article "Duct Fabrication, General."

C. Round Longitudinal Lock-Seam Ducts 14-inches and smaller:
   1. Manufacturers:
      a. Ductmate Industries, Incorporated
   2. Fabricate round ducts with longitudinal grooved "Green Seam" snap lock pipe. Figure 3-1, Type RL-5.
   3. Longitudinal snaplock seams may be used for round duct diameters 14-inches and smaller for 2-Inch Duct Pressure Classifications. Figure 3-1, Type RL-6, RL-7. RL-78.

D. Round and Flat Oval, Longitudinal and Spiral-Lock-Seam Ducts 16-inches and larger:
   1. Manufacturers:
      a. McGill AirFlow Corporation.
      b. Semco Incorporated.
      c. Sheetmetal Connectors Incorporated.
   2. Fabricate round ducts with spiral lockseam. Figure 3-1, Type RL-1.
   3. Fabricate round ducts with longitudinal grooved seam. Figure 3-1, Type RL-5.
   4. Provide continuous butt-welded longitudinal seams on ducts larger than 72-inches, and where otherwise indicated. Figure 3-1, Type RL-4.

E. Transverse Duct Joints.
   1. Manufacturers:
      a. Ductmate Industries Incorporated.
      b. Elgen Manufacturing
      c. Semco Incorporated.
   2. Duct up to 20-Inches Diameter: Interior, center-beaded slip coupling. Figure 3-2, Type TR-1.
      a. Beaded crimp joints may be used for round duct diameters 14-inches and smaller for 2-Inch Duct Pressure Classifications. Figure 3-2, Type TR-5.
      b. Prefabricated self sealing gasketed coupler: Ductmate "Bullet Band".
   3. Ducts 21 to 72-Inches Diameter: Prefabricated three-piece, gasketed, flanged joint consisting of two inner ring flanges with sealant and one external closure band with gasket. Ductmate "Spiralmate" or equivalent.
      a. Prefabricated flanged joint consisting of two external flanges with sealant and gasket may be used for concealed ducts. Ductmate "Econoflange," Semco "Accuflange," or equivalent.
      b. Prefabricated self sealing gasketed coupler: Ductmate "Bullet Band".
   4. Ducts larger than 72-Inches Diameter: Companion angle flanged joints with gasket, sealed before and after fastening. Figure 3-2, Type RT-2.
      a. Prefabricated self sealing gasketed coupler: Ductmate "Bullet Band".
   5. Joints shall be made with mechanical fasteners (sheet metal screws, blind rivets, welds, bolts). Use sealer before and after fastening.
   6. Traverse Duct Joints on exposed ducts.
      a. Prefabricated self sealing gasketed coupler: Ductmate "Bullet Band".

F. Unless otherwise indicated, the net free area of the duct dimensions given on the Drawings shall be maintained. The duct dimensions shall be increased as necessary to compensate for liner thickness

2.10 ROUND AND FLAT OVAL DUCT FITTING FABRICATION

A. Manufacturers:

a. Ductmate Industries, Inc.
b. Elgen Manufacturing
c. McGill AirFlow Corporation.
d. Semco Incorporated.
e. Sheetmetal Connectors Incorporated. (www.smcduct.com)

B. General: Fabricate elbows, transitions, offsets, branch connections, and other duct construction in accordance with SMACNA "HVAC Metal Duct Construction Standards-Metal and Flexible," Figures 3-3 through 3-5.

1. Duct fittings shall be fabricated from metal thickness not less than required for longitudinal-seam straight duct in Tables 3-2 and 3-3.

C. Round Duct Takeoffs from Rectangular Ducts: Fabricate takeoffs with clinch-lock or spin-in conical connectors with volume dampers.

1. Straight connectors may be used for 2-inch Duct Pressure Classification.

D. Elbows: Fabricate with welded seam, die-formed or segmented construction with bend radius 1.5 times the elbow diameter.

1. Die-Formed Elbows (8-Inches and smaller): Fabricate elbows with two-piece, die-formed construction.
2. Segmented Elbows (Larger than 8-Inches): Fabricate elbows with multiple segments or gores with number of pieces as follows:
   a. 90 degrees - 5 pieces.
   b. 60 degrees - 4 pieces.
   c. 45 degrees - 3 pieces.
   d. 30 degrees - 2 pieces.
3. 90 degrees, Two-piece Mitered Elbows: Use only where space restrictions do not permit the use of radius elbows. Fabricate elbows with single thickness turning vanes.
4. Adjustable Mitered Elbow (14-Inches and Smaller): Adjustable seam, mitered elbows (4-piece 90 degree, 3-piece 45 degree) with bend radius 0.6 times the elbow diameter may be used for 2-inch Duct Pressure Classifications. Joints shall be sealed after installation.

E. Laterals, Tees and Wyes: Fabricate with welded seam construction with conical branch taps with no excess material projecting from body into branch tap entrance.

1. Straight branch taps may be used for 2-inch Duct Pressure Classification.
2. Fittings with riveted or bonded joints may be used for duct diameters 16-inches and smaller for 2-inch Duct Pressure Classification. Joints shall be sealed after installation.

F. Diverging-Flow Fittings: Fabricate with welded seam with a reduced entrance to branch taps with no excess material projecting from the body onto branch tap entrance.

2.11 DOUBLE-WALL DUCT AND FITTING FABRICATION

A. Manufacturers:

1. Lindab Inc.
2. McGill AirFlow Corporation.
3. SEMCO Incorporated.
4. Sheetmetal Connectors 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, unless otherwise indicated. 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 degrees F mean temperature.
3. Solid Inner Ducts: Use the following sheet metal thickness and seam construction:

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.
c. Ducts 44 to 60 Inches in Diameter: 0.022 inch with single-rib spiral-seam construction.
d. Ducts 62 to 88 Inches in Diameter: 0.034 inch with standard spiral-seam construction.

4. Perforated Inner Ducts: Fabricate with 0.028-inch-thick sheet metal having 3/32-inch-diameter perforations, with overall open area of 23 percent.
5. 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: Use the following sheet metal thickness:
   a. Ducts 3 to 34 Inches in Diameter: 0.028 inch.
   b. Ducts 35 to 58 Inches in Diameter: 0.034 inch.
   c. Ducts 60 to 88 Inches in Diameter: 0.040 inch.
2. Perforated Inner Ducts: Fabricate with 0.028-inch-thick sheet metal having 3/32-inch-diameter perforations, with overall open area of 23 percent.

D. Unless otherwise indicated, the net free area of the duct dimensions given on the Drawings shall be maintained. The duct dimensions shall be increased as necessary to compensate for liner thickness

2.12 DUCT LINER

A. Fiber Glass Duct Liner: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 1071. Maximum temperature 250°F (ASTM C 411); air velocity 6000 fpm (ASTM C 1071). Maximum Flame Spread Index: 25; Maximum Smoke Developed Index 50; (NFPA 255, UL 723, ASTM E 1104). Fungi and Bacteria resistant (ASTM C 665, ASTM C 1138, ASTM G 21)

1. Manufacturers:
   a. CertainTeed Corp.; Insulation Group.
   b. Johns Manville International, Inc.
   c. Knauf Fiber Glass GmbH.
   d. Owens Corning.
2. Materials: ASTM C 1071; surfaces exposed to air stream shall be coated to prevent erosion of glass fibers.
   a. Thickness: 1 inch.
   b. Thermal Conductivity (k-Value): 0.24 at 75 degrees F mean temperature.
   c. Fire-Hazard Classification: Maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM E 84.
   d. Liner Adhesive: Comply with NFPA 90A or NFPA 90B and with ASTM C 916.
   e. 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.
      1) Tensile Strength: Indefinitely sustains a 50-lb-tensile, dead load test perpendicular to duct wall.
      2) Fastener Pin Length: As required for thickness of insulation and without projecting more than 1/8 inch into air stream.
      3) Adhesive for Attaching Mechanical Fasteners: Comply with fire-hazard classification of duct liner system.
   f. Acoustic Performance: Sound absorption coefficients at octave band center frequencies. (Hz)
      1) 125Hz: 0.05; 250Hz: 0.30; 500Hz: 0.60; 1000Hz: 0.87; 2000Hz: 0.98; 4000Hz: 1.05; NRC: 0.70

B. Polyester Duct Liner: Polyester fibers webbed into a thermal blanket and bonded to FSK facing. Comply with ASTM C 1071. Maximum temperature 250°F (ASTM C 411); air velocity 6000 fpm (ASTM C 1071). Maximum Flame Spread Index: 25; Maximum Smoke Developed Index 50; (NFPA 255, UL 723, ASTM E 1104). Fungi and Bacteria resistant (ASTM C 665, ASTM C 1138, ASTM G21)

1. Manufacturers:
   a. Poly Armor: Ductmate
2. Materials: ASTM C 1071; surfaces exposed to air stream shall be hypoallergenic FSK facing.

a. Thickness: 1 inch.
b. Thermal Conductivity (k-Value): 0.20 at 75 degrees F mean temperature.
c. Fire-Hazard Classification: Maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM E 84.
d. Liner Adhesive: Comply with NFPA 90A or NFPA 90B and with ASTM C 916.
e. 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.
    1) Tensile Strength: Indefinitely sustains a 50-lb-tensile, dead load test perpendicular to duct wall.
    2) Fastener Pin Length: As required for thickness of insulation and without projecting more than 1/8 inch into air stream.
    3) Adhesive for Attaching Mechanical Fasteners: Comply with fire-hazard classification of duct liner system.
f. Acoustic Performance: Sound absorption coefficients at octave band center frequencies. (Hz)
    1) 125Hz: 0.10; 250Hz: 0.25; 500Hz: 0.60; 1000Hz: 0.75; 2000Hz: 0.90; 4000Hz: 0.85; NRC: 0.65

2.13 APPLICATION OF LINER IN RECTANGULAR DUCTS

A. Application of Liner:
    1. Adhere a single layer of indicated thickness of duct liner with at least 90 percent adhesive coverage at liner contact surface area. Attaining indicated thickness with multiple layers of duct liner is prohibited.
    2. Apply adhesive to transverse edges of liner facing upstream that do not receive metal nosing.
    3. Butt transverse joints without gaps and coat joint with adhesive.
    4. Fold and compress liner in corners of rectangular ducts or cut and fit to ensure butted-edge overlapping.
    5. Do not apply liner in rectangular ducts with longitudinal joints, except at corners of ducts, unless duct size and standard liner product dimensions make longitudinal joints necessary.
    6. 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.

B. Terminate inner ducts with build-outs attached to fire-damper sleeves, dampers, turning vane assemblies, or other devices. Fabricated build-outs (metal hat sections) or other build-out means are optional; when used; secure build-outs to duct walls with bolts, screws, rivets, or welds.

PART 3 - EXECUTION

3.1 DUCT INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of duct system. Indicated duct locations, configurations, and arrangements were used to size ducts and calculate friction loss for air-handling equipment sizing and for other design considerations. Install duct systems as indicated unless deviations to layout are approved on Shop Drawings and Coordination Drawings.

B. Install ducts according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible," and the requirements of this Section.

C. Install ducts according to SMACNA's "Rectangular Industrial Duct Construction Standards" when duct construction is outside the scope of SMACNA's "HVAC Duct Construction Standards-Metal and Flexible."

D. Construct and install each duct system according to the Duct Pressure Classification and Duct Sealing Classification indicated in previous Article "Duct Fabrication, General."

E. Install round and flat-oval ducts in lengths not less than 12 feet unless interrupted by fittings.

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. Provide offset fittings where necessary to avoid structural interference's and in coordination with existing conditions and the Work of other trades.

J. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building. Provide a minimum clearance of 1 inch, plus an allowance for insulation thickness to other elements.

K. Install ducts as high as possible, unless otherwise indicated. Where overhead structure permits, route ducts between structural elements.

L. Conceal ducts from view in finished spaces by locating within mechanical shafts, within hollow construction, or above suspended ceilings. Do not encase horizontal runs in solid partitions unless specifically indicated.

M. Where exposed to view; install ducts as high as possible, unless otherwise indicated. Protect exposed duct from physical damage. Repair scratches, dents, cuts, and other physical imperfections. Remove stickers and markers. Prepare for field painting. Grind and polish exposed welds on un-insulated ducts and double wall ducts so no roughness shows and contours of welded surfaces match adjacent contours.

N. Install insulated ducts with 1-inch clearance outside of insulation.

O. Coordinate the duct layout with suspended ceiling, fire and smoke-control dampers, piping, lighting layouts and conduits, and the Work of other trades.

P. Non-Fire-Rated Partition Penetrations: Where ducts pass through interior partitions and exterior walls, and are exposed to view, conceal space between construction opening and duct or duct insulation with sheet metal flanges of same metal thickness as duct. Overlap opening on four sides by at least 1-1/2 inches.

Q. One hour rated fire barrier penetrations: (Where the building code allows fire barrier penetrations without fire dampers) Provide angles on both sides of the wall penetrations conforming to the requirements of wall system approval.

R. Fire-Rated Partition Penetrations: Where ducts pass through interior partitions and exterior walls, install appropriately rated fire dampers, sleeves, and fire stopping sealant.

1. Fire and smoke dampers are specified in Division 23 Section "Duct Accessories."
2. Fire stopping materials and installation methods are specified in Division 7 Section "Fire stopping."

S. Protect duct interiors from elements and foreign materials until building is enclosed. Refer to SMACNA's "Duct Cleanliness for New Construction."

3.2 DUCT LINER APPLICATIONS

A. Apply duct liner in the following duct sections:

1. Return and relief air ductwork: None, except as indicated on the Drawings.
2. Exhaust air ductwork: None, except as indicated on the Drawings.
3. Transfer air ducts: 1-inch thick
4. Provide 1-inch thick duct liner for any duct noted on the Drawings to be lined.

3.3 WALL LOUVERS

A. Provide watertight air plenum with soldered drain pan at each louver. Connect air plenum directly to louver frame. The air plenum drain pan shall be arranged to drain to a threaded drain connection. Extend plenum drain untrapped to a floor drain.

B. Provide 2 inch thick insulated double-wall blank-off panels at each unused wall louver. Blank-off panels shall be attached to the louver frame with a gasketed, watertight connection

3.4 SEAM AND JOINT SEALING

A. Seal duct seams and joints according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for duct pressure class indicated.

B. Duct Sealing Classification: Provide SMACNA “Seal Class A” for all duct pressure classifications.

1. Seal all transverse joints, longitudinal joints, and duct penetrations.
2. Seal to achieve no visible or audible leaks.

C. Seal externally insulated ducts before insulation is applied.

D. Seal exposed joints internally during installation. Do not use external sealant on exposed ducts.

3.5 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. Fastener System Installation:

1. Install powder-actuated fasteners for use in lightweight concrete or concrete slabs greater than 4 inches thick in concrete after concrete is placed and completely cured. Use operators that are licensed by powder-actuated tool manufacturer. Install fasteners according to powder-actuated tool manufacturer's operating manual.
2. Install mechanical fasteners for use in lightweight concrete or concrete slabs less than 4 inches thick in concrete after concrete is placed and completely cured.
3. Install mechanical-expansion anchors in concrete after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.

3.6 CONNECTIONS

A. Make connections to equipment with flexible connectors according to Division 23 Section "Duct Accessories."

B. For branch connections comply with SMACNA’s "HVAC Duct Construction Standards-Metal and Flexible," Figures 2-5 and 2-6.

C. For inlet and outlet connections comply with SMACNA’s "HVAC Duct Construction Standards-Metal and Flexible," Figures 2-14 and 2-15.

D. For equipment connections comply with SMACNA’s "HVAC Duct Construction Standards -Metal and Flexible," Figures 2-17.

3.7 PAINTING

A. Exposed galvanized ducts: Paint materials and methods are specified in Division 9 Sections.

3.8 FIELD QUALITY CONTROL

A. Perform field tests and inspections according to SMACNA’s “HVAC Air Duct Leakage Test Manual” and prepare test reports.

B. Disassemble, reassemble, and seal segments of systems to accommodate leakage testing and for compliance with test requirements.

C. Conduct tests at static pressures equal to Duct Pressure Classification designated static pressures.

D. Conduct tests in the presence of the Architect, or authorized representative. Give 7 day’s advanced notice for testing. Prepare test reports.

E. Remake leaking joints and retest until leakage is equal to or less than maximum allowable.

F. Leakage Tests:

1. Leak test each section of duct with a Duct Pressure Classification greater than 2-inches wg.
2. Leak test each section of duct within a concealed shaft.
3. Leak test each section of laboratory fume hood exhaust duct.
4. Leak test a representative section of duct with a Duct Pressure Classification of 2-inches or less. Test a section with a positive pressure classification, and a section with a negative pressure classification.
   a. Following a successful test, all other ductwork in the Duct Pressure Classification shall be visually inspected to assure duct construction methods are like the tested sections.
   b. Additional sections shall be tested as requested by the Architect.

G. Maximum Allowable Leakage: Comply with requirements for Leakage Class 3 for ducts with a Duct Pressure Classification greater than 2-inches, and for Leakage Class 6 for ducts with duct pressure classification 2-inches or less.
   a. For a duct section with 4-inch Duct Pressure Classification or greater and Duct Leakage Class 3, leakage shall not exceed 7.5 CFM per 100 sq. ft. of duct surface area.
   b. For a duct section with a 2-inch Duct Pressure Classification and Duct Leakage Class 6, leakage shall not exceed 9.5 CFM per 100-sq. ft. of duct surface area.
   c. For positive pressure exhaust ducts, leakage shall be zero at 4.0 inches wg.

3.9 TEMPORARY USE OF AIR HANDLING SYSTEMS

A. Refer to Division 1 Section 01510 “Temporary Utilities” for additional requirements.

B. Until the permanent air handling systems are used, duct openings shall have closures to preclude the entry of construction dirt and debris into the duct system and equipment.

C. If the permanent air handling systems are used for temporary heating or ventilating prior to completion of finishing operations, the supply air systems shall be operated with 100 percent outside air (no recirculation air) with pre-filters and final filters in place and maintained.
   1. Operation of air handling systems may not be possible during extreme outside air conditions.
   2. The return air and exhaust air systems shall not be used. The duct openings on these systems shall have permanent closures.

D. When the building is substantially complete, the permanent air handling systems may be utilized with return air with air filters in place. Extra-ordinary measures shall be taken to prevent dirt and/or moisture from entering the duct systems.
   1. Filters: Maintain clean filters in place. Install new permanent filters prior to Owner occupancy of the Project.
   2. Equipment: Maintain fans and equipment until Owner occupancy of the Project.

E. Air handling system ducts shall be vacuum cleaned, and equipment surfaces washed as may be necessary to restore the systems to new condition prior to final acceptance by the Owner.

3.10 CLEANING NEW SYSTEMS

A. Mark position of dampers and air-directional mechanical devices before cleaning, and perform cleaning before air balancing.

B. Use service openings, as required, for physical and mechanical entry and for inspection.
   1. Create other openings to comply with duct standards.
   2. Disconnect flexible ducts as needed for cleaning and inspection.
   3. Remove and reinstall ceiling sections to gain access during the cleaning process.

C. Vent vacuuming system to the outside. Include filtration to contain debris removed from HVAC systems, and locate exhaust down wind and away from air intakes and other points of entry into building.

D. Clean the following metal duct systems by removing surface contaminants and deposits:
   1. Air outlets and inlets (registers, grilles, and diffusers).
   2. Supply, return, and exhaust fans including fan housings, plenums (except ceiling supply and return plenums), scrolls, blades or vanes, shafts, baffles, dampers, and drive assemblies.
   3. Air-handling unit internal surfaces and components including mixing box, coil section, air wash systems, spray eliminators, condensate drain pans, humidifiers and dehumidifiers, filters and filter sections, and condensate collectors and drains.

4. Coils and related components.
5. Return-air ducts, dampers, and actuators except in ceiling plenums and mechanical equipment rooms.
6. Supply-air ducts, dampers, actuators, and turning vanes.

E. Mechanical Cleaning Methodology:

1. Clean metal duct systems using mechanical cleaning methods that extract contaminants from within duct systems and remove contaminants from building.
2. Use vacuum-collection devices that are operated continuously during cleaning. Connect vacuum device to downstream end of duct sections so areas being cleaned are under negative pressure.
3. Use mechanical agitation to dislodge debris adhered to interior duct surfaces without damaging integrity of metal ducts, duct liner, or duct accessories.
4. Clean fibrous-glass duct liner with HEPA vacuuming equipment; do not permit duct liner to get wet.
5. Clean coils and coil drain pans according to NADCA 1992. Keep drain pan operational. Rinse coils with clean water to remove latent residues and cleaning materials; comb and straighten fins.

F. Cleanliness Verification:

1. Visually inspect metal ducts for contaminants.
2. Where contaminants are discovered, re-clean and re-inspect ducts.

3.11 CLEANING EXISTING SYSTEMS

A. Use service openings, as required, for physical and mechanical entry and for inspection.

1. Use existing service openings where possible.
2. Create other openings to comply with duct standards.
3. Disconnect flexible ducts as needed for cleaning and inspection.
4. Reseal rigid fiberglass duct systems according to NAIMA recommended practices.
5. Remove and reinstall ceiling sections to gain access during the cleaning process.

B. Mark position of dampers and air-directional mechanical devices before cleaning, and restore to their marked position on completion.

C. Particulate Collection and Odor Control:

1. When venting vacuuming system inside the building, use HEPA filtration with 99.97 percent collection efficiency for 0.3-micron size (or larger) particles.
2. When venting vacuuming system to the outside, use filtration to contain debris removed from HVAC system, and locate exhaust down wind and away from air intakes and other points of entry into building.

D. Clean the following metal duct systems by removing surface contaminants and deposits:

1. Air outlets and inlets (registers, grilles, and diffusers).
2. Supply, return, and exhaust fans including fan housings, plenums (except ceiling supply and return plenums), scrolls, blades or vanes, shafts, baffles, dampers, and drive assemblies.
3. Air-handling unit internal surfaces and components including mixing box, coil section, air wash systems, spray eliminators, condensate drain pans, humidifiers and dehumidifiers, filters and filter sections, and condensate collectors and drains.
4. Coils and related components.
5. Return-air ducts, dampers, and actuators except in ceiling plenums and mechanical equipment rooms.
6. Supply-air ducts, dampers, actuators, and turning vanes.
7. Dedicated exhaust and ventilation components and makeup air systems.

E. Mechanical Cleaning Methodology:

1. Clean metal duct systems using mechanical cleaning methods that extract contaminants from within duct systems and remove contaminants from building.
2. Use vacuum-collection devices that are operated continuously during cleaning. Connect vacuum device to downstream end of duct sections so areas being cleaned are under negative pressure.

3. Use mechanical agitation to dislodge debris adhered to interior duct surfaces without damaging integrity of metal ducts, duct liner, or duct accessories.
4. Clean fibrous-glass duct liner with HEPA vacuuming equipment; do not permit duct liner to get wet. Replace fibrous-glass duct liner that is damaged, deteriorated, or delaminated or that has friable material, mold, or fungus growth.
5. Clean coils and coil drain pans according to NADCA 1992. Keep drain pan operational. Rinse coils with clean water to remove latent residues and cleaning materials; comb and straighten fins.
6. Provide operative drainage system for wash down procedures.
7. Biocidal Agents and Coatings: Apply biocidal agents if fungus is present. Apply biocidal agents according to manufacturer's written instructions after removal of surface deposits and debris.

F. Cleanliness Verification:

1. Verify cleanliness after mechanical cleaning and before application of treatment, including biocidal agents and protective coatings.
2. Visually inspect metal ducts for contaminants.
3. Where contaminants are discovered, re-clean and re-inspect ducts.

G. Verification of Coil Cleaning: Cleaning must restore coil pressure drop to within 10 percent of pressure drop measured when coil was first installed. If original pressure drop is not known, coil will be considered clean only if it is free of foreign matter and chemical residue, based on thorough visual inspection.

END OF SECTION

SECTION 233300
AIR DUCT ACCESSORIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
   1. Manual volume dampers.
   2. Fire dampers.
   3. Smoke dampers.
   4. Combination fire and smoke dampers.
   5. Flange connectors.
   6. Turning vanes.
   7. Remote damper operators.
   8. Duct-mounted access doors.
   9. Flexible connectors.
   10. Flexible ducts.
   11. Duct accessory hardware.

B. Related Requirements:
   1. Section 283111 "Digital, Addressable Fire-Alarm System" for duct-mounted fire and smoke detectors.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.
   1. For duct silencers, include pressure drop and dynamic insertion loss data. Include breakout noise calculations for high transmission loss casings.

B. Shop Drawings: For duct accessories. Include plans, elevations, sections, details and attachments to other work.
   1. Detail duct accessories fabrication and installation in ducts and other construction. Include dimensions, weights, loads, and required clearances; and method of field assembly into duct systems and other construction. Include the following:
      a. Special fittings.
      b. Manual volume damper installations.
      c. Control-damper installations.
      d. Fire-damper, smoke-damper, combination fire- and smoke-damper, ceiling, and corridor damper installations, including sleeves; and duct-mounted access doors and remote damper operators.
      e. Duct security bars.
      f. Wiring Diagrams: For power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which ceiling-mounted access panels and access doors required for access to duct accessories are shown and coordinated with each other, using input from Installers of the items involved.

B. Source quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For air duct accessories to include in operation and maintenance manuals.

1.6 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Fusible Links: Furnish quantity equal to 10 percent of amount installed.

PART 2 PRODUCTS

2.1 ASSEMBLY DESCRIPTION

A. Comply with NFPA 90A, "Installation of Air Conditioning and Ventilating Systems," and with NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."

B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

2.2 MANUAL VOLUME DAMPERS

A. Standard, Steel, Manual Volume Dampers: Maximum velocity 1500 fpm.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Air Balance Incorproated; a Division of Mestek, Incorporated. (www.airbalance.com)
      b. American Warming and Ventilating; a Division of Mestek, Incorporated. (www.arcat.com)
      c. Flexmaster U.S.A., Incorporated. (www.flexmasterusa.com)
      d. McGill AirFlow LLC. (www.mcgillairflow.com)
      e. Nailor Industries Incorproated. (www.nailor.com)
      f. Pottorff. (www.pottorff.com)
      g. Ruskin Company. (www.ruskin.com)
      h. Trox USA Incorporated. (www.troxusa.com)
      i. Vent Products Company, Incorporated. (www.ventproducts.com)
   2. Standard leakage rating, with linkage outside airstream.
   3. Maximum air velocity: 1500 fpm.
   4. Suitable for horizontal or vertical applications.
   5. Frames:
      a. Frame: 5-inches wide, Hat-shaped, 0.064-inch- thick, galvanized sheet steel with reinforced corners.
      b. Frame: 5-inches wide, Hat-shaped, 0.05-inch- thick, stainless steel with reinforced corners.
      c. Mitered and welded corners.
      d. Flanges for attaching to walls and flangeless frames for installing in ducts.
   6. Blades:
      a. Multiple or single blade.
      b. 6-inches wide.
      c. Parallel- or opposed-blade design.
      d. Stiffen damper blades for stability.
      e. Galvanized-steel, 0.064 inch thick.
      f. Stainless-steel, 0.064 inch thick.
   7. Blade Axles: ½-inch Galvanized steel.
   8. Blade Axles: ½-inch [Stainless steel] [Nonferrous metal].
   9. Bearings:
      a. Molded synthetic.
      b. [Oil-impregnated bronze] [Molded synthetic] [Oil-impregnated stainless-steel sleeve] [Stainless-steel sleeve].
      c. Dampers in ducts with pressure classes of 3-inch wg or less shall have axle's full length of damper blades and bearings at both ends of operating shaft.
   10. Tie Bars and Brackets: Galvanized steel.

B. Standard, Steel, Manual Volume Dampers: Maximum air velocity 3,000 fpm.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Air Balance Incorporated; a Division of Mestek, Incorporated. (www.airbalance.com)
b. American Warming and Ventilating; a Division of Mestek, Incorporated. (www.arcat.com)
c. Flexmaster U.S.A., Inc. (www.flexmasterusa.com)
d. McGill AirFlow LLC. (www.mcgillairflow.com)
e. Nailor Industries Incorporated. (www.nailor.com)
f. Pottorff. (www.pottorff.com)
g. Ruskin Company. (www.ruskin.com)
h. Trox USA Incorporated. (www.troxusa.com)
i. Vent Products Company, Incorproated. (www.ventproducts.com)
2. Standard leakage rating, with linkage outside airstream.
3. Maximum air velocity: 3000 fpm.
4. Suitable for horizontal or vertical applications.
5. Frames:
a. Frame: 5-inches wide, Hat-shaped, 0.064-inch- thick, galvanized sheet steel with reinforced corners.
b. Mitered and welded corners.
c. Flanges for attaching to walls and flangeless frames for installing in ducts.
6. Blades:
a. Multiple or single blade.
b. 6-inches wide.
c. Parallel- or opposed-blade design.
d. Double skin air foil damper blades.
e. Galvanized-steel, 0.078 inch thick.
7. Blade Axles: ½-inch Galvanized steel.
8. Bearings:
a. Stainless steel sleeve.
b. Dampers in ducts with pressure classes of 3-inch wg or less shall have axle’s full length of damper blades and bearings at both ends of operating shaft.
9. Tie Bars and Brackets: Galvanized steel.

C. Standard, Aluminum, Manual Volume Dampers:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Air Balance Incorporated; a Division of Mestek, Incorporated. (www.airbalance.com)
b. American Warming and Ventilating; a Division of Mestek, Incorporated. (www.arcat.com)
c. McGill AirFlow LLC. (www.mcgillairflow.com)
d. Nailor Industries Incorporated. (www.nailor.com)
e. Pottorff. (www.pottorff.com)
f. Ruskin Company. (www.ruskin.com)
g. Trox USA Incorporated. (www.troxusa.com)
h. Vent Products Company, Incorproated. (www.ventproducts.com)
2. Standard leakage rating, with linkage outside airstream.
3. Suitable for horizontal or vertical applications.
4. Frames: Hat-shaped, 0.125-inch- thick, extruded aluminum channels; frames with flanges for attaching to walls and flangeless frames for installing in ducts.
5. Blades:
a. Multiple or single blade.
b. Parallel- or opposed-blade design.
1) Stiffen damper blades for stability.
c. Extruded-Aluminum Blades: 0.0125-inch- thick extruded aluminum.
6. Blade Axles: Galvanized steel.
7. Bearings:
a. Molded synthetic.
b. Dampers in ducts with pressure classes of 3-inch wg or less shall have axle’s full length of damper blades and bearings at both ends of operating shaft.
8. Tie Bars and Brackets: Aluminum.

D. Low-Leakage, Steel, Manual Volume Dampers:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Air Balance Incorporated; a Division of Mestek, Incorporated. (www.airbalance.com)

b. American Warming and Ventilating; a Division of Mestek, Incorporated. (www.arcat.com)
c. McGill AirFlow LLC. (www.mcgillairflow.com)
d. Nailor Industries Incorporated. (www.nailor.com)
e. Pottorff. (www.pottorff.com)
f. Ruskin Company. (www.ruskin.com)
g. Trox USA Incorporated. (www.troxusa.com)
h. Vent Products Company, Incorproated. (www.ventproducts.com)

2. Comply with AMCA 500-D testing for damper rating.
3. Low-leakage rating, with linkage outside airstream, and bearing AMCA's Certified Ratings Seal for both air performance and air leakage.
4. Suitable for horizontal or vertical applications.
5. Frames:
   a. Hat shaped.
   b. 0.094-inch- thick, galvanized sheet steel.
   c. Mitered and welded corners.
   d. Flanges for attaching to walls and flangeless frames for installing in ducts.
6. Blades:
   a. Multiple or single blade.
   b. Parallel- or opposed-blade design.
   c. Stiffen damper blades for stability.
   d. Galvanized, roll-formed steel, 0.064 inch thick.
7. Blade Axles: Galvanized steel.
8. Bearings:
   a. Molded synthetic.
   b. Dampers in ducts with pressure classes of 3-inch wg or less shall have axle’s full length of damper blades and bearings at both ends of operating shaft.
9. Blade Seals: Extruded Vinyl.
10. Jamb Seals: Cambered stainless steel or aluminum.
11. Tie Bars and Brackets: Galvanized steel.
12. Accessories:
    a. Include locking device to hold single-blade dampers in a fixed position without vibration.

E. Low-Leakage, Aluminum, Manual Volume Dampers:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Air Balance Incorporated; a Division of Mestek, Incorporated. (www.airbalance.com)
   b. American Warming and Ventilating; a Division of Mestek, Incorporated. (www.arcat.com)
   c. McGill AirFlow LLC. (www.mcgillairflow.com)
   d. Nailor Industries Incorporated. (www.nailor.com)
   e. Pottorff. (www.pottorff.com)
   f. Ruskin Company. (www.ruskin.com)
   g. Trox USA Incorporated. (www.troxusa.com)
   h. Vent Products Company, Incorproated. (www.ventproducts.com)
2. Comply with AMCA 500-D testing for damper rating.
3. Low-leakage rating, with linkage outside airstream, and bearing AMCA's Certified Ratings Seal for both air performance and air leakage.
4. Suitable for horizontal or vertical applications.
5. Frames: Hat shaped, 0.10-inch- thick, aluminum sheet channels; frames with flanges for attaching to walls and flangeless frames for installing in ducts.
6. Blades:
   a. Multiple or single blade.
   b. Parallel- or opposed-blade design.
   c. Extruded-Aluminum Blades: 0.050-inch- thick extruded aluminum.
7. Blade Axles: Galvanized steel.
8. Bearings:
   a. Molded synthetic.
   b. Dampers in ducts with pressure classes of 3-inch wg or less shall have axle’s full length of damper blades and bearings at both ends of operating shaft.
9. Blade Seals: Extruded Vinyl.
10. Jamb Seals: Cambered stainless steel or aluminum.

11. Tie Bars and Brackets: Galvanized steel.
12. Accessories:
    a. Include locking device to hold single-blade dampers in a fixed position without vibration.

F. Jackshaft:
    1. Size: 0.5-inch diameter.
    2. Material: Galvanized-steel pipe rotating within pipe-bearing assembly mounted on supports at each mullion and at each end of multiple-damper assemblies.
    3. Length and Number of Mountings: As required to connect linkage of each damper in multiple-damper assembly.

G. Damper Hardware:
    1. Zinc-plated, die-cast core with dial and handle made of 3/32-inch- thick zinc-plated steel, and a 3/4-inch hexagon locking nut.
    2. Include center hole to suit damper operating-rod size.
    3. Include elevated platform for insulated duct mounting.

2.3 FIRE DAMPERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    1. Air Balance Incorporated; a Division of Mestek, Incorporated. (www.airbalance.com)
    2. Arrow United Industries; a Division of Mestek, Incorporated. (www.arrowunited.com)
    3. Cesco Products; a Division of Mestek, Incorporated. (www.cescoproducts.com)
    4. Greenheck Fan Corporation. (www.greenheck.com)
    5. Nailor Industries Incorporated. (www.nailor.com)
    6. NCA Manufacturing, Incorporated. (www.ncamfg.com)
    7. Pottorff. (www.pottorff.com)
    8. Prefco; Perfect Air Control, Incorporated. (www.prefco-hvac.com)
    9. Ruskin Company. (www.ruskin.com)
    10. Vent Products Company, Incorproated. (www.ventproducts.com)

B. Type: Static and dynamic; rated and labeled according to UL 555 by an NRTL.
    1. Closing rating in ducts up to 4-inch wg static pressure class and minimum 2000-fpm velocity.
    2. Fire Rating: 1-1/2 and 3 hours.
    3. Frame: Curtain type with blades outside airstream except when located behind grille where blades may be inside airstream; fabricated with roll-formed, 0.034-inch- thick galvanized steel; with mitered and interlocking corners.
    4. Mounting Sleeve: Factory- or field-installed, galvanized sheet steel.
        a. Minimum Thickness: 0.064 thick, as indicated, and of length to suit application.
        b. Exception: Omit sleeve where damper-frame width permits direct attachment of perimeter mounting angles on each side of wall or floor; thickness of damper frame must comply with sleeve requirements.
    5. Mounting Orientation: Vertical or horizontal as indicated.
    6. Blades: Roll-formed, interlocking, 0.064 thick, galvanized sheet steel. In place of interlocking blades, use full-length, 0.034-inch- thick, galvanized-steel blade connectors.
    7. Horizontal Dampers: Include blade lock and stainless-steel closure spring.
    8. Heat-Responsive Device: replaceable link and switch package, factory installed, 165 deg F rated.

2.4 SMOKE DAMPERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    1. Air Balance Incorporated; a Division of Mestek, Incorporated. (www.airbalance.com)
    2. Cesco Products; a Division of Mestek, Incorporated. (www.cescoproducts.com)
    3. Greenheck Fan Corporation. (www.greenheck.com)
    4. Nailor Industries Incorporated. (www.nailor.com)
    5. Pottorff. (www.pottorff.com)
    6. Ruskin Company. (www.ruskin.com)

B. General Requirements: Label according to UL 555S by an NRTL.

1. Frame: Hat-shaped, 0.044-inch- thick, galvanized sheet steel, with welded and mounting flange.
2. Blades: Roll-formed, horizontal, overlapping, 0.063-inch- thick, galvanized sheet steel.
3. Leakage: Class 3.
4. Rated pressure and velocity to exceed design airflow conditions.
5. Mounting Sleeve: Factory-installed, 0.063 thick, galvanized sheet steel; length to suit wall or floor application.
6. Damper Motors: two-position action.
7. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
   a. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven loads will not require motor to operate in service factor range above 1.0.
   b. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Section 230900 "Instrumentation and Control for HVAC."
   c. Permanent-Split-Capacitor or Shaded-Pole Motors: With oil-immersed and sealed gear trains.
   d. 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.
   e. Outdoor Motors and Motors in Outdoor-Air Intakes: Equip with O-ring gaskets designed to make motors weatherproof. Equip motors with internal heaters to permit normal operation at minus 40 deg F.
   f. Non-spring-Return Motors: For dampers larger than 25 sq. ft., size motor for running torque rating of 150 in. x lbf and breakaway torque rating of 300 in. x lbf.
   g. Electrical Connection: Refer to Division 26 drawings.
8. Accessories:
   a. Auxiliary switches for signaling, fan control or position indication.

2.5 COMBINATION FIRE AND SMOKE DAMPERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Air Balance Incorporated; a Division of Mestek, Incorporated. (www.airbalance.com)
2. Cesco Products; a Division of Mestek, Incorporated. (www.cescoproducts.com)
3. Greenheck Fan Corporation. (www.greenheck.com)
4. Nailor Industries Incorporated. (www.nailor.com)
5. Pottorff. (www.pottorff.com)
6. Ruskin Company. (www.ruskin.com)

B. Type: Dynamic; rated and labeled according to UL 555 and UL 555S by an NRTL.
1. Closing rating in ducts up to 4-inch wg static pressure class and minimum 2000-fpm velocity.
2. Fire Rating: 1-1/2 and 3 hours. Refer to drawings.
3. Frame: Hat-shaped, 0.063-inch- thick, galvanized sheet steel, with welded and mounting flange.
4. Heat-Responsive Device: Resettable, 165 deg F rated fusible links.
5. Heat-Responsive Device: Electric resettable device and switch package, factory installed, rated.
6. Blades: Roll-formed, horizontal, overlapping, 0.063-inch-thick, galvanized sheet steel.
7. Leakage: Class I.
8. Rated pressure and velocity to exceed design airflow conditions.
9. Mounting Sleeve: Factory-installed, 0.039-inch-thick, galvanized sheet steel; length to suit wall or floor application.
10. Damper Motors: Two-position action.
11. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
    a. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
    b. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Section 230900 "Instrumentation and Control for HVAC."

c. Permanent-Split-Capacitor or Shaded-Pole Motors: With oil-immersed and sealed gear trains.
d. 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.
e. Outdoor Motors and Motors in Outdoor-Air Intakes: Equip with O-ring gaskets designed to make motors weatherproof. Equip motors with internal heaters to permit normal operation at minus 40 deg F.
f. Non-spring-Return Motors: For dampers larger than 25 sq. ft., size motor for running torque rating of 150 in. x lbf and breakaway torque rating of 300 in. x lbf.
g. Electrical Connection: Refer to Division 26 drawings.

12. Accessories:
    a. Auxiliary switches for signaling, fan control or position indication.

2.6 FLANGE CONNECTORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Ductmate Industries, Incorporated. (www.ductmate.com)
   2. Elgen Manufacturing. (www.elgenmfg.com)
   3. Nexus PDQ; Division of Shilco Holdings Incorporated. (www.nexuspdq.com)

B. Description: Add-on or roll-formed, factory-fabricated, slide-on transverse flange connectors, gaskets, and components.
   1. Material: Galvanized steel.
   2. Gage and Shape: Match connecting ductwork.

2.7 TURNING VANES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Ductmate Industries, Incorporated. (www.ductmate.com)
   2. Elgen Manufacturing. (www.elgenmfg.com)
   3. Sheetmetal Connectors Incorporated. (www.smcduct.com)

B. Manufactured Turning Vanes for Metal Ducts: Curved blades of galvanized sheet steel; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.
   1. Acoustic Turning Vanes: Fabricate airfoil-shaped aluminum extrusions with perforated faces and fibrous-glass fill.

C. General Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 4-3, "Vanes and Vane Runners," and 4-4, "Vane Support in Elbows."
   1. Vane Construction: Single and Double wall.
   2. Vane Construction: Single wall for ducts up to 48 inches wide and double wall for larger dimensions.

2.8 REMOTE DAMPER OPERATORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Pottorff. (www.pottorff.com)
   2. Ventfabrics, Incorporated. (www.ventfabrics.com)
   3. Young Regulator Company. (www.youngregulator.com)

B. Description: Cable system designed for remote manual damper adjustment.
   1. Tubing: Aluminum.
   2. Cable: Stainless steel.
   3. Wall-Box Mounting: Recessed.
   4. Wall-Box Cover-Plate Material: Steel.

2.9 DUCT-MOUNTED ACCESS DOORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. American Warming and Ventilating; a Division of Mestek, Incorporated. (www.arcat.com)

2. Cesco Products; a Division of Mestek, Incorporated. (www.cescoproducts.com)
3. Ductmate Industries, Incorporated. (www.ductmate.com)
4. Elgen Manufacturing. (www.elgenmfg.com)
5. Flexmaster U.S.A., Incorporated. (www.flexmasterusa.com)
6. Greenheck Fan Corporation. (www.greenheck.com)
7. McGill AirFlow LLC. (www.mcgillairflow.com)
8. Nailor Industries Incorporated. (www.nailor.com)
9. Pottorff. (www.pottorff.com)
10. Ventfabrics, Incorporated. (www.ventfabrics.com)

B. Duct-Mounted Access Doors: Fabricate access panels according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 7-2, "Duct Access Doors and Panels," and 7-3, "Access Doors - Round Duct."

1. Door:
   a. Double wall, rectangular.
   b. Galvanized sheet metal with insulation fill and thickness as indicated for duct pressure class.
   c. Vision panel.
   d. Hinges and Latches: 1-by-1-inch butt or piano hinge and cam latches.
   e. Fabricate doors airtight and suitable for duct pressure class.
2. Frame: Galvanized sheet steel, with bend-over tabs and foam gaskets.
3. Number of Hinges and Locks:
   a. Access Doors Less Than 12 Inches Square: No hinges and two sash locks.
   b. Access Doors up to 18 Inches Square: Two hinges or Continuous and two sash locks.
   c. Access Doors up to 24 by 48 Inches: Three hinges or Continuous and two compression latches with outside and inside handles.
   d. Access Doors Larger than 24 by 48 Inches: Four hinges and two compression latches with outside and inside handles.

C. Pressure Relief Access Door:

1. Door and Frame Material: Galvanized sheet steel.
2. Door: Single wall for uninsulated ducts and double wall with insulation fill for insulated ducts. Duct material metal thickness applicable for duct pressure class.
3. Operation: Open outward for positive-pressure ducts and inward for negative-pressure ducts.
4. Factory set at 3.0- to 8.0-inch wg.
5. Doors close when pressures are within set-point range.
6. Hinge: Continuous piano.
7. Latches: Cam.
8. Seal: Neoprene or foam rubber.
9. Insulation Fill: 1-inch- thick, fibrous-glass or polystyrene-foam board.

2.10 DUCT ACCESS PANEL ASSEMBLIES

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

1. Pottorff. (www.pottorff.com)
2. Ruskin Company. (www.ruskin.com)

B. Labeled according to UL 1978 by an NRTL.

C. Panel and Frame: Minimum thickness 0.0528-inch carbon steel.

D. Fasteners: Carbon steel. Panel fasteners shall not penetrate duct wall.

E. Gasket: Comply with NFPA 96; grease-tight, high-temperature ceramic fiber, rated for minimum 2000 deg F.

F. Minimum Pressure Rating: 10-inch wg, positive or negative.

2.11 FLEXIBLE CONNECTORS

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

   a. Ductmate Industries, Incorporated. (www.ductmate.com)
   b. Duro Dyne Incorporated. (www.durodyne.com)

c. Elgen Manufacturing. (www.elgenmfg.com)
d. Ventfabrics, Incorporated. (www.ventfabrics.com)
e. Ward Industries, Incorporated.; a Division of Hart & Cooley, Incorporated. (www.hartandcooley.com)

2. Materials: Flame-retardant or noncombustible fabrics.
3. Coatings and Adhesives: Comply with UL 181, Class 1.
4. Metal-Edged Connectors: Factory fabricated with a fabric strip 5-3/4 inches wide attached to two strips of 2-3/4-inch- wide, 0.028-inch- thick, galvanized sheet steel or 0.032-inch- thick aluminum sheets. Provide metal compatible with connected ducts.
5. Indoor System, Flexible Connector Fabric: Glass fabric double coated with neoprene.
   a. Minimum Weight: 26 oz. /sq. yd.
   b. Tensile Strength: 480 lbf/inch in the warp and 360 lbf/inch in the filling.
   c. Service Temperature: Minus 40 to plus 200 deg F.
6. Outdoor System, Flexible Connector Fabric: Glass fabric double coated with weatherproof, synthetic rubber resistant to UV rays and ozone.
   a. Minimum Weight: 24 oz. /sq. yd.
   b. Tensile Strength: 530 lbf/inch in the warp and 440 lbf/inch in the filling.
   c. Service Temperature: Minus 50 to plus 250 deg F.
7. High-Temperature System, Flexible Connectors: Glass fabric coated with silicone rubber.
   a. Minimum Weight: 16 oz. /sq. yd.
   b. Tensile Strength: 285 lbf/inch in the warp and 185 lbf/inch in the filling.
   c. Service Temperature: Minus 67 to plus 500 deg F.
8. High-Corrosive-Environment System, Flexible Connectors: Glass fabric with chemical-resistant coating.
   a. Minimum Weight: 14 oz. /sq. yd.
   b. Tensile Strength: 450 lbf/inch in the warp and 340 lbf/inch in the filling.
   c. Service Temperature: Minus 67 to plus 500 deg F.
9. Thrust Limits: Combination coil spring and elastomeric insert with spring and insert in compression, and with a load stop. Include rod and angle-iron brackets for attaching to fan discharge and duct.
   a. Frame: Steel, fabricated for connection to threaded rods and to allow for a maximum of 30 degrees of angular rod misalignment without binding or reducing isolation efficiency.
   b. Outdoor Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
   c. Minimum Additional Travel: 50 percent of the required deflection at rated load.
   d. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
   e. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
   f. Elastomeric Element: Molded, oil-resistant rubber or neoprene.
   g. Coil Spring: Factory set and field adjustable for a maximum of 1/4-inch movement at start and stop.

2.12 FLEXIBLE DUCTS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Flexmaster U.S.A., Incorporated. (www.flexmasterusa.com)
   2. McGill AirFlow LLC. (www.mcgillairflow.com)
   3. ThermaFlex (www.thermaflex.net)

B. Non-insulated-Flexible Duct: UL 181, Class 1, heavy-coated fiberglass cloth supported by helically wound, spring-steel wire.
   1. Pressure Rating:
      a. Sizes 2-inches to 10-inches: 16-inch wg positive and 1.0-inch wg negative.
      b. Sizes 12-inches to 20-inches: 10-inch wg positive and 1.0-inch wg negative.
   2. Maximum Air Velocity: 5000 fpm.
   3. Temperature Range: Minus 20 to plus 250 Degrees.
   4. Examples: Flexmaster U.S.A., Incorporated (Type NI-45); Thermaflex (Model S-TL)

C. Insulated-Flexible Duct: UL 181, Class 1, heavy-coated fiberglass cloth liner supported by helically wound, spring-steel wire. Fiberglass insulation R-4.2 with aluminized vapor barrier.
   1. Pressure Rating:

a. Sizes 2-inches to 10-inches: 16-inch wg positive and 1.0-inch wg negative.
b. Sizes 12-inches to 20-inches: 10-inch wg positive and 1.0-inch wg negative.
2. Maximum Air Velocity: 5000 fpm.
3. Temperature Range: Minus 20 to plus 250 Degrees

D. Flexible Duct Connectors:
1. Clamps: Nylon strap in sizes 3 through 18 inches, to suit duct size.

2.13 DUCT ACCESSORY HARDWARE
1. 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.
2. Adhesives: High strength, quick setting, neoprene based, waterproof, and resistant to gasoline and grease.

PART 3 EXECUTION

3.1 INSTALLATION

A. Install duct accessories according to applicable details in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for metal ducts and in NAIMA AH116, "Fibrous Glass Duct Construction Standards," for fibrous-glass ducts.

B. Install duct accessories of materials suited to duct materials; use galvanized-steel accessories in galvanized-steel and fibrous-glass ducts, stainless-steel accessories in stainless-steel ducts, and aluminum accessories in aluminum ducts.

C. Install control dampers at inlet of exhaust fans or exhaust ducts as close as possible to exhaust fan unless otherwise indicated.
1. Duct openings shall be free of any obstruction or irregularities that interfere with blade or linkage rotation or actuator mounting. Duct openings shall measure 1/4" larger than damper dimensions and shall be square, straight, and level.
2. Multiple damper sections will be square and free from racking, twisting, or bending. Measure diagonally from upper corners to opposite lower corners of each damper section. Both dimensions must be equal ±1/8-inches.
3. Install extended shaft or jackshaft per manufacturer's instructions. (Typically, a sticker on the damper face shows recommended extended shaft location. Attach shaft on labeled side of damper to that blade.)
4. Damper blades, axles, and linkage shall operate without binding. Before system operation, cycle damper after installation to assure proper operation. On multiple section assemblies, all sections must open and close simultaneously.
5. Provide a visible and accessible indication of damper position on the drive shaft end.
6. After installation of low-leakage dampers with seals, caulk between frame and duct or opening to prevent leakage around perimeter of damper.

D. Install backdraft dampers at inlet of exhaust fans or exhaust ducts as close as possible to exhaust fan unless otherwise indicated.

E. Install manual volume 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. Install manual volume dampers as indicated on the Drawings and Details, and as necessary to accomplish system air balancing. As a minimum, manual volume dampers will be provided at every divided flow main or branch duct, at every branch duct take off, and every duct extending to individual register, grille, or diffuser. Manual volume dampers are not required upstream of variable volume air terminal units.
1. Install steel volume dampers in steel ducts.
2. Install aluminum volume dampers in aluminum ducts.
3. Install remote damper operators for volume dampers located above gypsum board, plaster, and other hard ceilings.
4. Set dampers to fully open position before testing, adjusting, and balancing.

F. Install test holes at fan inlets and outlets and elsewhere as indicated.

G. Install smoke dampers, and combination fire/smoke dampers according to manufacturer's UL-approved written instructions. Refer to the architectural drawings for fire rating requirements. Provide 1-1/2 hour rated dampers for wall and floor assembles rated for 3 hours or less. Provide 3 hour rated combination dampers for wall and floor assembles rated for more than 3 hours. Combination dampers will have 165-degree F links except as noted.

1. Refer to the combination fire/smoke damper schedule for additional data.
2. Coordinate the installation of duct smoke detectors provided by Division 26. Duct smoke detectors must be installed in an accessible location in accordance with the manufacturer's instructions and the UL listing.

H. Install fire dampers according to manufacturer's UL-approved written instructions. Refer to the architectural drawings for fire rating requirements. Provide 1-1/2 hour rated fire dampers for wall and floor assembles rated for 3 hours or less. Provide 3 hour rated fire dampers for wall and floor assembles rated for more than 3 hours. Fire dampers will have 165-degree F links except as noted.

I. Install duct access doors on sides of ducts to allow for inspecting, adjusting, and maintaining accessories and equipment at the following locations:

1. On both sides of duct coils.
2. Upstream and downstream from duct filters.
3. At outdoor-air intakes and mixed-air plenums.
4. At drain pans and seals.
5. Downstream from manual volume dampers, control dampers, backdraft dampers, and equipment.
6. Adjacent to and close enough to fire or smoke dampers, to reset or reinstall fusible links. Access doors for access to fire or smoke dampers having fusible links shall be pressure relief access doors and shall be outward operation for access doors installed upstream from dampers and inward operation for access doors installed downstream from dampers.
   a. At each change in direction and at maximum 50-foot spacing.
   b. Upstream and downstream from turning vanes.
   c. Upstream or downstream from duct silencers.
   d. Control devices requiring inspection.
   e. Elsewhere as indicated.
7. Install access doors with swing against duct static pressure.
8. Access Door Sizes:
   a. One-Hand or Inspection Access: 8 by 5 inches.
   b. Two-Hand Access: 12 by 6 inches.
   c. Head and Hand Access: 18 by 10 inches.
   d. Head and Shoulders Access: 21 by 14 inches.
   e. Body Access: 25 by 14 inches.
   f. Body plus Ladder Access: 25 by 17 inches.
9. Label access doors according to Section 230553 "Identification for HVAC Piping and Equipment" to indicate the purpose of access door.

J. Install duct access panel assemblies at locations where greases duct access is required and as indicated on drawings. Label duct access panel assemblies according to Section 230553 "Identification for HVAC Piping and Equipment" to indicate the purpose of access assembly.

K. Install flexible connectors to connect ducts to equipment.

1. For fans developing static pressures of 5-inch wg and more, cover flexible connectors with loaded vinyl sheet held in place with metal straps.

L. Installation of Flexible Ducts

1. Install flexible ducts according to the manufacturer's instructions, applicable SMACNA standards, drawing details, and as follows:
   a. Duct Collars: Provide tap-in collars 4-inches minimum in length with a formed bead 1-inch from the end for attachment of flexible duct. Extend minimum collar length for manual volume dampers.
   b. Connections: Attach flexible duct to the tap-in collars and to sleeves with a duct clamp (draw band) around the inner liner and a second draw band around the insulation jacket. Position duct clamps behind the beads on the collar or sleeve. Duct clamps may be screwed stainless steel bands or nylon straps tightened with a compression tool.

c. Duct Supports: Support flexible duct at the manufacturer's recommended interval, but not less than every 5 feet. Maximum permissible sag is 1/2-inch per foot of spacing between supports (maximum of 1-1/4-inches over five feet).
d. Duct Hangers: Provide hanger straps in contact with the flexible duct at least 2-inch wide so the internal diameter of the duct is not reduced at the point of support.
e. Duct Bends: Make bends or turns in flexible ducts with not less than a one-duct diameter throat radius.
f. Connect diffusers, registers, grilles, and light troffer boots to low pressure ducts with maximum 60-inch lengths of flexible duct clamped or strapped in place. Refer to drawing details for additional requirements.

3.2 FIELD QUALITY CONTROL

A. Tests and Inspections:
1. Operate dampers to verify full range of movement.
2. Inspect locations of access doors and verify that purpose of access door can be performed.
3. Operate fire, smoke, and combination fire and smoke dampers to verify full range of movement and verify that proper heat-response device is installed.
4. Inspect turning vanes for proper and secure installation.
5. Install duct test holes where required for testing and balancing purposes.
6. Operate remote damper operators to verify full range of movement of operator and damper.

END OF SECTION

SECTION 233600
AIR TERMINAL UNITS

PART 1 GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
1. Shutoff, single-duct air terminal units.
2. Fan-powered air terminal units.
3. Bypass, single-duct air terminal units.
4. Dual-duct air terminal units.
5. Induction air terminal units.
6. Diffuser-type air terminal units.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of the following products, including rated capacities, furnished specialties, sound-power ratings, and accessories.
1. Air terminal units.
2. Liners and adhesives.
3. Sealants and gaskets.

B. Shop Drawings: For air terminal units. 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.
3. Hangers and supports, including methods for duct and building attachment and vibration isolation.

1.4 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For air terminal units to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:
1. Instructions for resetting minimum and maximum air volumes.
2. Instructions for adjusting software set points.

1.6 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
1. Fan-Powered-Unit Filters: Furnish one spare filter for each filter installed.

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

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

2.2 SHUTOFF, SINGLE-DUCT AIR TERMINAL UNITS

A. Manufacturers: Subject to compliance with requirements provide products by one of the following:
   1. Anemostat Products; a Mestek Company. (www.anemostat.com)
   2. Krueger. (www.krueger-hvac.com)
   3. METALAIRE, Inc. (www.metalaire.com)
   4. Nailor Industries Inc. (www.nailor.com)
   5. Price Industries. (www.price-hvac.com)
   6. Titus. (www.titus-hvac.com)
   7. Trane (www.trane.com)
   8. Tuttle & Bailey. (www.tuttleandbailey.com)

B. Configuration: Volume-damper assembly inside unit casing with control components inside a protective metal shroud.

C. Casing: Minimum 0.034-inch steel single wall.
   1. Casing Lining: Adhesive attached, 1/2-inch-thick, polyurethane foam insulation complying with NFPA 90A and UL 181 erosion requirements, and having a maximum flame-spread index of 25 and a maximum smoke-developed index of 50, for both insulation and adhesive, when tested according to ASTM E 84.
   2. Air Inlet: Round stub connection or S-slip and drive connections for duct attachment.
   3. Air Outlet: S-slip and drive connections.
   4. Access: Removable panels for access to parts requiring service, adjustment, or maintenance; with airtight gasket.
   5. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

D. Volume Damper: Galvanized steel with peripheral gasket and self-lubricating bearings.
   1. Maximum Damper Leakage: ARI 880 rated, 2 percent of nominal airflow at 3-inch wg inlet static pressure.
   2. Damper Position: Normally open.

E. Hydronic Coils: Copper tube, 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 220 deg F. Include manual air vent and drain valve.
   1. Minimum 2-rows.
   2. Where indicated in the equipment schedules

F. Pneumatic Controls: Damper operator and velocity controller. Control devices shall be compatible with temperature controls specified in Section 230900 "Instrumentation and Control for HVAC" and shall have the following features:
   1. Pneumatic Damper Operator: [0- to 13-psig] <Insert range> spring range.
   2. Velocity Controller: Factory calibrated and field adjustable to minimum and maximum air volumes; shall maintain constant airflow dictated by thermostat within 5 percent of set point while compensating for inlet static-pressure variations up to 4-inch wg; and shall have a multipoint velocity sensor at air inlet.
   3. Thermostat: Wall-mounted pneumatic type with appropriate mounting hardware.

G. Direct Digital Controls: Single-package unitary controller and actuator specified in Section 230900 "Instrumentation and Control for HVAC."

H. Direct Digital Controls: Bidirectional damper operators and microprocessor-based controller and room sensor. Control devices shall be compatible with temperature controls specified in Section 230900 "Instrumentation and Control for HVAC" and shall have the following features:
   1. Damper Actuator: 24 V, powered closed, [spring return open] [powered open].
   2. Terminal Unit Controller: Pressure-independent, variable-air-volume controller with electronic airflow transducer with multipoint velocity sensor at air inlet, factory calibrated to minimum and maximum air volumes, and having the following features:
      a. Occupied and unoccupied operating mode.
      b. Remote reset of airflow or temperature set points.
      c. Adjusting and monitoring with portable terminal.

d. Communication with temperature-control system specified in Section 230900 "Instrumentation and Control for HVAC."
3. Room Sensor: Wall mounted with temperature set-point adjustment and access for connection of portable operator terminal.

I. Capacities and Characteristics
1. Refer to equipment schedules for capacities and characteristics.

2.3 PARALLEL FAN-POWERED AIR TERMINAL UNITS

A. Manufacturers: Subject to compliance with requirements provide products by one of the following:
1. Anemostat Products; a Mestek Company. (www.anemostat.com)
2. Krueger. (www.krueger-hvac.com)
3. METALAIRE, Inc. (www.metalaire.com)
4. Nailor Industries Inc. (www.nailor.com)
5. Price Industries. (www.price-hvac.com)
6. Titus. (www.titus-hvac.com)
7. Trane (www.trane.com)
8. Tuttle & Bailey. (www.tuttleandbailey.com)

B. Configuration: Volume-damper assembly and fan in parallel arrangement inside unit casing with control components inside a protective metal shroud.

C. Casing: 0.034-inch steel single wall.
1. Casing Lining: Adhesive attached, 1-inch-thick, polyurethane foam insulation complying with NFPA 90A, UL 181 erosion requirements, and having a maximum flame-spread index of 25 and a maximum smoke-developed index of 50, for both insulation and adhesive, when tested according to ASTM E 84.
2. Air Inlets: Round stub connections or S-slip and drive connections for duct attachment.
3. Air Outlet: S-slip and drive connections.
4. Access: Removable panels for access to parts requiring service, adjustment, or maintenance; with airtight gasket and quarter-turn latches.
5. Fan: Forward-curved centrifugal, located at plenum air inlet.
6. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

D. Volume Damper: Galvanized steel with flow-sensing ring and peripheral gasket and self-lubricating bearings.
1. Maximum Damper Leakage: ARI 880 rated, 3 percent of nominal airflow at 3-inch wg inlet static pressure.
2. Damper Position: Normally closed.

E. Velocity Sensors: Multipoint array with velocity sensors in cold- and hot-deck air inlets and air outlets.

F. Direct Drive:
1. Motors: Electronically commutated brushless DC single phase.
a. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
b. Motor Bearings: Ball type.
c. Fan-Motor Assembly Isolation: Rubber isolators.
2. Motor speed control:
a. Motor mounted manual speed control adjustment dial; 350 RPM to 1725 RPM.

G. Filters: Minimum arrestance according to ASHRAE 52.1 and a minimum efficiency reporting value (MERV) according to ASHRAE 52.2.
1. Material: Pleated cotton-polyester media having 90 percent arrestance and 7 MERV.
2. Thickness: 1 inch.

H. Hydronic Coils: Copper tube, 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 220 deg F. Include manual air vent and drain valve.

1. Minimum 2-rows.
2. Location: Plenum air inlet.

I. Electric-Resistance Heating Coils: Nickel-chromium heating wire, free of expansion noise and hum, mounted in ceramic inserts in galvanized-steel housing; with primary automatic and secondary manual, reset thermal cutouts. Terminate elements in stainless-steel, machine-staked terminals secured with stainless-steel hardware.

1. Location: Plenum air inlet.
2. Stage(s): See drawings and schedules.
3. Access door interlocked disconnect switch.
4. Downstream air temperature sensor with local connection to override discharge-air temperature to not exceed a maximum temperature set point (adjustable.)
5. Nickel chrome 80/20 heating elements.
6. Airflow switches for proof of airflow.
7. Fan interlock contacts.
8. Fuses in terminal box for overcurrent protection (for coils more than 48 A).
9. Mercury contactors.
10. Pneumatic-electric switches and relays.
11. Magnetic contactor for each step of control (for three-phase coils).

J. Factory-Mounted and -Wired Controls: Electrical components mounted in control box with removable cover. Incorporate single-point electrical connection to power source.

1. Control Transformer: Factory mounted for control voltage on electric and electronic control units with terminal strip in control box for field wiring of thermostat and power source.
2. Wiring Terminations: Fan and controls to terminal strip. Terminal lugs to match quantities, sizes, and materials of branch-circuit conductors. Enclose terminal lugs in terminal box that is sized according to NFPA 70.
3. Disconnect Switch: Factory-mounted, fuse type.

K. Control Panel Enclosure: NEMA 250, Type 1, with access panel sealed from airflow and mounted on side of unit.

L. Electric Controls: 24-V damper actuator with wall-mounted electric thermostat and appropriate mounting hardware.

M. Pneumatic Controls: Damper operator, velocity controller, and thermostat. Control devices shall be compatible with temperature controls specified in Section 230900 "Instrumentation and Control for HVAC" and shall have the following features:

1. Pneumatic Damper Operator: 0- to 13-psig spring range.
2. Velocity Controller: Factory calibrated and field adjustable to minimum and maximum air volumes; shall maintain constant airflow dictated by thermostat within 5 percent of set point while pressure independent up to 4-inch wg; and shall have a multipoint velocity sensor at air inlet.
3. Thermostat: Wall-mounted pneumatic type with appropriate mounting hardware.

N. Electronic Controls: Bidirectional damper operator and microprocessor-based controller with integral airflow transducer and room sensor. Control devices shall be compatible with temperature controls specified in Section 230900 "Instrumentation and Control for HVAC" and shall have the following features:

1. Occupied and unoccupied operating mode.
2. Remote reset of airflow or temperature set points.
3. Adjusting and monitoring with portable terminal.
4. Communication with temperature-control system specified in Section 230900 "Instrumentation and Control for HVAC."

O. Capacities and Characteristics

1. Refer to equipment schedules for capacities and characteristics and control type.

2.4 SERIES FAN-POWERED AIR TERMINAL UNITS

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

1. Anemostat Products; a Mestek Company. (www.anemostat.com)
2. Krueger. (www.krueger-hvac.com)

3. METALAIRE, Inc. (www.metalaire.com)
4. Nailor Industries Inc. (www.nailor.com)
5. Price Industries. (www.price-hvac.com)
6. Titus. (www.titus-hvac.com)
7. Trane (www.trane.com)
8. Tuttle & Bailey. (www.tuttleandbailey.com)

B. Configuration: Volume-damper assembly and fan in series arrangement inside unit casing with control components inside a protective metal shroud.

C. Casing: 0.034-inch steel single wall.

1. Casing Lining: Adhesive attached, 1-inch-thick, polyurethane foam insulation complying with UL 181 erosion requirements, and having a maximum flame-spread index of 25 and a maximum smoke-developed index of 50, for both insulation and adhesive, when tested according to ASTM E 84.
2. Air Inlets: Round stub connections or S-slip and drive connections for duct attachment.
3. Air Outlet: S-slip and drive connections.
4. Access: Removable panels for access to parts requiring service, adjustment, or maintenance; with airtight gasket and quarter-turn latches.
5. Fan: Forward-curved centrifugal.
6. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

D. Volume Damper: Galvanized steel with flow-sensing ring and peripheral gasket and self-lubricating bearings.

1. Maximum Damper Leakage: ARI 880 rated, 3 percent of nominal airflow at 3-inch wg inlet static pressure.
2. Damper Position: Normally closed.

E. Velocity Sensors: Multipoint array with velocity sensors in cold- and hot-deck air inlets and air outlets.

F. Motor:

1. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
2. Type: Electronically commutated motor.
3. Fan-Motor Assembly Isolation: Rubber isolators.
4. Motor Bearings: Ball Type
5. Motor Speed: Variable
   a. Field adjustable factory preset motor speed.
   b. Speed Control: Infinitely adjustable with pneumatic-electric and electronic controls.
6. Electrical Characteristics:
   a. Volts: refer to drawings and schedules.
   b. Phase: Single.
   c. Hz: 60.

G. Filters: Minimum arrestance according to ASHRAE 52.1 and a minimum efficiency reporting value (MERV) according to ASHRAE 52.2.

1. Material: Pleated cotton-polyester media having 90 percent arrestance and 7 MERV.
2. Thickness: 1 inch.

H. Attenuator Section: 0.034-inch steel.

1. Lining: Adhesive attached, 3/4-inch- thick, polyurethane foam insulation complying with UL 181 erosion requirements, and having a maximum flame-spread index of 25 and a maximum smoke-developed index of 50, for both insulation and adhesive, when tested according to ASTM E 84.
2. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

I. Hydronic Coils: Copper tube, 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 220 deg F. Include manual air vent and drain valve.

1. Minimum 2-rows.

J. Electric-Resistance Heating Coils: Nickel-chromium heating wire, free of expansion noise and hum, mounted in ceramic inserts in galvanized-steel housing; with primary automatic and secondary manual, reset thermal cutouts. Terminate elements in stainless-steel, machine-staked terminals secured with stainless-steel hardware.

1. Stage(s): see drawings and schedules
2. Access door interlocked disconnect switch.
3. Downstream air temperature sensor with local connection to override discharge-air temperature to not exceed a maximum temperature set point (adjustable.)
4. Nickel chrome 80/20 heating elements.
5. Airflow switch for proof of airflow.
6. Fan interlock contacts.
7. Fuses in terminal box for overcurrent protection (for coils more than 48 A).
8. Mercury contactors.
9. Pneumatic-electric switches and relays.
10. Magnetic contactor for each step of control (for three-phase coils).

K. Factory-Mounted and -Wired Controls: Electrical components mounted in control box with removable cover. Incorporate single-point electrical connection to power source.

1. Control Transformer: Factory mounted for control voltage on electric and electronic control units with terminal strip in control box for field wiring of thermostat and power source.
2. Wiring Terminations: Fan and controls to terminal strip. Terminal lugs to match quantities, sizes, and materials of branch-circuit conductors. Enclose terminal lugs in terminal box that is sized according to NFPA 70.
3. Disconnect Switch: Factory-mounted, fuse type.
4. Pressure independent fan control.
5. LED visual indication of fan air volume.
6. Adjustable fan air volume.
7. Remote BAS fan air volume adjustment.

L. Control Panel Enclosure: NEMA 250, Type 1, with access panel sealed from airflow and mounted on side of unit.

M. Electric Controls: 24-V damper actuator with wall-mounted electric thermostat and appropriate mounting hardware.

N. Pneumatic Controls: Damper operator, velocity controller, and thermostat. Control devices shall be compatible with temperature controls specified in Section 230900 "Instrumentation and Control for HVAC" and shall have the following features:

1. Pneumatic Damper Operator: 0- to 13-psig spring range.
2. Velocity Controller: Factory calibrated and field adjustable to minimum and maximum air volumes; shall maintain constant airflow dictated by thermostat within 5 percent of set point while pressure independent up to 4-inch wg; and shall have a multipoint velocity sensor at air inlet.
3. Thermostat: Wall-mounted pneumatic type with appropriate mounting hardware.

O. Electronic Controls: Bidirectional damper operator and microprocessor-based controller with integral airflow transducer and room sensor. Control devices shall be compatible with temperature controls specified in Section 230900 "Instrumentation and Control for HVAC" and shall have the following features:

1. Occupied and unoccupied operating mode.
2. Remote reset of airflow or temperature set points.
3. Adjusting and monitoring with portable terminal.
4. Communication with temperature-control system specified in Section 230900 "Instrumentation and Control for HVAC."

P. Capacities and Characteristics

1. Refer to equipment schedules for capacities and characteristics.

2.5 DUAL-DUCT AIR TERMINAL UNITS

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

1. Anemostat Products; a Mestek Company. (www.anemostat.com)
2. Carnes. (www.carnes.com)
3. Environmental Technologies, Inc. (www.enviro-tec.com)
4. Krueger. (www.krueger-hvac.com)
5. METALAIRE, Inc. (www.metalaire.com)
6. Nailor Industries Inc. (www.nailor.com)
7. Price Industries. (www.price-hvac.com)
8. Titus. (www.titus-hvac.com)
9. Trane (www.trane.com)
10. Tuttle & Bailey. (www.tuttleandbailey.com)

B. Configuration: Two volume dampers inside unit casing with mixing attenuator section and control components inside a protective metal shroud.

C. Casing: 0.034-inch steel single wall.

1. Casing Lining: Adhesive attached, 1/2-inch-thick, polyurethane foam insulation complying with NFPA 90A, UL 181 erosion requirements, and having a maximum flame-spread index of 25 and a maximum smoke-developed index of 50, for both insulation and adhesive, when tested according to ASTM E 84.
2. Air Inlets: Round stub connections or S-slip and drive connections for duct attachment.
3. Air Outlet: S-slip and drive connections.
4. Access: Removable panels for access to parts requiring service, adjustment, or maintenance; with airtight gasket.
5. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

D. Volume Damper: Galvanized steel with peripheral gasket and self-lubricating bearings.

1. Maximum Damper Leakage: ARI 880 rated, 3 percent of nominal airflow at 3-inch wg inlet static pressure.

E. Velocity Sensors: Multipoint array with velocity sensors in cold- and hot-deck air inlets and air outlets.

F. Pneumatic Controls: Damper operator, velocity controllers, and thermostat. Control devices shall be compatible with temperature controls specified in Section 230900 "Instrumentation and Control for HVAC" and shall have the following features:

1. Pneumatic Damper Operator: 0- to 13-psig spring range.
2. Velocity Controllers: Factory calibrated and field adjustable to minimum and maximum air volumes; shall maintain constant airflow dictated by thermostat within 5 percent of set point while compensating for inlet static-pressure variations up to 4-inch wg; and shall have a multipoint velocity sensor. Locate velocity sensors in cold- and hot-deck air inlets and supply air outlets.
3. Thermostat: Wall-mounted pneumatic type with appropriate mounting hardware.

G. Electronic Controls: Bidirectional damper operator and microprocessor-based thermostat with integral airflow transducer and room sensor. Control devices shall be compatible with temperature controls specified in Section 230900 "Instrumentation and Control for HVAC" and shall have the following features:

1. Damper Actuator: 24 V, powered closed, spring return open
2. Velocity Controller: Factory calibrated and field adjustable to minimum and maximum air volumes; shall maintain constant airflow dictated by thermostat within 5 percent of set point while compensating for inlet static-pressure variations up to 4-inch wg; and shall have a multipoint velocity sensor. Locate velocity sensors in cold-deck air inlets and air outlets.
3. Thermostat: Wall-mounted electronic type with temperature set-point display in Fahrenheit.

H. Direct Digital Controls: Single-package unitary controller and actuator specified in Section 230900 "Instrumentation and Control for HVAC."

I. Direct Digital Controls: Bidirectional damper operators and microprocessor-based controller and room sensor. Control devices shall be compatible with controls specified in Section 230900 "Instrumentation and Control for HVAC" and shall have the following features:

1. Damper Actuators: 24 V, powered closed, spring return open

2. Terminal Unit Controller: Pressure-independent, variable-air-volume controller with electronic airflow transducers factory calibrated to minimum and maximum air volumes, and having the following features:
   a. Occupied and unoccupied operating mode.
   b. Remote reset of airflow or temperature set points.
   c. Adjusting and monitoring with portable terminal.
   d. Communication with temperature-control system specified in Section 230900 "Instrumentation and Control for HVAC."
3. Room Sensor: Wall mounted with temperature set-point adjustment and access for connection of portable operator terminal.

J. Capacities and Characteristics
   1. Refer to equipment schedules for capacities and characteristics.

2.6 HANGERS AND SUPPORTS

A. Hanger Rods for Noncorrosive Environments: Cadmium-plated steel rods and nuts.

B. Hanger Rods for Corrosive Environments: Electro galvanized all-thread rods or galvanized rods with threads painted with zinc-chromate primer after installation.

C. Steel Cables: Galvanized steel complying with ASTM A 603 or Stainless steel complying with ASTM A 492.

D. Steel Cable End Connections: Cadmium-plated steel assemblies with brackets, swivel, and bolts designed for duct hanger service; with an automatic-locking and clamping device.

E. Air Terminal Unit Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.

F. Trapeze and Riser Supports: Steel shapes and plates for units with steel casings; aluminum for units with aluminum casings.

2.7 SOURCE QUALITY CONTROL

A. Factory Tests: Test assembled air terminal units according to ARI 880.
   1. Label each air terminal unit with plan number, nominal airflow, maximum and minimum factory-set airflows, coil type, and ARI certification seal.

PART 3 EXECUTION

3.1 INSTALLATION

A. Install air terminal units according to NFPA 90A, "Standard for the Installation of Air Conditioning and Ventilating Systems" and the manufacturers installation instructions.

B. Install air terminal units’ level and plumb. Maintain sufficient clearance for normal service and maintenance.

C. Install return air inlet sound attenuator on fan powered air terminal units.

3.2 HANGER AND SUPPORT INSTALLATION

A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 5, "Hangers and Supports."

B. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.
   1. Where practical, install concrete inserts before placing concrete.
   2. Install powder-actuated concrete fasteners after concrete is placed and completely cured.
   3. Use powder-actuated concrete fasteners for standard-weight aggregate concretes and for slabs more than 4 inches thick.
   4. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes and for slabs less than 4 inches thick.

C. Hangers Exposed to View: Threaded rod and angle or channel supports.

D. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

3.3 CONNECTIONS

A. Install piping adjacent to air terminal unit to allow service and maintenance.

B. Hot-Water Piping: In addition to requirements in Section 232113 "Hydronic Piping" and Section 232116 Hydronic Piping Specialties," connect heating coils to return with balancing valve, control valve, shutoff valve, and air vent; and to supply with shutoff valve.

1. Connect steel heating-coil supply and return piping with union or flange. Copper piping connections do not require unions or flanges.

C. Connect ducts to air terminal units according to Section 233113 "Metal Ducts."

D. Make supply duct connections to fan powered air terminal units with flexible connectors complying with requirements in Section 233300 "Air Duct Accessories."

3.4 IDENTIFICATION

A. Label each air terminal unit with plan number, nominal airflow, and maximum and minimum factory-set airflows. Comply with requirements in Section 230553 "Identification for HVAC Piping and Equipment" for equipment labels and warning signs and labels.

3.5 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Tests and Inspections:

1. After installing air terminal units and after electrical circuitry has been energized, test for compliance with requirements.
2. Leak Test: After installation, fill water coils and test for leaks. Repair leaks and retest until no leaks exist.
3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. Air terminal unit will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

3.6 STARTUP SERVICE

A. Perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.
2. Verify that inlet duct connections are as recommended by air terminal unit manufacturer to achieve proper performance.
3. Verify that controls and control enclosure are accessible.
4. Verify that control connections are complete.
5. Verify that nameplate and identification tag are visible.
6. Verify that controls respond to inputs as specified.

END OF SECTION

SECTION 233713
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 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
   1. Round ceiling diffusers.
   2. Rectangular and square ceiling diffusers.
   3. Perforated diffusers.
   4. Louver face diffusers.
   5. Linear bar diffusers.
   6. Linear slot diffusers.
   7. Ceiling-integral continuous diffusers.
   8. Light troffer diffusers.
   9. Round induction diffusers.
   10. Linear floor diffuser plenums.
   11. Adjustable bar registers.
   12. Fixed face grilles.
   13. Linear bar grilles.

B. Related Sections:
   1. Section 089116 "Operable Wall Louvers" and Section 089119 "Fixed Louvers" for fixed and adjustable louvers and wall vents, whether or not they are connected to ducts.
   2. Section 233300 "Air Duct Accessories" for fire and smoke dampers and volume-control dampers not integral to diffusers, registers, and grilles.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated, include the following:
   1. Data Sheet: Indicate materials of construction, finish, and mounting details; and performance data including throw and drop, static-pressure drop, and noise ratings.
   2. Diffuser, Register, and Grille Schedule: Indicate drawing designation, room location, quantity, model number, size, mounting surface, border, frame, and accessories furnished.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from Installers of the items involved:
   1. Ceiling suspension assembly members.
   2. Method of attaching hangers to building structure.
   3. Size and location of initial access modules for acoustical tile.
   4. Ceiling-mounted items including lighting fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings.
   5. Duct access panels.

B. Source quality-control reports.

1.5 COORDINATION

A. Review the architectural drawings for diffuser, register, and grille mounting surfaces.

PART 2 - PRODUCTS

2.1 EXISTING CONDITIONS

A. Where there are existing grilles, registers and diffusers the new grilles, registers and diffusers shall match the existing.

2.2 CEILING DIFFUSERS

A. Round Ceiling Diffuser:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Anemostat Products; a Mestek company.
      b. Hart & Cooley Inc.
      c. METALAIRE, Inc.
      d. Nailor Industries Inc.
      e. Price Industries.
      f. Titus.
      g. Tuttle & Bailey.
   2. Face Style: four cones.
   3. Mounting: Duct connection.
   4. Accessories: Refer to the drawings and equipment schedules for accessories.
      a. Equalizing grid.
      b. Plaster ring.

B. Rectangular and Square Ceiling Diffusers:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Anemostat Products; a Mestek company.
      b. Hart & Cooley Inc.
      c. Krueger.
      d. METALAIRE, Inc.
      e. Nailor Industries Inc.
      f. Price Industries.
      g. Titus.
      h. Tuttle & Bailey.
   2. Face Style: three cones.
   3. Accessories: Refer to the drawings and equipment schedules for accessories.
      a. Equalizing grid.
      b. Plaster ring.

C. Perforated Diffuser:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Anemostat Products; a Mestek company.
      b. Hart & Cooley Inc.
      c. Krueger.
      d. METALAIRE, Inc.
      e. Nailor Industries Inc.
      f. Price Industries.
      g. Titus.
      h. Tuttle & Bailey.
   2. Accessories: Refer to the drawings and equipment schedules for accessories.
      a. Equalizing grid.
      b. Plaster ring.

D. Louver Face Diffuser:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Anemostat Products; a Mestek company.
      b. METALAIRE, Inc.

c. Nailor Industries Inc.
d. Price Industries.
e. Titus.
f. Tuttle & Bailey.

2. Accessories: Refer to the drawings and equipment schedules for accessories.
   a. Equalizing grid.
   b. Plaster ring.

2.3 CEILING LINEAR SLOT OUTLETS

A. Linear Bar Diffuser:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Anemostat Products; a Mestek company.
   b. Hart & Cooley Inc.
   c. Krueger.
   d. METALAIRE, Inc.
   e. Nailor Industries Inc.
   f. Price Industries.
   g. Titus.
   h. Tuttle & Bailey.

B. Linear Slot Diffuser:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Anemostat Products; a Mestek company.
   b. Hart & Cooley Inc.
   c. Krueger.
   d. METALAIRE, Inc.
   e. Nailor Industries Inc.
   f. Price Industries.
   g. Titus.
   h. Tuttle & Bailey.

C. Ceiling-Integral Continuous Diffuser:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Anemostat Products; a Mestek company.
   b. Hart & Cooley Inc.
   c. Krueger.
   d. METALAIRE, Inc.
   e. Nailor Industries Inc.
   f. Price Industries.
   g. Titus.
   h. Tuttle & Bailey.

D. Light Troffer Diffuser:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Anemostat Products; a Mestek company.
   b. Hart & Cooley Inc.
   c. Krueger.
   d. METALAIRE, Inc.
   e. Nailor Industries Inc.
   f. Price Industries.
   g. Titus.
   h. Tuttle & Bailey.
2. Devices shall be specifically designed for variable-air-volume flows.
3. Material: Steel
4. Finish: See schedules
5. Slot Width: See schedules.

6. Number of Sides: Two
7. Length: See schedules and drawings.
8. Pattern: See schedules.
9. Inlet: Side
10. Inlet Size: See schedules and drawings.

2.4 UNDERFLOOR AIR DISTRIBUTION DIFFUSERS

A. Round Induction Diffusers:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Air Research Diffuser Products, Inc.
      b. Anemostat Products; a Mestek company.
      c. Carnes.
      d. Hart & Cooley Inc.
      e. Krueger.
      f. METALAIRE, Inc.
      g. Nailor Industries Inc.
      h. Price Industries.
      i. Titus.
      j. Tuttle & Bailey.
   2. Airflow Principle: Swirl-pattern induction or displacement. See schedule.
   3. Material: Plastic, high impact, and resistant to cart and foot traffic.
   4. Color: Black.
   5. Components:
      a. Diffuser core.
      b. Flow regulator.
      c. Dirt and liquid catch pan.
      d. Spacer flange.
      e. Gasketed, underfloor compression ring.

B. Linear Floor Diffuser Plenums:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Anemostat Products; a Mestek company.
      b. Hart & Cooley Inc.
      c. Krueger.
      d. METALAIRE, Inc.
      e. Nailor Industries Inc.
      f. Price Industries.
      g. Titus.
      h. Tuttle & Bailey.
   2. Material: Steel.
   3. Finish: White baked acrylic.
   4. Deflection: Zero or 15 degrees. See schedule.
   5. Components:
      a. Aluminum diffuser core.
      b. Diffuser frame.
      c. Plenum, 0.034-inch steel.

2.5 REGISTERS AND GRILLES

A. Adjustable Blade Register:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Anemostat Products; a Mestek company.
      b. Hart & Cooley Inc.
      c. Krueger.
      d. METALAIRE, Inc.
      e. Nailor Industries Inc.
      f. Price Industries.

g. Titus.
h. Tuttle & Bailey.
2. Frame: Minimum 20 gauge steel.
3. Mounting: See schedules
4. Damper Type: See schedules.

B. Adjustable Bar Grille:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Anemostat Products; a Mestek company.
b. Hart & Cooley Inc.
c. Krueger.
d. METALAIRE, Inc.
e. Nailor Industries Inc.
f. Price Industries.
g. Titus.
h. Tuttle & Bailey.
2. Frame: Minimum 20 gauge steel.
3. Mounting: See schedules.

C. Fixed Face Register:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Anemostat Products; a Mestek company.
b. Hart & Cooley Inc.
c. Krueger.
d. Nailor Industries Inc.
e. Price Industries.
f. Titus.
g. Tuttle & Bailey.
2. Material: Steel
3. Finish: Baked enamel, white
4. Face Arrangement: Refer to register schedule.
5. Core Construction: Refer to register schedule.
6. Frame: Minimum 20 Gauge Steel.
7. Mounting Frame: Refer to register schedule.
8. Mounting: Concealed
9. Damper Type: Adjustable opposed blade

D. Fixed Face Grille:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Anemostat Products; a Mestek company.
b. Hart & Cooley Inc.
c. Krueger.
d. Nailor Industries Inc.
e. Price Industries.
f. Titus.
g. Tuttle & Bailey.
2. Material: Steel
3. Finish: Baked enamel, white
4. Face Arrangement: Refer to grille schedule.
5. Core Construction: Refer to grille schedule.
6. Frame: Minimum 20 Gauge Steel.
7. Mounting: Concealed

E. Linear Bar Grille:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Anemostat Products; a Mestek company.
b. Dayus Register & Grille Inc.

c. Krueger.
d. Nailor Industries Inc.
e. Price Industries.
f. Titus.
g. Tuttle & Bailey.

2. Material: Aluminum
3. Finish: Anodized, color selected by architect
4. Face Arrangement: Refer to Grille schedule.
5. Frame: Refer to Grille schedule.
6. Mounting: Concealed
7. Damper Type: Adjustable opposed blade

2.6 SOURCE QUALITY CONTROL

A. Verification of Performance: Rate diffusers, registers, and grilles according to ASHRAE 70, "Method of Testing for Rating the Performance of Air Outlets and Inlets."

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas where diffusers, registers, and grilles are to be installed for compliance with requirements for installation tolerances and other conditions affecting performance of equipment.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

C. Provide the appropriate mounting frame or border for each diffuser register or grille location. Verify ceiling grid type for lay-in type inlets and outlets. Non-lay-in diffusers, registers, and grilles will have frames or borders for surface mounting.

3.2 INSTALLATION

A. Diffuser, register, and grille sizes and locations are indicated on the drawings and schedules.

B. Install diffusers, registers, and grilles level and plumb.

C. Ceiling-Mounted Outlets and Inlets: Drawings indicate general arrangement of ducts, fittings, and accessories. Air outlet and inlet locations have been indicated to achieve design requirements for air volume, noise criteria, airflow pattern, throw, and pressure drop. Make final locations where indicated, as much as practical. For units installed in lay-in ceiling panels, locate units in the center of panel. Where architectural features or other items conflict with installation, notify Architect for a determination of final location.

D. Install diffusers, registers, and grilles with airtight connections to ducts and to allow service and maintenance of dampers, air extractors, and fire dampers.

E. Install equalizing grids on round neck ceiling diffusers with an inlet duct of less than one diameter in length.

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

SECTION 238239
CABINET UNIT HEATERS

PART 1 GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes cabinet unit heaters with centrifugal fans and hot-water coils.

B. Do not use cabinet unit heaters with electric-resistance heating coils.

1.3 DEFINITIONS

A. BAS: Building automation system.

B. CWP: Cold working pressure.

C. PTFE: Polytetrafluoroethylene plastic.

D. TFE: Tetrafluoroethylene plastic.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include rated capacities, operating characteristics, furnished specialties, and accessories.

B. Shop Drawings:

1. Include plans, elevations, sections, and details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, and required clearances, method of field assembly, components, and location and size of each field connection.
3. Include location and size of each field connection.
4. Include details of anchorages and attachments to structure and to supported equipment.
5. Include equipment schedules to indicate rated capacities, operating characteristics, furnished specialties, and accessories.
6. Indicate location and arrangement of piping valves and specialties.
7. Wiring Diagrams: Power, signal, and control wiring.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor plans reflected ceiling plans, and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Suspended ceiling components.
2. Structural members to which cabinet unit heaters will be attached.
3. Method of attaching hangers to building structure.
4. Size and location of initial access modules for acoustical tile.
5. Items penetrating finished ceiling, including the following:
   a. Lighting fixtures.
   b. Air outlets and inlets.
   c. Speakers.
   d. Sprinklers.
   e. Access panels.
6. Perimeter moldings for exposed or partially exposed cabinets.

B. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For cabinet unit heaters to include in emergency, operation, and maintenance manuals.

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by the following:
   1. Airtherm; a Mestek company.
   2. International Environmental Corporation.
   3. McQuay International.
   4. Rittling
   5. Sterling
   6. Trane Incorporated

2.2 DESCRIPTION

A. Factory-assembled and -tested unit complying with AHRI 440.

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

C. Comply with UL 2021.

2.3 PERFORMANCE REQUIREMENTS

A. ASHRAE/IESNA 90.1 Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

2.4 COIL SECTION INSULATION

A. Insulation Materials: Comply with NFPA 90A or NFPA 90B. Unicellular polyethylene thermal plastic, preformed sheet insulation complying with ASTM C 534, Type II, except for density.
   1. Thickness: 1/2 inch.
   2. Thermal Conductivity (k-Value): 0.24 Btu x in./h x sq. ft. at 75 deg F mean temperature.
   3. Fire-Hazard Classification: Maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM C 411.
   4. Adhesive: As recommended by insulation manufacturer and complying with NFPA 90A or NFPA 90B.
   5. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

2.5 CABINETS

A. Material: Steel with baked-enamel finish with manufacturer's standard paint, in color selected by Architect.
   1. Vertical Unit, Exposed Front Panels: Minimum 0.0528-inch-thick sheet steel, removable panels with channel-formed edges secured with tamperproof cam fasteners.
   2. Recessed Flanges: Steel, finished to match cabinet.
   3. Control Access Door: Key operated.
   4. Base: Minimum 0.0528-inch- thick steel, finished to match cabinet, 4 inches high with leveling bolts.
   5. Extended Piping Compartment: 8-inch-wide piping end pocket.
   6. False Back: Minimum 0.0428-inch- thick steel, finished to match cabinet.

2.6 FILTERS

A. Minimum Arrestance: According to ASHRAE 52.1 and a minimum efficiency reporting value (MERV) according to ASHRAE 52.2.
   1. Pleated: 90 percent arrestance and MERV 7.

2.7 COILS

A. Hot-Water Coil: Copper tube, 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 220 deg F. Include manual air vent and drain.

2.8 CONTROLS

A. Fan and Motor Board: Removable.
   1. Fan: Forward curved, high static, double width, centrifugal, directly connected to motor; thermoplastic or painted-steel wheels and aluminum, painted-steel, or galvanized-steel fan scrolls.
   2. Motor: Permanently lubricated, multispeed; resiliently mounted on motor board. Comply with requirements in Section 230513 "Common Motor Requirements for HVAC Equipment."
   3. Wiring Terminations: Connect motor to chassis wiring with plug connection.

B. Control devices and operational sequences are specified in Section 230900 "Instrumentation and Control for HVAC" and Section 230993 "Sequence of Operations for HVAC Controls."

C. Basic Unit Controls:
   a. Manual fan-speed switch.

D. Electrical Connection: Factory-wired motors and controls for a single field connection.

2.9 CAPACITIES AND CHARACTERISTICS

A. Refer to the Cabinet Unit Heater Schedule on the drawings.

PART 3 EXECUTION

3.1 EXAMINATION

A. Examine areas to receive cabinet unit heaters for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for 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 cabinet unit heaters to comply with NFPA 90A.

B. Install new filters in each fan-coil unit within two weeks of Substantial Completion.

3.3 CONNECTIONS

A. Piping installation requirements are specified in Section 232113 "Hydronic Piping," Section 232116 Hydronic Piping Specialties," Drawings indicate general arrangement of piping, fittings, and specialties.

B. For concealed cabinet unit heaters connect supply and return ducts to cabinet unit heaters with flexible duct connectors specified in Section 233300 "Air Duct Accessories."

C. Comply with safety requirements in UL 1995.

D. Unless otherwise indicated, install union and gate or ball valve on supply-water connection and union and calibrated balancing valve on return-water connection of cabinet unit heater. Hydronic specialties are specified in Section 232113 "Hydronic Piping" and Section 232116 Hydronic Piping Specialties."

E. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

F. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.4 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.

B. Units will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

END OF SECTION