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DIVISION 26 ELECTRICAL

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260526  GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS
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SECTION 210500
COMMON WORK RESULTS FOR FIRE SUPPRESSION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. In addition to Division 01 Specification Sections, related sections include the following:
   1. Division 01 Section "Cutting and Patching"
   2. Division 02 Section "Selective Structure Demolition" for general demolition requirements and procedures.
   3. Division 03 Sections "Cast-in-Place Concrete" and "Miscellaneous Cast-in-Place Concrete".
   4. Division 05 Section "Metal Fabrications" for structural steel.
   5. Division 09 Sections "Interior Painting" and "Exterior Painting".
   6. Division 08 Section "Access Doors and Frames" for access panels and doors.

1.2 RELATED REQUIREMENTS

A. All conditions imposed by these documents shall be applicable to all portions of the Work under this Division. These references are intended to point out specific items to the Contractor, but in no way relieve him of the responsibility of reading and complying with all relevant parts of the entire Specification.

B. The Contractor shall examine and coordinate with all Contract Drawings and Specifications, and all Addenda issued. Failure to comply shall not relieve them of responsibility. The omission of details of other portions of the Work from this Division shall not be used as a basis for a request for additional compensation.

C. The specific features and details for other portions of the Work related to the construction in progress or to the building(s) shall be determined by examination at the site.

1.3 SUMMARY

A. This Section includes the following:
   1. Piping materials and installation instructions common to most piping systems.
   2. Mechanical sleeve seals.
   3. Sleeves.
   5. Equipment installation requirements common to equipment sections.
   6. Painting and finishing.
   7. Supports and anchorages.
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.

1.5 SCOPE OF WORK

A. Refer to other Divisions of the Specifications for related Work.

B. It is the intent, unless otherwise indicated, that all products and materials described and specified under this Division, shall be provided for a complete working system irrespective of use of the phrases “install”, “furnish”, “furnish and install”, or “provide” as described above has been actually included.

C. The Contractor shall be responsible for all Work of every description in connection with this Division of the Specifications.

D. The Contractor shall specifically and distinctly assume, and does so assume, all risk for damage or injury from whatever cause to property or person used or employed on or in connection with this Work and of all damages or injury to any person or property wherever located, resulting from an action or operation under the Contract in connection with the Work, and undertake the promise to defend the Owner against all claims on account of any such damage or injury.

E. The Contractor will be held responsible for the satisfactory execution and completion of the Work in accordance with the true intent of the Documents.

F. The Contractor shall provide without extra charge all incidental items required as part of the Work, even though it may not be specifically indicated. If the Contractor has reason for objecting to the use of any material, equipment, device or method of construction as indicated, he shall make report of such objections to the Owner's Representative, obtain proper approval and adjustment to the Contract, and shall proceed with the Work.

G. Electric wiring
1. All electric wiring shall be installed under Division 26, except for such equipment items as are prewired at their point of manufacture and so delivered to the project, and except for the following:
   a. Temperature Control Wiring and Power Wiring provided by controls contractor.
2. Prepare and submit for review wiring diagrams for all equipment furnished under this Division. Show on these diagrams all power, interlock, and control circuits. When the Architect takes no exception to these drawings, they shall become installation drawings for the Contractor.

1.6 ORDINANCES, PERMITS AND CODES

A. It shall be the Contractor's duty to perform the work and provide the materials covered by these specifications in conformance with all ordinances and regulations of all authorities having jurisdiction.

B. The work shall be in accordance with, but not limited to, the requirements of:
   1. National Fire Protection Association
   2. Florida Building Code

C. Codes and standards referred to are minimum standards. Where the requirements of these specifications or drawings exceed those of the codes and regulations, the drawings, and specifications govern.

D. The Contractor shall obtain permits, plan checks, connection and specification fees, inspections, and approvals applicable to the Work as required by the regulatory authorities.

E. Fees and costs of any nature whatsoever incidental to permits, inspections, and approvals shall be assumed and paid by the Contractor.

F. The pro-rata costs, if any, for utilities serving this property will be paid for by the Owner and shall not be included as part of this Contract.

1.7 SUBMITTALS

A. Shop Drawings
   1. Prepare shop drawings as called for elsewhere herein or directed by the Architect to coordinate this work with the work of other Divisions, to illustrate changes in this work to facilitate its concealment in finished spaces, to avoid obstructions, or to illustrate the installation of a substitute equipment item. Shop drawings shall be provided for the following:
      a. Fire Protection Systems (prepared at a minimum scale of 1/8"=1'-0")

B. Product Data: For the following:
   1. Mechanical sleeve seals.

C. Welding certificates.
1.8 QUALITY ASSURANCE

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

B. Steel Pipe Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."
   1. Comply with provisions in ASME B31 Series, "Code for Pressure Piping."
   2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.

C. 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.

1.9 DELIVERY, STORAGE, AND HANDLING

A. Deliver products and materials with factory-applied end caps or “heat shrink” wrappings to protect openings. Maintain opening protection through shipping, storage, and handling to prevent damage and the entrance of dirt, debris, and moisture.

B. Store light sensitive products and materials away from and protected against direct sunlight.

C. Support products and materials at all times to prevent sagging and bending.

D. The area provided for product and material storage at the jobsite shall be clean, dry and exposure to dust minimized.

E. Responsibility for the protection of products and materials shall extend to existing equipment, systems, and products and materials. Erect temporary sheltering structures, provide temporary bracing and supports, or cover existing equipment, systems, and products and materials to prevent damage and the entrance of dirt, debris, and moisture.

F. Failure on the part of the Contractor to comply with the above to the satisfaction of the Architect, Engineer, or either’s authorized representative shall be sufficient cause for the rejection of products and materials in question.

1.10 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. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the manufacturers specified.
   2. Manufacturers: Subject to compliance with requirements, provide products by the manufacturers specified.

2.2 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. All piping and tubing shall be American manufactured, unless otherwise indicated.

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 (3.2-mm) 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 (3.2 mm) 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. 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 MECHANICAL SLEEVE SEALS

A. Description: Modular sealing element unit, designed for field assembly, to fill annular space between pipe and sleeve.
1. Manufacturers:
   a. Innerlinx by Mason Dallas.
   b. Metraflex Co.
   c. Linkseal by Thunderline.
2. Sealing Elements: NBR interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
3. Pressure Plates: Include two for each sealing element.
4. Connecting Bolts and Nuts: Stainless steel of length required to secure pressure plates to sealing elements. Include one for each sealing element.

2.5 SLEEVES
   A. Steel Pipe: ASTM A 53, Type E, Grade B, Schedule 10, galvanized, plain ends.
   B. Cast Iron: Cast or fabricated "wall pipe" equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.
   C. Stack Sleeve Fittings: Manufactured, cast-iron sleeve with integral clamping flange. Include clamping ring and bolts and nuts for membrane flashing.
      1. Underdeck Clamp: Clamping ring with set screws.

2.6 GROUT
   A. Description: ASTM C 1107, Grade B, nonshrink and nonmetallic, dry hydraulic-cement grout.
      2. Design Mix: 5000-psi (34.5-MPa), 28-day compressive strength.

PART 3 - EXECUTION

3.1 PIPING SYSTEMS - COMMON REQUIREMENTS
   A. Install piping according to the following requirements and Division 21 Sections specifying piping systems.
   B. It is the intent of these Specifications to cover the complete installation of the wet type automatic sprinkler and dry pipe sprinkler system. The sprinkler contractor shall furnish and install the entire fire protection system, from the designated water supply connection to the final installation of each sprinkler head.
   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 free of sags and bends.

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

I. Select system components with pressure rating equal to or greater than system operating pressure.

J. Sleeves are not required for core-drilled holes.

K. Install sleeves for pipes passing through concrete and masonry walls and concrete floor and roof slabs.
   1. Penetration assemblies shall comply with U.L. Fire Resistance Directory requirements for wall penetrations
   2. Except for underground wall penetrations, seal annular space between sleeve and pipe or pipe insulation, using joint sealants appropriate for size, depth, and location of joint. Refer to Division 07 Section "Joint Sealants" for materials and installation.

L. Underground, Exterior-Wall Pipe Penetrations: Install cast-iron "wall pipes" for sleeves. Seal pipe penetrations using mechanical sleeve seals. Select sleeve size to allow for 1-inch (25-mm) annular clear space between pipe and sleeve for installing mechanical sleeve seals.
   1. Mechanical Sleeve Seal Installation: Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

M. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Refer to Division 07 Section "Penetration Firestopping" for materials.

N. Verify final equipment locations for roughing-in.

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

3.2 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. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
   1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
   2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

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

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

3.3 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.

3.4 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.

3.5 GROUTING

A. Mix and install grout for fire-suppression equipment base bearing surfaces 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 around anchors.

G. Cure placed grout.

3.6 INSTALLATION, INSPECTIONS AND CERTIFICATIONS

A. The Contractor shall obtain timely inspections of the installation by the constituted authorities. Remedy any deficiencies to the satisfaction of the inspecting authority.

B. Upon final completion of the work, obtain certificates of acceptance from the constituted authorities. Deliver the certificates to the Architect for transmission to the Owner.

3.7 INSTRUCTION OF OWNER'S PERSONNEL

A. Provide the services of competent engineers and/or technicians acceptable to the Owner's Representative to instruct other representatives of the Owner in the complete and detailed operation of each item of equipment or device of all the various electrical systems. These instructions shall be provided for whatever periods may be necessary to accomplish the desired results.

B. Upon completion of these instructions, the Contractor shall obtain a letter of release, acknowledged by the Owner or his authorized representative, stating the dates on which the various kinds of instruction were given, and the personnel to whom the instructions were given.

C. The Contractor shall be fully responsible for proper maintenance of equipment and systems until the instructions have been given the Owner's personnel and the letter of release acknowledged.

D. In providing the instructions to the Owner's personnel, the written operating and maintenance manuals shall be followed in all instances, and the Owner's personnel shall be familiarized with such manuals.

E. Operating and maintenance manuals used for instructions shall include wiring diagrams, manufacturer's operating and maintenance instructions, parts lists (with sources identified), and other data as appropriate for each system.

END OF SECTION
PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following fire-suppression piping inside the building:
   1. Wet-pipe sprinkler systems.
   2. Dry-pipe sprinkler systems.

B. Related Sections include the following:
   1. Division 10 Section "Fire Extinguisher Cabinets" and "Fire Extinguishers" for cabinets and fire extinguishers.
   2. Division 28 Section "Fire Detection and Alarm" for alarm devices not specified in this Section.
   3. Division 31 Section "Earth Moving" for excavating, trenching, and backfilling.

1.2 DEFINITIONS

A. CR: Chlorosulfonated polyethylene synthetic rubber.

B. Underground Service-Entrance Piping: Underground service piping below the building.

1.3 SYSTEM DESCRIPTIONS

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

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

1.4 PERFORMANCE REQUIREMENTS

A. The fire protection system is a delegated design. Our drawings indicate the intent of the system to be provided; however, the contractor shall submit installation drawings signed and sealed by a professional engineer as part of the submittal process for review.

B. Standard Piping System Component Working Pressure: Listed for at least 175 psig (1200 kPa).
C. Fire-suppression sprinkler system installation drawings shall be approved by authorities having jurisdiction. Contractor to follow the design intent as shown on engineering drawings.
1. Sprinkler Occupancy Hazard Classifications shall be in accordance with the latest edition of NFPA 13.
3. Maximum Protection Area per Sprinkler: Per NFPA 13

1.5 SUBMITTALS

A. Product Data: For the following:
1. Piping materials, including dielectric fittings, flexible connections, and sprinkler specialty fittings.
2. Pipe hangers and supports.
3. Valves, including listed fire-protection valves, unlisted general-duty valves, and specialty valves and trim.
4. Air compressors, including electrical data.
5. Sprinklers, escutcheons, and guards. Include sprinkler flow characteristics, mounting, finish, and other pertinent data.
6. Alarm devices, including electrical data.

B. Shop Drawings: Diagram power, signal, and control wiring.

C. Approved Sprinkler Piping Drawings: Working plans, prepared according to NFPA 13, that have been approved by authorities having jurisdiction.

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

E. Welding certificates.

F. Field quality-control test reports.

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

1.6 QUALITY ASSURANCE

A. Installer Qualifications:
1. Installer's responsibilities include designing, fabricating, and installing fire-suppression systems.

B. Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX.

C. NFPA Standards: Fire-suppression-system equipment, specialties, accessories, installation, and testing shall comply with the following:
1. NFPA 13, "Installation of Sprinkler Systems."
2. NFPA 24, "Installation of Private Fire Service Mains and Their Appurtenances."
1.7 COORDINATION

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

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. Sprinkler Cabinets: Finished, wall-mounting, steel cabinet with hinged
cover, 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 on Project.

PART 2 - PRODUCTS

2.1 DUCTILE-IRON PIPE AND FITTINGS

A. Mechanical-Joint, Ductile-Iron Pipe: AWWA C151, with mechanical-joint bell
end and plain end.
1. Mechanical-Joint, Ductile-Iron Fittings: AWWA C110, ductile- or gray-iron
standard pattern or AWWA C153, ductile-iron compact pattern.
2. Glands, Gaskets, and Bolts: AWWA C111, ductile- or gray-iron gland,
rubber gasket, and steel bolts and nuts.

B. Grooved-End, Ductile-Iron Pipe: AWWA C151, with factory- or field-formed,
radius-cut-grooved ends according to AWWA C606.
1. Grooved-Joint Piping Systems:
a. Manufacturers:
   1) Victaulic Co. of America.
   2) Anvil International.
b. Grooved-End Fittings: ASTM A 536, ductile-iron casting with OD
   matching ductile-iron-pipe OD.
c. Grooved-End-Pipe Couplings: AWWA C606, gasketed fitting
   matching ductile-iron-pipe OD. Include ductile-iron housing with
   keys matching ductile-iron-pipe and fitting grooves, rubber gasket
   with center leg, and steel bolts and nuts.
d. Grooved-End-Pipe Transition Coupling: UL 213 and AWWA C606,
gasketed fitting with end matching ductile-iron-pipe OD and end
matching steel-pipe OD. Include ductile-iron housing with key
matching ductile-iron-pipe groove and key matching steel-pipe
groove, rubber gasket listed for use with housing, and steel bolts
and nuts.
e. Grooved-End Transition Flange: UL 213, gasketed fitting with key
for ductile-iron-pipe dimensions. Include flange-type, ductile-iron
housing with rubber gasket listed for use with housing and steel
bolts and nuts.
2.2 STEEL PIPE AND FITTINGS

A. Threaded-End, Standard-Weight Steel Pipe:  ASTM A 53/A 53M, ASTM A 135, or ASTM A 795, with factory- or field-formed threaded ends.
   5. Steel Threaded Couplings:  ASTM A 865.

   2. Steel Flanges and Flanged Fittings:  ASME B16.5.

C. Grooved-End, Standard-Weight Steel Pipe:  ASTM A 53/A 53M, ASTM A 135, or ASTM A 795, with factory- or field-formed, roll-grooved ends.
   1. Grooved-Joint Piping Systems:
      a. Manufacturers:
         1) Anvil International, Inc.
         2) TYCO
         3) National Fittings, Inc.
         4) Star Pipe Products; Star Fittings Div.
         5) Victaulic Co. of America.
      b. Grooved-End Fittings:  UL-listed, ASTM A 536, ductile-iron casting with OD matching steel-pipe OD.
      c. Grooved-End-Pipe Couplings:  UL 213 and AWWA C606, rigid pattern, unless otherwise indicated; gasketed fitting matching steel-pipe OD. Include ductile-iron housing with keys matching steel-pipe and fitting grooves, rubber gasket listed for use with housing, and steel bolts and nuts.

2.3 DIELECTRIC FITTINGS

A. Assembly shall be copper alloy, ferrous, and insulating materials with ends matching piping system.

B. Dielectric Unions:  Factory-fabricated assembly, designed for 250-psig (1725-kPa) minimum working pressure at 180 deg F (82 deg C). Include insulating material that isolates dissimilar materials and ends with inside threads according to ASME B1.20.1.
   1. Manufacturers:
      a. Epco Sales, Inc.
      c. Zurn Industries, Inc.; Wilkins Div.
C. Dielectric Flanges: Factory-fabricated companion-flange assembly, for 175-psig (1200-kPa) minimum working-pressure rating as required for piping system.
   1. Manufacturers:
      a. Epco Sales, Inc.

D. Dielectric Couplings: Galvanized steel with inert and noncorrosive thermoplastic lining and threaded ends and 300-psig (2070-kPa) working-pressure rating at 225 deg F (107 deg C).
   1. Manufacturers:
      a. Calpico, Inc.
      b. Lochinvar Corp.

E. Dielectric Nipples: Electroplated steel with inert and noncorrosive thermoplastic lining, with combination of plain, threaded, or grooved ends and 300-psig (2070-kPa) working-pressure rating at 225 deg F (107 deg C).
   1. Manufacturers:
      a. Perfection Corporation.
      b. Precision Plumbing Products, Inc.
      c. Victaulic Co. of America.

2.4 CORROSION-PROTECTIVE ENCASEMENT FOR PIPING

A. Encasement for Underground Metal Piping: ASTM A 674 or AWWA C105, PE film, 0.008-inch (0.20-mm) minimum thickness, tube or sheet.

2.5 SPRINKLER SPECIALTY FITTINGS

A. Sprinkler specialty fittings shall be UL listed or FMG approved, with 175-psig (1200-kPa) minimum working-pressure rating, and made of materials compatible with piping. Sprinkler specialty fittings shall have 300-psig (2070-kPa) working-pressure rating if fittings are components of high-pressure piping system.

B. Outlet Specialty Fittings:
   1. Manufacturers:
      a. Anvil International, Inc.
      b. TYCO
      c. National Fittings, Inc.
      d. Star Pipe Products; Star Fittings Div.
      e. Victaulic Co. of America.
   2. Mechanical-T and -Cross Fittings: UL 213, ductile-iron housing with gaskets, bolts and nuts, and threaded, locking-lug, or grooved outlets.
   3. Snap-On and Strapless Outlet Fittings: UL 213, ductile-iron housing or casting with gasket and threaded outlet.

C. Sprinkler Drain and Alarm Test Fittings: Cast- or ductile-iron body; with threaded or locking-lug inlet and outlet, test valve, and orifice and sight glass.
   1. Manufacturers:
      a. TYCO
b. Fire-End and Croker Corp.
c. Viking Corp.
d. Victaulic Co. of America.

D. Sprinkler Branch-Line Test Fittings: Brass body with threaded inlet, capped drain outlet, and threaded outlet for sprinkler.
   1. Manufacturers:
      b. Fire-End and Croker Corp.
      c. Potter-Roemer; Fire-Protection Div.

E. Sprinkler Inspector's Test Fitting: Cast- or ductile-iron housing with threaded inlet and drain outlet and sight glass.
   1. Manufacturers:
      a. AGF Manufacturing Co.
      b. TYCO
      c. G/J Innovations, Inc.
      d. Triple R Specialty of Ajax, Inc.

F. Drop-Nipple Fittings: UL 1474, adjustable with threaded inlet and outlet, and seals.
   1. Manufacturers:
      a. CECA, LLC.
      b. Merit.

G. Dry-Pipe-System Fittings: UL listed for dry-pipe service.

2.6 LISTED FIRE-PROTECTION VALVES

A. Valves shall be UL listed or FMG approved, with 175-psig (1200 kPa) minimum pressure rating. Valves shall have 300-psig (2070-kPa) pressure rating if valves are components of high-pressure piping system.

B. Ball Valves: Comply with UL 1091, except with ball instead of disc.
   1. NPS 1-1/2 (DN 40) and Smaller: Bronze body with threaded ends.
   2. NPS 2 and NPS 2-1/2 (DN 50 and DN 65): Bronze body with threaded ends or ductile-iron body with grooved ends.
   3. Manufacturers:
      a. NIBCO.
      b. Victaulic Co. of America.

C. Butterfly Valves: UL 1091.
   1. NPS 3 (DN 80) and Larger: Bronze, cast-iron, or ductile-iron body; wafer type or with flanged or grooved ends.
      a. Manufacturers:
         1) TYCO
         2) Global Safety Products, Inc.
         3) McWane, Inc.; Kennedy Valve Div.
         4) Mueller Company.
         5) NIBCO.
         6) Pratt, Henry Company.
         7) Victaulic Co. of America.
D. Check Valves NPS 2 (DN 50) and Larger: UL 312, swing type, cast-iron body with flanged or grooved ends.
   1. Manufacturers:
      a. TYCO
      b. Crane Co.; Crane Valve Group; Crane Valves.
      c. Crane Co.; Crane Valve Group; Jenkins Valves.
      d. Globe Fire Sprinkler Corporation.
      e. Grinnell Fire Protection.
      f. McWane, Inc.; Kennedy Valve Div.
      g. Mueller Company.
      h. NIBCO.
      i. Potter-Roemer; Fire Protection Div.
      j. Reliable Automatic Sprinkler Co., Inc.
      k. Victaulic Co. of America.
      l. Watts Industries, Inc.; Water Products Div.

E. Gate Valves: UL 262, OS&Y type.
   1. NPS 2 (DN 50) and Smaller: Bronze body with threaded ends.
      a. Manufacturers:
         1) Crane Co.; Crane Valve Group; Crane Valves.
         2) NIBCO.
   2. NPS 2-1/2 (DN 65) and Larger: Cast-iron body with flanged ends.
      a. Manufacturers:
         1) Crane Co.; Crane Valve Group; Crane Valves.
         2) Crane Co.; Crane Valve Group; Jenkins Valves.
         3) Milwaukee Valve Company.
         4) Mueller Company.
         5) NIBCO.

F. Indicating Valves: UL 1091, with integral indicating device and ends matching connecting piping.
   1. Indicator: Electrical, 115-V ac, prewired, single-circuit, supervisory switch.
   2. NPS 2-1/2 (DN 65) and Smaller: Ball or butterfly valve with bronze body and threaded ends.
      a. Manufacturers:
         1) Milwaukee Valve Company.
         2) NIBCO.
         3) Victaulic Co. of America.
   3. NPS 3 (DN 80) and Larger: Butterfly valve with cast- or ductile-iron body; wafer type or with flanged or grooved ends.
      a. Manufacturers:
         1) TYCO
         2) Grinnell Fire Protection.
         3) McWane, Inc.; Kennedy Valve Div.
         4) Milwaukee Valve Company.
         5) NIBCO.
         6) Victaulic Co. of America.
2.7 SPECIALTY VALVES

A. Sprinkler System Control Valves: UL listed or FMG approved, cast- or ductile-iron body with flanged or grooved ends, and 175-psig (1200-kPa) minimum pressure rating. Control valves shall have 300-psig (2070-kPa) pressure rating if valves are components of high-pressure piping system.
   1. Manufacturers:
      a. TYCO
      b. Grinnell Fire Protection.
      c. Victaulic Co. of America.
      d. Viking Corp.

2. Alarm Check Valves: UL 193, designed for horizontal or vertical installation, with bronze grooved seat with O-ring seals, single-hinge pin, and latch design. Include trim sets for bypass, drain, electrical sprinkler alarm switch, pressure gages, retarding chamber, and fill-line attachment with strainer.
   a. Drip Cup Assembly: Pipe drain without valves and separate from main drain piping.

3. Dry-Pipe Valves: UL 260, differential type; with bronze seat with O-ring seals, single-hinge pin, and latch design. Include UL 1486, quick-opening devices, trim sets for air supply, drain, priming level, alarm connections, ball drip valves, pressure gages, priming chamber attachment, and fill-line attachment.
   a. Air Compressor: UL 753, fractional horsepower, 120-V ac, 60 Hz, single phase.
      1) Manufacturers:
         a) TYCO
         b) Grinnell Fire Protection.
         c) Viking Corp.

B. Pressure-Regulating Valves: UL 1468, brass or bronze, NPS 1-1/2 and NPS 2-1/2 (DN 40 and DN 65), 400-psig (2760-kPa) minimum rating. Include female NPS inlet and outlet, adjustable setting feature, and straight or 90-degree-angle pattern design as indicated.
   1. Finish: Rough metal.
   2. Manufacturers:
      b. Fire-End and Croker Corp.
      c. GMR International Equipment Corporation.
      d. Grinnell Fire Protection.
      e. Potter-Roemer; Fire Protection Div.
      f. Zurn Industries, Inc.; Wilkins Div.

C. Automatic Drain Valves: UL 1726, NPS 3/4 (DN 20), ball-check device with threaded ends.
   1. Manufacturers:
      a. AFAC Inc.
      b. Grinnell Fire Protection.
2.8 SPRINKLERS

A. Sprinklers shall be UL listed or FMG approved, with 175-psig (1200-kPa) minimum pressure rating.

B. Manufacturers:
   1. TYCO
   2. Grinnell Fire Protection.
   3. Victaulic Co. of America.
   4. Viking Corp.

C. Automatic Sprinklers: With heat-responsive element complying with the following:
   1. UL 199, for nonresidential applications.
   2. UL 1767, for early-suppression, fast-response applications.

D. Sprinkler Types and Categories: Nominal 1/2-inch (12.7-mm) orifice for "Ordinary" temperature classification rating, unless otherwise indicated or required by application.
   1. All Sprinklers shall be Quick Response.

E. Sprinkler types, features, and options as follows:
   1. Concealed ceiling sprinklers, including cover plate.
   2. Extended-coverage sprinklers.
   3. Flush ceiling sprinklers, including escutcheon.
   4. Pendent sprinklers.
   5. Quick-response sprinklers.
   6. Recessed sprinklers, including escutcheon.
   7. Sidewall sprinklers.
   8. Upright sprinklers.

F. Sprinkler Finishes: Chrome plated, bronze, and painted.

G. Special Coatings: Corrosion-resistant paint.

H. Sprinkler Escutcheons: Materials, types, and finishes for the following sprinkler mounting applications. Escutcheons for concealed, flush, and recessed-type sprinklers are specified with sprinklers.
   1. Ceiling Mounting: Chrome-plated steel, one piece, flat.
   2. Sidewall Mounting: Chrome-plated steel, one piece, flat.

I. Sprinkler Guards: Wire-cage type, including fastening device for attaching to sprinkler.

2.9 ALARM DEVICES

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

B. Electrically Operated Alarm: UL 464, with 8-inch- (200-mm-) minimum-diameter, vibrating-type, metal alarm bell with red-enamel factory finish and suitable for outdoor use.
   1. Manufacturers:

b. System Sensor.

C. Pressure Switch: UL 753, electrical-supervision-type, water-flow switch with retard feature. Include single-pole, double-throw, normally closed contacts and design that operates on rising pressure and signals water flow.

1. Manufacturers:
   b. Potter Electric Signal Company.
   c. System Sensor.
   d. Viking Corp.

D. Valve Supervisory Switch: UL 753, electrical, single-pole, double-throw switch with normally closed contacts. Include design that signals controlled valve is in other than fully open position.

1. Manufacturers:
   a. McWane, Inc.; Kennedy Valve Div.
   b. Potter Electric Signal Company.
   c. System Sensor.

E. Indicator-Post Supervisory Switch: UL 753, electrical, single-pole, double-throw switch with normally closed contacts. Include design that signals controlled indicator-post valve is in other than fully open position.

1. Manufacturers:
   b. System Sensor.

2.10 PRESSURE GAGES

A. Available Manufacturers:
   1. AGF Manufacturing Co.
   2. AMETEK, Inc.; U.S. Gauge.
   5. Marsh Bellofram.
   6. WIKA Instrument Corporation.

B. Description: UL 393, 3-1/2- to 4-1/2-inch- (90- to 115-mm-) diameter, dial pressure gage with range of 0 to 300 psig (0 to 2070 kPa).

1. Water System Piping: Include caption "WATER" or "AIR/WATER" on dial face.

2. Air System Piping: Include retard feature and caption "AIR" or "AIR/WATER" on dial face.

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS, GENERAL

A. Flanges, flanged fittings, unions, nipples, and transition and special fittings with finish and pressure ratings same as or higher than system's pressure rating may be used in aboveground applications, unless otherwise indicated.
B. Underground Service Piping: Ductile-iron, grooved-end pipe and fittings; grooved-end-pipe couplings; and grooved joints. Include corrosion-protective encasement.

3.2 SPRINKLER SYSTEM PIPING APPLICATIONS

A. Standard-Pressure, Wet-Pipe or Dry-pipe Sprinkler System, 175-psig (1200-kPa) Maximum Working Pressure:
1. Sprinkler-Piping Fitting Option: Specialty sprinkler fittings, NPS 2-1/2 (DN 65) and smaller, including mechanical-T and -cross fittings, may be used downstream from sprinkler zone valves.
2. NPS 2 and Smaller (DN 50): Threaded-end, black or galvanized, standard-weight steel pipe; cast- or malleable-iron threaded fittings; and threaded joints.
3. NPS 2-1/2 to NPS 6 (DN 65 to DN 150): Threaded-end, black or galvanized, standard-weight steel pipe; cast- or malleable-iron threaded fittings; and threaded joints.
4. NPS 2-1/2 to NPS 6 (DN 65 to DN 150): Plain-end, black, standard-weight steel pipe; steel welding fittings; and welded joints.
5. NPS 2-1/2 to NPS 6 (DN 65 to DN 150): Grooved-end, black or galvanized, standard-weight steel pipe; grooved-end fittings; grooved-end-pipe couplings; and grooved joints.

3.3 VALVE APPLICATIONS

A. Listed Fire-Protection Valves: UL listed and FMG approved for applications where required by NFPA 13 and NFPA 14.
1. Shutoff Duty: Use ball, butterfly, or gate valves.

3.4 JOINT CONSTRUCTION

A. Refer to Division 21 Section "Common Work Results for Fire Suppression" for basic piping joint construction.

B. Threaded Joints: Comply with NFPA 13 for pipe thickness and threads. Do not thread pipe smaller than NPS 8 (DN 200) with wall thickness less than Schedule 40 unless approved by authorities having jurisdiction and threads are checked by a ring gage and comply with ASME B1.20.1.

C. Grooved Joints: Assemble joints with listed coupling and gasket, lubricant, and bolts.
2. Steel Pipe: Roll-groove piping as indicated. Use grooved-end fittings and rigid, grooved-end-pipe couplings, unless otherwise indicated.
3. Dry-Pipe Systems: Use fittings and gaskets listed for dry-pipe service.

D. Dissimilar-Metal Piping Joints: Construct joints using dielectric fittings compatible with both piping materials.
1. NPS 2 (DN 50) and Smaller: Use dielectric unions, couplings, or nipples.
2. NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Use dielectric flanges.
3. NPS 5 (DN 125) and Larger: Use dielectric flange insulation kits.
3.5 SERVICE-ENTRANCE PIPING

A. Install shutoff valve, pressure gage, drain, and other accessories indicated at water-service entrance.

3.6 PIPING INSTALLATION

A. Refer to Division 21 Section "Common Work Results for Fire Suppression" for basic piping installation.

B. Install underground ductile-iron service-entrance piping according to NFPA 24 and with restrained joints. Encase piping in corrosion-protective encasement.

C. Use approved 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 (DN 50) and smaller. Unions are not required on flanged devices or in piping installations using grooved joints.

E. Install flanges or flange adapters on valves, apparatus, and equipment having NPS 2-1/2 (DN 65) and larger connections.

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

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

H. Install alarm devices.

I. Hangers and Supports: Comply with NFPA 13 for hanger materials.
   1. Install sprinkler system piping according to NFPA 13.

J. Install pressure gages on riser or feed main and at each sprinkler test connection. Include pressure gages with connection not less than NPS 1/4 (DN 8) 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.

K. Drain dry-pipe sprinkler piping.

L. Pressurize and check dry-pipe sprinkler system piping and air compressors.

M. Fill wet-pipe sprinkler system piping with water.

3.7 VALVE INSTALLATION

A. Install listed fire-protection valves, unlisted general-duty valves, specialty valves and trim, controls, and specialties according to NFPA 13 and NFPA 14 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. Specialty Valves:
   1. Alarm Check Valves: Install in vertical position for proper direction of flow, including bypass check valve and retarding chamber drain-line connection.
   2. Dry-Pipe Valves: Install trim sets for air supply, drain, priming level, alarm connections, ball drip valves, pressure gages, priming chamber attachment, and fill-line attachment.
      a. Install air compressor and compressed-air supply piping.

3.8 SPRINKLER APPLICATIONS

A. Where specific types are not indicated, use the following sprinkler types:
   1. Rooms without Ceilings: Upright sprinklers.
   2. Public areas with Suspended Ceilings: Concealed sprinklers.
   3. Non public areas with Suspended Ceilings: Concealed sprinklers.
   5. Special Applications: All Sprinkler heads to be Quick Response type.
   6. Sprinkler Finishes:
      a. 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.
      b. Concealed Sprinklers: Rough brass, with factory-painted bright white cover plate.
      c. Flush Sprinklers: Bright chrome, with painted bright white escutcheon.
      d. Semi-Recessed Sprinklers: Bright chrome, with bright chrome escutcheon.

3.9 SPRINKLER INSTALLATION

A. Install sprinklers in suspended ceilings in center of acoustical ceiling panels and tiles.

3.10 CONNECTIONS

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

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

C. Connect piping to specialty valves, specialties and accessories.

D. Connect compressed-air supply to dry-pipe sprinkler piping.

E. Connect air compressor to the following piping and wiring:
   1. Pressure gages and controls.
   2. Electrical power system.
3. Fire alarm devices, including low-pressure alarm.

F. Electrical Connections: Power wiring is specified in Division 26.

G. Connect alarm devices to fire alarm.

H. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

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

J. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

3.11 LABELING AND IDENTIFICATION

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

3.12 FIELD QUALITY CONTROL

A. Perform the following field tests and inspections and prepare test reports:
   1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
   2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
   3. Energize circuits to electrical equipment and devices.
   4. Start and run air compressors.
   5. Flush, test, and inspect sprinkler systems according to NFPA 13, "Systems Acceptance" Chapter.
   6. Coordinate with fire alarm tests. Operate as required.

B. Report test results promptly and in writing to Architect and authorities having jurisdiction.

3.13 CLEANING AND PROTECTION

A. Clean dirt and debris from sprinklers.

B. Remove and replace sprinklers with paint other than factory finish.

C. Protect sprinklers from damage until Substantial Completion.

3.14 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain specialty valves. Refer to Division 01 Section "Demonstration and Training."
SECTION 220500
COMMON WORK RESULTS FOR PLUMBING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. In addition to Division 01 Specification Sections, related sections include the following:

1. Division 01 Section "Cutting and Patching"
2. Division 02 Section "Selective Structure Demolition" for general demolition requirements and procedures.
3. Division 03 Sections "Cast-in-Place Concrete" and "Miscellaneous Cast-in-Place Concrete".
4. Division 05 Section "Metal Fabrications" for structural steel.
5. Division 09 Sections "Interior Painting" and "Exterior Painting".
6. Division 08 Section "Access Doors and Frames" for access panels and doors.

1.2 RELATED REQUIREMENTS

A. All conditions imposed by these documents shall be applicable to all portions of the Work under this Division. These references are intended to point out specific items to the Contractor, but in no way relieve him of the responsibility of reading and complying with all relevant parts of the entire Specification.

B. The Contractor shall examine and coordinate with all Contract Drawings and Specifications, and all Addenda issued. Failure to comply shall not relieve them of responsibility. The omission of details of other portions of the Work from this Division shall not be used as a basis for a request for additional compensation.

C. The specific features and details for other portions of the Work related to the construction in progress or to the building(s) shall be determined by examination at the site.

1.3 SUMMARY

A. This Section includes the following:

1. Scope of work.
2. Piping materials and installation instructions common to most piping systems.
3. Transition fittings.
4. Dielectric fittings.
5. Mechanical sleeve seals.
7. Escutcheons.
8. Grout.
10. Equipment installation requirements common to equipment sections.
11. Painting and finishing.
12. Concrete bases.

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. Products and Materials: Components and assemblies for the construction of the systems as indicated in the Documents including, but not limited to pipes, tubes, valves, and equipment.

G. Products or Materials: See “Products and Materials”.

H. Provide: The materials and equipment described shall be furnished, installed and connected under this Division, complete for operation, unless specifically noted to the contrary. Identical to the phrase “furnish and install”.

I. Furnish: The material, equipment, etc. to be supplied, but not installed by the supplier.

J. The following are industry abbreviations for materials:

1. CPVC: Chlorinated polyvinyl chloride plastic.
2. PE: Polyethylene plastic.
3. PVC: Polyvinyl chloride plastic.
4. EPDM: Ethylene-propylene-diene terpolymer rubber.
5. NBR: Acrylonitrile-butadiene rubber.

K. VFD: Variable frequency drive. This may be used interchangeably with VSD (variable speed drive), VSC (variable speed controller), and VFMC (variable frequency motor controller). This technology varies the frequency of the incoming electrical signal to change the speed of driven equipment.
1.5 SCOPE OF WORK

A. Inspection Of Site

1. The accompanying drawings do not indicate existing plumbing installations other than to identify modifications of and extensions thereof. The Contractor shall visit the site, inspect the installations and ascertain the conditions to be met and the work.

2. Failure to comply with an inspection of the site shall not constitute ground for any additional payments in connection with removing or modifying any part of the existing installations and/or installing any new work under this Division.

3. Review construction details of the existing portion of the building during the site inspection and include all work required to modify the existing plumbing installations and install new materials, comprising a part of the plumbing installation, within the present structure.

B. Products and Materials Description

1. Where two or more units of the same kind or class of a specific item are required, these shall be the products of a single manufacturer; however, the component parts of the item need not be the products of one manufacturer.

2. In describing the various products and materials, in general each item will be described singularly, even though there may be a multiplicity of identical items. Also, where the description is only general in nature, exact sizes, duties, space arrangements, horsepower requirements and other data shall be determined by reference to the Documents.

C. The Work shall include modifications and extensions to existing systems, and the modification of the existing structure as required accommodating the installation of the Work.

D. Refer to other Divisions of the Specifications for related Work.

E. Contractor shall install, hang, support, etc. all MEP systems and equipment to satisfy all requirements of the applicable seismic zone using performance requirements and design criteria for project site as indicated by architect.

F. It is the intent, unless otherwise indicated, that all products and materials described and specified under this Division, shall be provided for a complete working system irrespective of use of the phrases “install”, “furnish”, “furnish and install”, or “provide” as described above has been actually included.

G. The Contractor shall be responsible for all Work of every description in connection with this Division of the Specifications.

H. The Contractor shall specifically and distinctly assume, and does so assume, all risk for damage or injury from whatever cause to property or person used or employed on or in connection with this Work and of all damages or injury to any person or property wherever located, resulting from an action or operation under the Contract in connection with the Work, and undertake the promise to defend the Owner against all claims on account of any such damage or injury.
I. The Contractor will be held responsible for the satisfactory execution and completion of the Work in accordance with the true intent of the Documents.

J. The Contractor shall provide without extra charge all incidental items required as part of the Work, even though it may not be specifically indicated. If the Contractor has reason for objecting to the use of any material, equipment, device or method of construction as indicated, he shall make report of such objections to the Owner's Representative, obtain proper approval and adjustment to the Contract, and shall proceed with the Work.

K. Electric wiring

1. All electric wiring shall be installed under Division 26, except for such equipment items as are prewired at their point of manufacture and so delivered to the project, and except for the following:
   a. Temperature Control Wiring and Power Wiring provided by controls contractor.

2. Prepare and submit for review wiring diagrams for all equipment furnished under this Division. Show on these diagrams all power, interlock, and control circuits. When the Architect takes no exception to these drawings, they shall become installation drawings for the Contractor.

3. All domestic cold and hot water piping shall be heat traced when routed external to the building or in areas susceptible to freezing conditions.

1.6 ORDINANCES, PERMITS AND CODES

A. It shall be the Contractor's duty to perform the work and provide the materials covered by these specifications in conformance with all ordinances and regulations of all authorities having jurisdiction.

B. All work herein shall conform to all applicable laws, ordinances, and regulations of the local utility companies.

C. The work shall be in accordance with, but not limited to, the requirements of:

1. National Fire Protection Association
3. Florida Building Codes
5. Florida Boiler Code
6. Florida Department Of State Health Services

D. Codes and standards referred to are minimum standards. Where the requirements of these specifications or drawings exceed those of the codes and regulations, the drawings, and specifications govern.

E. The Contractor shall obtain permits, plan checks, connection and specification fees, inspections, and approvals applicable to the Work as required by the regulatory authorities.
F. Fees and costs of any nature whatsoever incidental to permits, inspections, and approvals shall be assumed and paid by the Contractor.

G. The pro-rata costs, if any, for utilities serving this property will be paid for by the Owner and shall not be included as part of this Contract.

1.7 REFERENCE STANDARDS

A. Where differences between building codes, state laws, local ordinances, industry standards, utility company regulations and the Contract Documents occur, the most stringent shall govern. The Contractor shall promptly notify the Owner's Representative in writing of any such difference.

B. Should the Contractor perform any Work that does not comply with local codes, laws and ordinances, industry standards or other governing regulations, the Work shall be corrected on noncompliance deficiencies with the Contractor bearing all costs.

C. In addition to the aforementioned ordinances, industry standards published by the following organizations shall apply:

1. AIA AMERICAN INSTITUTE OF ARCHITECTS
2. AASHO AMERICAN ASSOCIATION OF STATE HIGHWAY OFFICIALS
3. ACI AMERICAN CONCRETE INSTITUTE
4. AGA AMERICAN GAS ASSOCIATION
5. AISC AMERICAN INSTITUTE OF STEEL CONSTRUCTION
6. ANSI AMERICAN NATIONAL STANDARDS INSTITUTE
7. API AMERICAN PETROLEUM INSTITUTE
8. ARI AIR CONDITIONING & REFRIGERATION INSTITUTE
9. ASHRAE AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR CONDITIONING ENGINEERS, INC.
10. ASME AMERICAN SOCIETY OF MECHANICAL ENGINEERS
11. ASTM AMERICAN SOCIETY FOR TESTING AND MATERIALS
12. AWSG AMERICAN WELDING SOCIETY CODE
13. AWWA AMERICAN WATER WORKS ASSOCIATION
14. CISPI CAST IRON SOIL PIPE INSTITUTE
15. ASPE AMERICAN SOCIETY OF PLUMBING ENGINEERS
16. FM FACTORY MUTUAL
17. IRI INDUSTRIAL RISK INSURERS
18. NBS NATIONAL BUREAU OF STANDARDS
19. NFPA NATIONAL FIRE PROTECTION ASSOCIATION
20. PDI PLUMBING AND DRAINAGE INSTITUTE
21. UL UNDERWRITER’S LABORATORIES

D. Where the Contract Documents exceed the above requirements, the Contract Documents shall govern. In no case shall Work be installed contrary to or below the minimum legal standards.
1.8 DRAWINGS AND SPECIFICATIONS

A. The inter-relation of the specifications, the drawings, and the schedules are as follows:

1. The specifications provide the written requirements for the quality, standard, nature of the materials, equipment and construction systems.
2. The drawings establish the quantities, approximate dimensions, details and location of equipment.
3. The schedules give the capacities, characteristics and components.

B. For any individual project, if there is conflict between the drawings and or specifications, they are equivalent in authority and priority. Should they disagree in themselves, or with each other, prices shall be based on the most expensive combination of quality and quantity of work indicated. In the event of the above mentioned disagreements the resolution shall be determined by the Architect.

C. Contractor is responsible to bring any conflicts in drawings and/or specifications to the attention of the Architect, immediately, prior to any work being done.

D. Where the specifications do not fully agree with the schedules, the schedules shall govern. Figures given on drawings govern scale measurements and large scale details govern small scale drawings.

E. Review all construction details illustrated on the architectural and structural drawings and be guided thereby.

1.9 SUBMITTAL PROCEDURES

A. Common Requirements for Product Data: Where this Section and other Sections of this Division require Product Data to be submitted, meet the requirements defined in Division 01 Section "Submittal Procedures". In addition to the requirements of Division 01 comply with the following:

1. Submit hardcopy of Product Data in the quantity as required under Division 01 Section "Submittal Procedures". Hardcopies of product data submittals shall be bound materials as defined above. Separate products under distinct subheadings that correspond to paragraphs in specification text. Divide sections in binder with labeled divider tabs.
2. In addition to hardcopies required by Division 01, submit one copy of product data in electronic format. All files on disc shall be in Portable Document Format (.pdf).
3. Product Data shall not consist of manufacturer's catalogs or cut sheets that contain no indication of the exact item offered. The submission on individual items shall designate the exact item offered.

B. Product Data: For the following:

1. Dielectric fittings.
2. Mechanical sleeve seals.
3. Escutcheons.
C. Common Requirements for Shop Drawings: Where this Section and other Sections of this Division require Shop Drawings to be submitted, meet the requirements defined in Division 01 Section "Submittal Procedures". In addition to the requirements of Division 01 comply with the following:

1. Prepare Shop Drawings using computerized drafting software compatible with AutoDesk’s AutoCAD®.
2. Submit hardcopy of Shop Drawings in the quantity as required under Division 01 Section "Submittal Procedures". Hardcopies of Shop Drawings shall have each sheet clearly labeled with a unique sheet identification number.
3. In addition to hardcopies required by Division 01, submit one copy of Shop Drawings in electronic format. Files shall be include both AutoCAD® compatible source files and files printed to Portable Document Format (.pdf).
4. Shop Drawings shall be of appropriate scale based on the following:
   a. Piping Systems, including all underfloor work: Minimum 1/8” = 1'-0".
   b. Mechanical rooms: 1/4” = 1’ – 0”.
5. Shop drawings shall include the following items:
   a. Concrete pads and foundations.
   b. Equipment room layouts with actual dimensions and offsets for all systems.
   c. Roof layouts.
   d. Trench locations and sizes.
   e. Dimensioned floor drain locations.

D. Common Requirements for Coordination Drawings: Where this Section and other Sections of this Division require Coordination Drawings to be submitted, meet the requirements defined in Division 01 Section "Submittal Procedures" and Division 01 Section "Project Management and Coordination". In addition to the requirements of Division 01 comply with the following:

1. Prepare Coordination Drawings using computerized drafting software compatible with AutoDesk’s AutoCAD®. Drawings files must be composite with multiple distinctive layers for each of the various trades.
2. Submit hardcopy of Coordination Drawings in the quantity as required under Division 01. Hardcopies of Coordination Drawings shall have each sheet clearly labeled with a unique sheet identification number.
3. In addition to hardcopies required by Division 01, submit one copy of Shop Drawings in electronic format. Files shall be include both AutoCAD® compatible source files and files printed to Portable Document Format (.pdf).
4. Coordination Drawings shall be of appropriate scale but shall not be smaller than a scale of 1/4-inch equals one foot.
5. Coordination Drawings shall be multi-color prints with each system printed in a separate and unique color.

E. Coordination Drawings: Prepare drawings showing dimensioned layout for the following:

1. Penetration and Structural Opening: Floor plans showing sleeves and formed structural penetrations. Show sleeve and formed penetration layouts and relationships between structural components and other adjacent building
elements, including but not limited to pre-tensioning and post-tensioning members where used.

2. Shop drawings shall be provided for the following:

   1) Sheet Metal and Duct Systems, including all underfloor work (prepared at a minimum scale of 1/8" = 1'-0"")
   2) Piping and equipment systems for storm, domestic water, waste and vent and other plumbing piping systems. (Preferably at 1/4" = 1’ – 0” and not less than 1/8" = 1’ – 0”).
   3) Equipment room layouts with actual equipment, piping, and duct at 1/4” = 1’ – 0” scale. Show clearances, access spaces, relative heights of piping.
   4) Housekeeping and equipment concrete pads.
   5) Dimensioned floor drain locations and the equipment each serves.
   6) Roof layouts.
   7) Trench locations and sizes.

   b. Equipment support locations, type of support, and weight on each support.
   c. Location of structural supports for structure-supported raceways.
   d. For floor mounted equipment: concrete base dimension, outline of equipment, and required clearances.

Common Requirements for Specification Compliance Certification: Where this Section and other Sections of this Division require Specification Compliance Certification to be submitted, meet the requirements defined in Division 01 Section "Submittal Procedures" for “Other Informational Submittals”. In addition to the requirements of Division 01 comply with the following:

3. Prepare a line-by-line Specification Compliance Certification by marking up a copy of the Contract Document specification section in the left margin. Accompany the markup with a written report explaining all items that are not marked with “Compliance”. Submit line-by-line markup, written report of deviations and alternates and a cover letter certified by Manufacturer or Installer that prepared the Specification Compliance Certification. Use the following key for preparing the line-by-line markup.

   a. "C" for Compliance: By noting the term "compliance" or "C" in the margin, it shall be understood that the manufacturer is in full compliance with the item specified and will provide exactly the same with no deviations.
   b. "D" for Deviation: By noting the term "deviation" or "D" in the margin, it shall be understood that the manufacturer prefers to provide a different component in lieu of that specified.
   c. "A" for Alternate: By noting the term "alternate" or "A" in the margin, it shall be understood that the manufacturer proposes to provide the same operating function but prefers to do it in a different manner.
   d. "N/A" for Not Applicable: By noting the term "not applicable" or "N/A" in the margin, it shall be understood that the specified item is not applicable to the project.

F. Common Requirements For Qualification Data:
1. Professional Engineer Qualifications: Where this Section and other Sections of this Division require a Professional Engineer to be responsible for Delegated Design requirements; Submit Qualification data for Professional Engineer including, but not limited to, proof of registration in the Project location.

2. Independent Testing and Inspecting Agency Certification: Where this Section and other Sections of this Division require an Independent Testing and Inspecting agency to be responsible for Acceptance Testing and Field Quality Control requirements; Submit certification documentation for such agency that demonstrates compliance with the Quality Assurance paragraph of this Section.

G. Qualification Data: For Independent Testing and Inspecting Agency.

H. Welding certificates.

1.10 SUBSTITUTIONS

A. Where the product of a single manufacturer is mentioned by trade name or manufacturer's name in this Division, it is the only acceptable manufacturer.

B. Where two or more manufacturers are named, only those manufacturers will be considered or approved.

C. Manufacturers not listed will be considered for substitution prior to bid only. The substitute manufacturer shall submit a complete copy of the appropriate technical specification section minimum ten (10) business days prior to bid with each sub-paragraph noted with the comment, "compliance", "deviation", "alternate" or "not applicable". In the case of non-primary, vendor-supplied items, the name of the sub-vendor supplying said item, including model number, shall be indicated.

1. By noting the term "compliance" or "C", it shall be understood that the manufacturer is in full compliance with the item specified and will provide exactly the same with no deviations.

2. By noting the term "deviation" or "D", it shall be understood that the manufacturer prefers to provide a different component in lieu of that specified. Manufacturer shall indicate all deviations.

3. By noting the term "alternate" or "A", it shall be understood that the manufacturer proposes to provide the same operating function but prefers to do it in a different manner. An alternate shall be fully described as to what the manufacturer proposes to provide.

4. By noting the term "not applicable" or "N/A", it shall be understood that the specified item is not applicable to the project.

D. It shall be understood that space allocations have been made on the basis of present and known future requirements and the dimensions of items of equipment or devices of a particular manufacturer whether indicated or not.

E. Any product or material offered in substitution which differs in dimension or configuration from the Documents, the Contractor shall provide as part of the submittal a drawing, minimum 1/4” = 1'-0” scale, showing that the substitution can be installed in the space available without interfering with other portions of the work or with access for operations and maintenance in the completed project.
F. Where substitute products or materials requiring different arrangement or connections from that indicated is accepted by the Owner's Representative, install the equipment or devices to operate properly and in harmony with the intent of the Documents, making all incidental changes in piping or wiring resulting from the substitution without any additional cost to the Owner.

G. The Contractor shall pay all additional costs incurred by other portions of the work in connection with all substitutions.

H. The Owner's Representative reserves the right to call for samples of any item of product or material offered in substitution, together with a sample of the specific item when, in their opinion, the quality of the item and/or the appearance is involved, and it is deemed that an evaluation of the item may be better made by visual inspection.

I. When any request for a substitution of a product or material is submitted and rejected, the item named in the Documents shall be furnished. Repetitive submittal of substitutions for the same item will not be considered.

1.11 QUALITY ASSURANCE

A. All Work shall be performed by properly licensed technicians skilled in their respective trades. All materials, equipment and devices shall be installed in accordance with the recommendations of the manufacturer and in the best standard practice to bring about results of a first class condition.

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:
   1. 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.
   2. Where variable frequency drives are provided for equipment, whether installed separately or integral to the equipment, the VFDs shall conform to Division 26 section, "Variable Frequency Motor Controllers."

E. Wherever a UL standard has been established for a particular type of material, equipment or device, each item of such material, equipment or device provided on this project shall meet the requirements of the UL standard in every way, and shall be UL listed and labeled.
F. Products and materials shall be of the best quality customarily applied in quality commercial practice, and shall be by reputable manufacturers.

G. Each major component shall bear a nameplate giving the name and address of the manufacturer, and the catalog number or designation of the component.

H. Products and materials provided under this Division of the Specifications shall be essentially the standard item, unless otherwise noted, of the specified manufacturer, or where allowed, an alternate manufacturer.

1.12 DELIVERY, STORAGE, AND HANDLING

A. Deliver products and materials with factory-applied end caps or “heat shrink” wrappings to protect openings. Maintain opening protection through shipping, storage, and handling to prevent damage and the entrance of dirt, debris, and moisture.

B. Store light sensitive products and materials away from and protected against direct sunlight.

C. Support products and materials at all times to prevent sagging and bending.

D. The area provided for product and material storage at the jobsite shall be clean, dry and exposure to dust minimized.

E. Responsibility for the protection of products and materials shall extend to existing equipment, systems, and products and materials. Erect temporary sheltering structures, provide temporary bracing and supports, or cover existing equipment, systems, and products and materials to prevent damage and the entrance of dirt, debris, and moisture.

F. Failure on the part of the Contractor to comply with the above to the satisfaction of the Architect, Engineer, or either’s authorized representative shall be sufficient cause for the rejection of products and materials in question.

1.13 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.

D. Installation Drawings

1. Prepare special drawings as called for elsewhere herein or directed by the Architect to coordinate this work with the work of other Divisions, to illustrate
changes in this work to facilitate its concealment in finished spaces, to avoid obstructions, or to illustrate the installation of a substitute equipment item.

2. Use these drawings in the field for the installation of the work. Unless otherwise directed, do not submit these drawings for review, but provide 3 copies to the Architect for information.

E. Schedule And Sequence Of Work

1. The Contractor shall meet and cooperate with the Owner and Owner's Representative to schedule and sequence Work so as to ensure meeting scheduled completion dates and avoid delaying other portions of the Work. Work requiring special sequencing shall be at no additional cost to the Owner and shall have no impact on the schedule.

2. Work schedules and completion dates as established shall be rigidly adhered to. Cooperate in establishing these schedules and perform the work under this Division at such times as directed so as to ensure meeting scheduled dates and avoid delaying any other Contractor.

3. The facility will continue to be in use throughout the construction period, and the schedule contemplates working in designated areas in the present facility while other adjacent areas are occupied. Execute work in this Division to minimize disturbance to occupants in adjacent areas.

4. When any work affects any services to any occupied area new permanent or temporary services, or a combination of both, shall be installed to enable occupied areas to function properly. Additional valves required shall be installed without added cost to the Owner.

5. Perform no work in the present facility that interferes with normal hours of occupancy, unless special permission is granted by the Owner. Included are operations which would cause objectionable noise or service interruptions. Each discipline shall coordinate their work with the established phases of construction.

6. Any work involving a service suspension shall be scheduled in advance with the Owner.

7. Should it be necessary to perform certain operations on an "overtime" basis in order not to interrupt the normal usage of the facility, include the costs of such overtime without change in the Contract amount.

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

2. Manufacturers: Subject to compliance with requirements, provide products by the manufacturers specified.
2.2 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.
   C. All piping and tubing shall be American manufactured, unless otherwise indicated.

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. 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.
   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.
   H. Fiberglass Pipe Adhesive: As furnished or recommended by pipe manufacturer.

2.4 TRANSITION FITTINGS
   A. 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.
B. 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.

C. 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.

D. Flexible Transition Couplings for Underground Nonpressure Drainage Piping: ASTM C 1173 with elastomeric sleeve, ends same size as piping to be joined, and corrosion-resistant metal band on each end.

2.5 DIELECTRIC FITTINGS

A. Description: Combination fitting of copper alloy and ferrous materials with threaded, solder-joint, plain, or weld-neck end connections that match piping system materials.

B. Insulating Material: Suitable for system fluid, pressure, and temperature.

C. Dielectric Unions: Factory-fabricated, union assembly, for 250-psig minimum working pressure at 180 deg F.

D. Dielectric Flanges: Factory-fabricated, companion-flange assembly, for 150- or 300-psig minimum working pressure as required to suit system pressures.

E. Dielectric-Flange Kits: Companion-flange assembly for field assembly. Include flanges, full-face- or ring-type neoprene or phenolic gasket, phenolic or polyethylene bolt sleeves, phenolic washers, and steel backing washers.

1. Separate companion flanges and steel bolts and nuts shall have 150- or 300-psig minimum working pressure where required to suit system pressures.

F. Dielectric Couplings: Galvanized-steel coupling with inert and noncorrosive, thermoplastic lining; threaded ends; and 300-psig minimum working pressure at 225 deg F.

G. Dielectric Nipples: Electroplated steel nipple with inert and noncorrosive, thermoplastic lining; plain, threaded, or grooved ends; and 300-psig minimum working pressure at 225 deg F.

2.6 MECHANICAL SLEEVE SEALS

A. Description: Modular sealing element unit, designed for field assembly, to fill annular space between pipe and sleeve.

1. Manufacturers:

   a. Innerlinx by Mason Dallas.
   b. Metraflex Co.
   c. Linkseal by Thunderline.
2. Sealing Elements: EPDM for high temperature applications and NBR for all others unless otherwise indicated, interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
3. Pressure Plates: Include two for each sealing element.
4. Connecting Bolts and Nuts: Stainless steel of length required to secure pressure plates to sealing elements. Include one for each sealing element.

2.7 SLEEVES

A. Steel Pipe: ASTM A 53, Type E, Grade B, Schedule 10, galvanized, plain ends.

2.8 ESCUTCHEONS

A. Description: Manufactured wall and ceiling escutcheons and floor plates, with an ID to closely fit around pipe, tube, and insulation of insulated piping and an OD that completely covers opening.

B. One-Piece, Cast-Brass Type: With set screw.
   1. Finish: Polished chrome-plated and rough brass, pending approval by Architect.

C. Split-Casting, Cast-Brass Type: With concealed hinge and set screw.
   1. Finish: Polished chrome-plated and rough brass, pending approval by Architect.

D. One-Piece, Floor-Plate Type: Cast-iron floor plate.

E. Split-Casting, Floor-Plate Type: Cast brass with concealed hinge and set screw.

2.9 GROUT

A. Description: ASTM C 1107, Grade B, nonshrink and nonmetallic, dry hydraulic-cement grout.
   2. Design Mix: 5000-psi, 28-day compressive strength.

PART 3 - EXECUTION

3.1 PLUMBING DEMOLITION

A. Disconnect, demolish, and remove plumbing systems, equipment, and components indicated to be removed.
1. Piping to Be Removed: Remove portion of piping indicated to be removed and cap or plug remaining piping with same or compatible piping material.
2. Piping to Be Abandoned in Place: Drain piping and cap or plug piping with same or compatible piping material.
3. Equipment to Be Removed: Disconnect and cap services and remove equipment.
4. Equipment to Be Removed and Reinstalled: Disconnect and cap services and remove, clean, and store equipment; when appropriate, reinstall, reconnect, and make equipment operational.
5. Equipment to Be Removed and Salvaged: Disconnect and cap services and remove equipment and deliver to Owner.

B. 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 SALVAGED MATERIALS

A. Reuse no salvaged material except as noted on the Drawings, specified herein, or directed by the Architect. Remove from the premises all present materials falling under this Division, which are removed from the existing building. Upon completion, leave no "dead" line or equipment installed in any portion of the area being remodeled.

3.3 PIPING SYSTEMS - COMMON REQUIREMENTS

A. Install piping according to the following requirements and Division 22 Sections specifying piping systems.

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

C. Install piping in concealed locations, unless otherwise indicated and except in equipment rooms and service areas.

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

E. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

F. Install piping to permit valve servicing.

G. Install piping at indicated slopes.

H. Install piping free of sags and bends.
I. Install fittings for changes in direction and branch connections.

J. Install piping to allow application of insulation.

K. Select system components with pressure rating equal to or greater than system operating pressure.

L. Install escutcheons, after Architect’s final approval of finish, for penetrations of walls, ceilings, and floors according to the following:

1. New piping penetrations shall be one-piece escutcheons.
2. Existing piping penetrations shall be two-piece escutcheons.
3. All sleeved penetrations shall be deep-drawn to allow flush installation between escutcheon and finished surface.

M. Install sleeves for pipes passing through concrete and masonry walls, gypsum-board partitions, and concrete floor and roof slabs.

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 to prevent water entrance to the sleeved hole. Vertical pipe supports must be extended to and supported by the floor and not the sleeve.
   b. Strike above subparagraph and retain subparagraph below when a pipe curb is required at all floor penetrations in lieu of extended sleeves.
   c. Provide concrete pipe curb in floors of mechanical equipment areas or other wet areas 4 inches above finished floor level.

2. Install sleeves in new walls and slabs as new walls and slabs are constructed.
3. Install sleeves that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation. Use the following sleeve materials:
   a. Steel Pipe Sleeves: For pipes smaller than NPS 6.
   b. Steel Sheet Sleeves: For pipes NPS 6 and larger, penetrating gypsum-board partitions.
   c. Stack Sleeve Fittings: For pipes penetrating floors with membrane waterproofing. Secure flashing between clamping flanges. Install section of cast-iron soil pipe to extend sleeve to 2 inches above finished floor level. Refer to Division 07 Section "Sheet Metal Flashing and Trim" for flashing.
      1) Seal space outside of sleeve fittings with grout.

4. Except for underground wall penetrations, seal annular space between sleeve and pipe or pipe insulation, using joint sealants appropriate for size, depth, and location of joint. Refer to Division 07 Section "Joint Sealants" for materials and installation.

N. Exterior-Wall Pipe Penetrations: Seal penetrations using sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.
1. Install steel pipe for sleeves smaller than 6 inches in diameter for above ground locations.
2. Install cast-iron "wall pipes" for sleeves 6 inches and larger in diameter for above ground and all underground locations.
3. Mechanical Sleeve Seal Installation: Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

O. Underground, Exterior-Wall Pipe Penetrations: Install cast-iron "wall pipes" for sleeves. Seal pipe penetrations using mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.

P. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Refer to Division 07 Section "Penetration Firestopping" for materials.

Q. Verify final equipment locations for roughing-in.

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

3.4 PIPING JOINT CONSTRUCTION

A. Join pipe and fittings according to the following requirements and Division 22 Sections specifying piping systems.

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

C. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

D. Soldered Joints: Apply ASTM B 813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B 32.


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 Nonpressure Piping: Join according to ASTM D 2855.

J. 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.

K. Fiberglass Bonded Joints: Prepare pipe ends and fittings, apply adhesive, and join according to pipe manufacturer's written instructions.

3.5 PIPING CONNECTIONS

A. Make connections according to the following, unless otherwise indicated:
   1. Install unions, in piping NPS 2 and smaller, adjacent to each valve and at final connection to each piece of equipment.
   2. Install flanges, in piping NPS 2-1/2 and larger, adjacent to flanged valves and at final connection to each piece of equipment.
   3. Dry Piping Systems: Install dielectric unions and flanges to connect piping materials of dissimilar metals.

3.6 EQUIPMENT INSTALLATION - COMMON REQUIREMENTS

A. Equipment called for on the plans and not listed herein shall be provided as though it were fully described herein.
B. Equipment called for herein shall be completely provided, whether fully detailed or not on the plans, and/or scheduled.

C. All equipment as indicated on the plans and as described herein shall be installed per manufacturer’s recommendations to allow for proper operation and maintenance of the equipment.

D. Install equipment to allow maximum possible headroom unless specific mounting heights are indicated.

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

F. 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.

G. Where any piece of equipment is too large for ingress through normal building openings, it shall be placed in its containing space before the enclosing structure is completed.

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

3.7 PAINTING

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

3.8 CONCRETE BASES

A. Concrete Bases: Anchor equipment to concrete base according to equipment manufacturer's written instructions and according to seismic codes at Project.

1. Construct concrete bases not less than 4 inches larger in both directions than supported unit.
2. Concrete bases for all equipment shall be 4 inches (100 mm) tall above finished floor.

3.9 ERECTION OF METAL SUPPORTS AND ANCHORAGES

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

B. Field Welding: Comply with AWS D1.1.
3.10 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.

3.11 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.

3.12 INSTALLATION, INSPECTIONS AND CERTIFICATIONS

A. The Contractor shall obtain timely inspections of the installation by the constituted authorities. Remedy any deficiencies to the satisfaction of the inspecting authority.

B. Upon final completion of the work, obtain certificates of acceptance from the constituted authorities. Deliver the certificates to the Architect for transmission to the Owner.

3.13 OPERATION PRIOR TO COMPLETION

A. When any piece of mechanical or electrical equipment is operable and it is to the advantage of the contractor to operate the equipment, he may do so with permission of Owner, providing that he properly supervises the operation, retains full responsibility for the equipment operated, and protects against dirt accumulations during operation. The warranty period shall, however, not commence until such time as the equipment is operated for the beneficial use of the Owner or until final acceptance by the Owner.
B. Regardless of whether or not the equipment has or has not been operated, the Contractor shall properly clean the equipment, install clean filter media, and properly adjust the operation of the equipment before final acceptance by the Owner.

3.14 INSTRUCTION OF OWNER’S PERSONNEL

A. Provide the services of competent engineers and/or technicians acceptable to the Owner's Representative to instruct other representatives of the Owner in the complete and detailed operation of each item of equipment or device of all the various electrical systems. These instructions shall be provided for whatever periods may be necessary to accomplish the desired results.

B. Upon completion of these instructions, the Contractor shall obtain a letter of release, acknowledged by the Owner or his authorized representative, stating the dates on which the various kinds of instruction were given, and the personnel to whom the instructions were given.

C. The Contractor shall be fully responsible for proper maintenance of equipment and systems until the instructions have been given the Owner's personnel and the letter of release acknowledged.

D. In providing the instructions to the Owner's personnel, the written operating and maintenance manuals shall be followed in all instances, and the Owner's personnel shall be familiarized with such manuals.

E. Operating and maintenance manuals used for instructions shall include wiring diagrams, manufacturer's operating and maintenance instructions, parts lists (with sources identified), and other data as appropriate for each system.

3.15 SEALANT

A. Apply sealant to penetrations of all floor and wall assemblies to maintain pressure differentials required by AIA for all pressure sensitive rooms including: [Isolation rooms, Protective Environment rooms, Operating rooms, C-section rooms, and Pharmacy including Chemo Prep, Sterile Prep and Ante rooms]. Sealant materials and installation requirements are specified in Division 07 Section “Joint Sealants” and Division 09 Section “Gypsum Board Assemblies.

END OF SECTION
SECTION 220523
GENERAL-DUTY VALVES FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Provide piping, valves, fittings and related products as listed on Drawings and described herein.

B. This Section includes the following general-duty valves:
   1. Copper-alloy ball valves.
   2. Bronze check valves.

C. 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.

1.2 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.
   6. NRS: Nonrising stem.
   7. OS&Y: Outside screw and yoke.

1.3 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; furnished specialties; and accessories.
1.4 QUALITY ASSURANCE

A. ASME Compliance for Ferrous Valves: ASME B16.10 and ASME B16.34 for dimension and design criteria.

B. NSF Compliance: NSF 61-G for valve materials for potable-water service.

C. Bronze valves shall be made with dezincification-resistant materials. All valves shall comply with the current edition of recognized industry standards for design, materials and testing. These standards include but are not limited to MSS SP-80 and MSS SP-110.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Prepare valves for shipping as follows:
   1. Protect internal parts against rust and corrosion.
   2. Protect threads, flange faces, grooves, and weld ends.
   3. Set ball and plug valves open to minimize exposure of functional surfaces.
   4. Set butterfly valves closed or slightly open.
   5. Block check valves in either closed or open position.

B. Use the following precautions during storage:
   1. Maintain valve end protection.
   2. Store valves indoors and maintain at higher than ambient dew-point temperature. If outdoor storage is necessary, store valves off the ground in watertight enclosures.

C. Use sling to handle large valves; rig sling to avoid damage to exposed parts. Do not use handwheels or stems as lifting or rigging points.

PART 2 - PRODUCTS

2.1 VALVES, GENERAL

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

B. Bronze Valves: NPS 2 and smaller with threaded ends, unless otherwise indicated.

C. Ferrous Valves: NPS 2-1/2 and larger with flanged or grooved ends, unless otherwise indicated.

D. Valve Pressure and Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.

E. Valve Sizes: Same as upstream 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. Lever Handle: For quarter-turn valves NPS 6 and smaller, except plug valves.
4. Wrench: For plug valves with square heads. Furnish Owner with 1 wrench for every 10 plug valves, for each size square plug head.

G. Extended Valve Stems: On insulated valves. Valves shall have 2-inch (50-mm) stem extensions and the following features:

1. Ball Valves: Shall have extended operating handle of non-thermal-conductive material, protective sleeve that allows operation of valve without breaking the vapor seal or disturbing insulation, and memory stops that are fully adjustable after insulation is applied.
   1) NIBCO Nib-seal handle extension
   2) Conbraco Industries, Inc.; Apollo Div.
   3) Jamesbury, Inc.
   4) Kitz Insulated Stem Extension Model #ISE 1 thru 4
   5) Milwaukee Valve: The Insulator/MS

2. Butterfly Valves: Shall have extended necks.


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 check valves; below 421 deg F for ball valves.

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

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

2.2 COPPER-ALLOY BALL VALVES

A. Brass Ball Valves, General: MSS SP-110 and have a brass body complying with ASTM B 283.

B. Bronze Ball Valves, General: MSS SP-110 and have a copper alloy body complying with ASTM B 584, except for Class 250 which shall comply with ASTM B 61, full-depth ASME B1.20.1 threaded or solder ends, and blowout-proof stems.

C. Two-Piece, Full-Port, Bronze Ball Valves with Bronze Trim: Chrome-plated bronze ball and bronze stem and; reinforced TFE seats; threaded body packnut design (no threaded stem designs allowed) with adjustable stem packing, solder or threaded ends; and 150 psig SWP 600-psigCWP rating.

   1. NIBCO Model S-585-80-LF or T-585-80-LF
2. Conbraco Industries, Inc.; Apollo 77CALF
3. Crane Co.
4. Watts Model

5. Kitz Model 868 or 869
6. Milwaukee UPBA450 or UPBA400
7. Hammond UP8311A or UP88301A

D. Two-Piece, Full-Port, Copper-alloy Ball Valves with Stainless-Steel Trim: Type 316 stainless-steel vented ball and stem, reinforced TFE seats, threaded body packnut design (no threaded stem designs allowed) with adjustable stem packing, soldered or threaded ends; 150 psig SWP and 600-psig CWP ratings.

1. NIBCO Model S-585-66-LF or T-585-66-LF
2. Conbraco Industries, Inc.; Apollo 77CALF
3. Crane Co. Model
4. Watts Model

E. Three-Piece, Full Port, Copper-alloy Ball Valves with Stainless-Steel Trim: Type 316 stainless-steel vented ball and stem, threaded body packnut design (no threaded stem designs allowed) with adjustable stem packing, stainless nuts and bolts on valve body, soldered or threaded ends; 150 psig SWP and 600-psig CWP rating.

2. Conbraco Industries, Inc.; Apollo 82LF
3. Crane Co.

2.3 BRONZE CHECK VALVES

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

B. Class 125, Bronze, Lift Check Valves with TFE Disc: ASTM B-584 bronze body and integral seat with soldered or threaded end connections, and having 250-psig CWP rating.

1. Crane Co.; Crane Valve Group; Crane Valves.
2. Kitz Model 836 or 826
3. NIBCO Model S-480-Y-LF or T-480-Y-LF
4. Conbraco Industries, Inc; Apollo Model 61
5. Powell, Wm. Co.
6. Milwaukee UP1548T, UP548T
7. Hammond UP947, UP943

C. Class 125, Bronze, Swing Check Valves with TFE Disc: ASTM B-62 bronze body and seat with TFE disc in bronze seat holder, Y-pattern design, soldered or threaded end connections, and having 200 psig CWP rating.

1. Crane Co.; Crane Valve Group; Crane Valves.
2. Kitz Model 822T or 823T
3. NIBCO Model S-413-Y-LF or T-413-Y-LF
4. Conbraco Industries, Inc; Apollo 163S or 163T
5. Powell, Wm. Co.
6. Milwaukee UP1509, UP509  
7. Hammond UP912, UP904  

D. Class 150, Bronze, Swing Check Valves with TFE Disc: ASTM B-62 bronze body and seat with TFE disc in bronze seat holder, Y-pattern design, soldered or threaded end connections, and having 300 psig CWP rating.  
1. Crane Co.; Crane Valve Group; Crane Valves.  
2. Kitz #30T or #29T  
3. NIBCO Model S-433-Y or T-433-Y  
4. Conbraco Industries, Inc; Apollo 164T  
5. Powell, Wm. Co.  
6. Milwaukee 1510T, 510T  
7. Hammond IB945  

PART 3 - EXECUTION  

3.1 EXAMINATION  
A. Examine piping system for compliance with requirements for installation tolerances and other conditions affecting performance.  
1. Proceed with installation only after unsatisfactory conditions have been corrected.  

B. Examine valve interior for cleanliness, freedom from foreign matter, and corrosion. Remove special packing materials, such as blocks, used to prevent disc movement during shipping and handling.  

C. Operate valves in positions from fully open to fully closed. Examine guides and seats made accessible by such operations.  

D. Examine threads on valve and mating pipe for form and cleanliness.  

E. Examine mating flange faces for conditions that might cause leakage. Check bolting for proper size, length, and material. Verify that gasket is of proper size, that its material composition is suitable for service, and that it is free from defects and damage.  

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

3.2 VALVE APPLICATIONS  
A. Refer to piping Sections for specific valve applications. If valve applications are not indicated, use the following:  
1. Shutoff Service: Ball or butterfly valves.  
2. Throttling Service: Ball or butterfly 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 2 and Smaller: Two-piece, full port, stainless-steel trim, bronze.
2. Lift Check Valves, NPS 2 and Smaller: Class 125, bronze with TFE disc.

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

1. For Copper Tubing, NPS 2 and Smaller: Solder-joint or threaded ends.
2. For Copper Tubing, NPS 2-1/2: Flanged ends.
3. For Grooved-End, Copper Tubing: 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 SUMMARY

A. This Section includes the following hangers and supports for plumbing system piping and equipment:

1. Steel pipe hangers and supports.
2. Trapeze pipe hangers.
3. 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 supports.
2. Division 21 Section "Water-Based Fire-Suppression Systems" for pipe hangers for fire-suppression piping.
3. Division 22 Section "Vibration and Seismic Controls for Plumbing Piping and Equipment" for vibration isolation devices.

1.2 DEFINITIONS

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

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

1.3 PERFORMANCE REQUIREMENTS

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

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

C. Pipe hangers and supports shall conform to the recommendations of ASHRAE, ASPE, ANSI, and MSS, unless otherwise indicated.
1.4 SUBMITTALS

A. Product Data: For the following:

1. Steel pipe hangers and supports.
2. Fiberglass pipe hangers.
3. Thermal-hanger shield inserts.
4. 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. Fiberglass strut systems. Include Product Data for components.
4. Pipe stands. Include Product Data for components.
5. Equipment supports.

C. Welding certificates.

1.5 QUALITY ASSURANCE


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

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

PART 2 - PRODUCTS

2.1 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. Available Manufacturers:

1. AAA Technology & Specialties Co., Inc.
2. Bergen-Power Pipe Supports.
4. Carpenter & Paterson, Inc.
5. Empire Industries, Inc.
6. ERICO/Michigan Hanger Co.
7. Globe Pipe Hanger Products, Inc.
8. Grinnell Corp.
9. GS Metals Corp.
11. PHD Manufacturing, Inc.
12. PHS Industries, Inc.
13. Piping Technology & Products, Inc.
14. Tolco Inc.
15. Anvil International

C. Galvanized, Metallic Coatings: Pregalvanized or hot dipped.

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

E. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion for support of bearing surface of piping.

2.2 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.

2.3 METAL FRAMING SYSTEMS

A. Description: MFMA-3, shop- or field-fabricated pipe-support assembly made of steel channels and other components.

B. Available Manufacturers:

2. ERICO/Michigan Hanger Co.; ERISTRUT Div.
3. GS Metals Corp.
5. Thomas & Betts Corporation.
6. Tolco Inc.
7. Unistrut Corp.; Tyco International, Ltd.
8. Anvil International

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

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

2.4 CUSHION CLAMPS FOR MEDICAL GAS

A. Clamps for trapeze style hangers, designed to isolate copper medical gas piping from dissimilar metals.

B. Manufacturers:

1. Tolco Inc.
2. HOLDRITE Corp.; Hubbard Enterprises.

2.5 FASTENER SYSTEMS

B. Mechanical-Expansion Anchors: Insert-wedge-type zinc-coated or 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. Available Manufacturers:
   b. Empire Industries, Inc.
   c. Hilti, Inc.
   d. ITW Ramset/Red Head.
   e. MKT Fastening, LLC.
   f. Powers Fasteners.

2.6 PIPE STAND FABRICATION

A. Pipe Stands, General: 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.

1. Available Manufacturers:
   a. ERICO/Caddy Pyramid
   b. MIRO Industries.

C. Low-Type, Single-Pipe Stand: One-piece plastic or stainless-steel base unit with plastic roller, for roof installation without membrane penetration.

1. Available Manufacturers:
   a. MIRO Industries.
   b. Portable Pipe Hangers.
   c. ERICO/Caddy Pyramid

D. High-Type, Single-Pipe Stand: Assembly of base, vertical and horizontal members, and pipe support, for roof installation without membrane penetration.

1. Available Manufacturers:
   a. ERICO/Caddy Pyramid
   b. MIRO Industries.
   c. Portable Pipe Hangers.

2. Base: Plastic or Stainless steel.
3. Vertical Members: Two or more cadmium-plated-steel or stainless-steel, continuous-thread rods.
4. Horizontal Member: Cadmium-plated-steel or stainless-steel rod with plastic or stainless-steel, roller-type pipe support.

E. High-Type, Multiple-Pipe Stand: Assembly of bases, vertical and horizontal members, and pipe supports, for roof installation without membrane penetration.

1. Available Manufacturers:
   a. Portable Pipe Hangers.

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-Mounting-Type Pipe Stands: Shop- or field-fabricated pipe support made from structural-steel shape, continuous-thread rods, and rollers for mounting on permanent stationary roof curb.

1. Available Manufacturers:
   a. Pate.
   b. Thy Curb.

   1) Models:
      a) TC-1 for insulated roof decks.
      b) TC-2 for un-insulated and existing roof decks.
      c) TC-3 for Bulb-T roof decks.

2. Pipe curbs and rails with covers shall be all welded 18 gauge galvanized steel shell and baseplate, wood nailer, and TP-1 Duro EPDM cover or TP-2 pipe cover, as detailed on the drawings, for pipe penetration(s).

2.7 PIPE POSITIONING SYSTEMS

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

B. Manufacturers:

2. HOLDRITE Corp.; Hubbard Enterprises.
3. Samco Stamping, Inc.

2.8 EQUIPMENT SUPPORTS

A. Description: Welded, shop- or field-fabricated equipment support made from structural-steel shapes.
1. Available Manufacturers:
   a. Pate.
   b. Thy Curb.

1) Models:
   a) TEMS-1 for insulated roof decks.
   b) TEMS-2 for un-insulated and existing roof decks.
   c) TEMS-3 for single-ply roof systems.

2. Equipment supports shall be all welded 18 gauge galvanized steel shell, baseplate and counterflashing with internal bulkhead re-enforcement and wood nailer.

2.9 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, nonshrink and nonmetallic grout; suitable for interior and exterior applications.

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

PART 3 - EXECUTION

3.1 PREPARATION

A. Proceed with installation of hangers, supports and anchors only after required building structural work has been completed in areas where the work is to be installed. Correct inadequacies including, but not limited to proper placement of inserts, anchors and other building structural attachments.

3.2 HANGER AND SUPPORT APPLICATIONS

A. Use only one type hangers and supports, by one manufacturer, for each piping service.

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

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

D. Use hangers and supports with galvanized, metallic coatings for piping and equipment that will not have field-applied finish.
E. Use nonmetallic coatings on attachments for electrolytic protection where attachments are in direct contact with copper tubing.

F. Use nonmetallic coatings on attachments for electrolytic protection where attachments are in direct contact with copper tubing or provide copper-plated hangers and supports for copper piping systems where hangers are in contact with bare pipe.

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

H. Horizontal-Piping Hangers and Supports, Select size of hangers and supports to exactly fit pipe size for bare piping, and around piping insulation with saddle or shield for insulated piping. Unless otherwise indicated and except as specified in piping system Sections, install the following types. Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of noninsulated or insulated stationary pipes, NPS 1/2 to NPS 30.
2. Yoke-Type Pipe Clamps (MSS Type 2): For suspension of 120 to 450 deg F pipes, NPS 4 to NPS 16, requiring up to 4 inches of insulation.
3. Carbon- or Alloy-Steel, Double-Bolt Pipe Clamps (MSS Type 3): For suspension of pipes, NPS 3/4 to NPS 24, requiring clamp flexibility and up to 4 inches of insulation.
4. Steel Pipe Clamps (MSS Type 4): For suspension of cold and hot pipes, NPS 1/2 to NPS 24, if little or no insulation is required.
5. Pipe Hangers (MSS Type 5): For suspension of pipes, NPS 1/2 to NPS 4, to allow off-center closure for hanger installation before pipe erection.
6. Adjustable, Swivel Split- or Solid-Ring Hangers (MSS Type 6): For suspension of noninsulated stationary pipes, NPS 3/4 to NPS 8.
7. Adjustable, Steel Band Hangers (MSS Type 7): For suspension of noninsulated stationary pipes, NPS 1/2 to NPS 8.
8. Adjustable Band Hangers (MSS Type 9): For suspension of noninsulated stationary pipes, NPS 1/2 to NPS 8.
9. Adjustable, Swivel-Ring Band Hangers (MSS Type 10): For suspension of noninsulated stationary pipes, NPS 1/2 to NPS 2.
10. Split Pipe-Ring with or without Turnbuckle-Adjustment Hangers (MSS Type 11): For suspension of noninsulated stationary pipes, NPS 3/8 to NPS 8.
11. Extension Hinged or 2-Bolt Split Pipe Clamps (MSS Type 12): For suspension of noninsulated stationary pipes, NPS 3/8 to NPS 3.
12. U-Bolts (MSS Type 24): For support of heavy pipes, NPS 1/2 to NPS 30.
13. Clips (MSS Type 26): For support of insulated pipes not subject to expansion or contraction.
14. Pipe Saddle Supports (MSS Type 36): For support of pipes, NPS 4 to NPS 36, with steel pipe base stanchion support and cast-iron floor flange.
15. Pipe Stanchion Saddles (MSS Type 37): For support of pipes, NPS 4 to NPS 36, with steel pipe base stanchion support and cast-iron floor flange and with U-bolt to retain pipe.
16. Adjustable, Pipe Saddle Supports (MSS Type 38): For stanchion-type support for pipes, NPS 2-1/2 to NPS 36, if vertical adjustment is required, with steel pipe base stanchion support and cast-iron floor flange.
17. Single Pipe Rolls (MSS Type 41): For suspension of pipes, NPS 1 to NPS 30, from 2 rods if longitudinal movement caused by expansion and contraction might occur.
18. Adjustable Roller Hangers (MSS Type 43): For suspension of pipes, NPS 2-1/2 to NPS 20, from single rod if horizontal movement caused by expansion and contraction might occur.
19. Complete Pipe Rolls (MSS Type 44): For support of pipes, NPS 2 to NPS 42, if longitudinal movement caused by expansion and contraction might occur but vertical adjustment is not necessary.
20. Pipe Roll and Plate Units (MSS Type 45): For support of pipes, NPS 2 to NPS 24, if small horizontal movement caused by expansion and contraction might occur and vertical adjustment is not necessary.
21. Adjustable Pipe Roll and Base Units (MSS Type 46): For support of pipes, NPS 2 to NPS 30, if vertical and lateral adjustment during installation might be required in addition to expansion and contraction.

I. Vertical-Piping Clamps: Select size of vertical piping clamps to exactly fit pipe size of bare pipe. 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.

J. Hanger-Rod Attachments: Select size of hanger rod attachments to suit hanger rods. 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.

K. 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.

L. 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.

M. Spring Hangers and Supports: Select spring hangers and supports to suit pipe size and loading. Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Restraint-Control Devices (MSS Type 47): Where indicated to control piping movement.
2. Spring Cushions (MSS Type 48): For light loads if vertical movement does not exceed 1-1/4 inches.
3. Spring-Cushion Roll Hangers (MSS Type 49): For equipping Type 41 roll hanger with springs.
4. Spring Sway Braces (MSS Type 50): To retard sway, shock, vibration, or thermal expansion in piping systems.
5. Variable-Spring Hangers (MSS Type 51): Preset to indicated load and limit variability factor to 25 percent to absorb expansion and contraction of piping system from hanger.
6. Variable-Spring Base Supports (MSS Type 52): Preset to indicated load and limit variability factor to 25 percent to absorb expansion and contraction of piping system from base support.
7. Variable-Spring Trapeze Hangers (MSS Type 53): Preset to indicated load and limit variability factor to 25 percent to absorb expansion and contraction of piping system from trapeze support.
8. Constant Supports: For critical piping stress and if necessary to avoid transfer of stress from one support to another support, critical terminal, or connected equipment. Include auxiliary stops for erection, hydrostatic test, and load-adjustment capability. These supports include the following types:
a. Horizontal (MSS Type 54): Mounted horizontally.
b. Vertical (MSS Type 55): Mounted vertically.
c. Trapeze (MSS Type 56): Two vertical-type supports and one trapeze member.

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

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

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

3.3 MEDICAL GAS HANGER AND SUPPORT INSTALLATION

A. Comply with requirements in Division 22 Section "Hangers and Supports for Plumbing Piping and Equipment" for pipe hanger and support devices.

B. Use cushion clamps on all medical gas piping

C. Vertical Piping: MSS Type 8 or 42, clamps.

D. Individual, Straight, Horizontal Piping Runs:
   1. 100 Feet and Less: MSS Type 1, adjustable, steel, clevis hangers.
   2. Longer Than 100 Feet: MSS Type 43, adjustable, roller hangers.

E. Multiple, Straight, Horizontal Piping Runs 100 Feet or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze. Comply with requirements in Division 22 Section "Hangers and Supports for Plumbing Piping and Equipment" for trapeze hangers.

F. Base of Vertical Piping: MSS Type 52, spring hangers.

G. Support horizontal piping within 12 inches of each fitting and coupling.

H. Rod diameter may be reduced 1 size for double-rod hangers, with 3/8-inch minimum rods.

I. Install hangers for copper tubing with the following maximum horizontal spacing and minimum rod diameters:
   1. NPS 1/4: 60 inches with 3/8-inch rod.
   2. NPS 3/8 and NPS 1/2: 72 inches with 3/8-inch rod.
   4. NPS 1: 96 inches with 3/8-inch rod.
   6. NPS 1-1/2: 10 feet with 3/8-inch rod.
   7. NPS 2: 11 feet with 3/8-inch rod.
   8. NPS 2-1/2: 13 feet with 1/2-inch rod.
   9. NPS 3: 14 feet with 1/2-inch rod.
10. NPS 3-1/2: 15 feet with 1/2-inch rod.
11. NPS 4: 16 feet with 1/2-inch rod.
12. NPS 5: 18 feet with 1/2-inch rod.
14. NPS 8: 23 feet with 3/4-inch rod.

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

3.4 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 by the following table to properly support piping from building structure.

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<td>20</td>
<td>1-1/4</td>
<td>8</td>
<td>7/8</td>
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</tbody>
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B. Trapeze Pipe Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Arrange for grouping of parallel runs of horizontal piping and support together on field-fabricated trapeze pipe hangers.

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

C. 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:
   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-Mounting Type: Assemble components and mount on smooth roof surface. Do not penetrate roof membrane.
   2. Curb-Mounting-Type Pipe Stands: Assemble components or fabricate pipe stand and mount on permanent, stationary roof curb. Refer to Division 07 Section "Roof Accessories" for curbs.

G. Pipe Positioning System Installation: Install support devices to make rigid supply and waste piping connections to each plumbing fixture. Refer to Division 22 Section "Plumbing Fixtures" for plumbing fixtures.

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


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

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

L. Install building attachments within concrete slabs or attach to structural steel. Install additional attachments at concentrated loads, including valves, flanges, and strainers, 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.

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

N. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and so maximum pipe deflections allowed by ASME B31.9 (for building services piping) are not exceeded.

O. Insulated Piping: Comply with the following:
   1. Attach clamps and spacers to piping.
      a. Piping Operating above Ambient Air Temperature: Clamp may project through insulation.
      b. Piping Operating below Ambient Air Temperature: Use thermal-hanger shield insert with clamp sized to match OD of insert.
c. Do not exceed pipe stress limits according to ASME B31.9 for building services piping.

2. Install MSS SP-58, Type 39, protection saddles if insulation without vapor barrier is indicated. Fill interior voids with insulation that matches adjoining insulation.
   a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.

3. Install MSS SP-58, Type 40, protective shields on cold piping with vapor barrier. Shields shall span an arc of 180 degrees.
   a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.

4. Shield Dimensions for Pipe: Not less than the following:
   □

5. Pipes NPS 8 and Larger: Include wood inserts.
6. Insert Material: Length at least as long as protective shield.
7. Thermal-Hanger Shields: Install with insulation same thickness as piping insulation.

3.5 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.

3.6 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 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.

3.7 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 inch

3.8 PAINTING

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

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

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

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

END OF SECTION
SECTION 220553
IDENTIFICATION FOR PLUMBING PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Equipment labels.
2. Warning signs and labels.
3. Pipe labels.
4. Valve tags.
5. Warning tags.

1.2 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.

1.3 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. Plastic Labels for Equipment:
1. Material and Thickness: Multilayer, multicolor, laminated phenolic with a black surface and white substrate for mechanical engraving, 1/16 inch thick, and having predrilled holes for attachment hardware and beveled edges.
2. Letter Color: White
3. Background Color: Black
4. Maximum Temperature: Able to withstand temperatures up to 160 deg F.
5. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
7. Fasteners: Stainless-steel rivets or self-tapping screws.
8. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

B. Label Content: Include equipment's Drawing designation or unique equipment number, as directed by the owner. Secondary lettering shall indicate date of installation.

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.

D. Punched plastic tape for labels is not acceptable.

2.2 WARNING SIGNS AND LABELS

A. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16 inch thick, and having predrilled holes for attachment hardware.

B. Letter Color: White

C. Background Color: Red

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

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

F. Minimum Letter Size: 1 inch for name of units. Include secondary lettering two-thirds to three-fourths the size of principal lettering.

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

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

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

A. General Requirements for Manufactured Pipe Labels: Preprinted, color-coded, with lettering indicating service, and showing flow direction. Labels shall conform to ANSI A13.1 and the following table:

<table>
<thead>
<tr>
<th>Outside Diameter of Pipe of Covering</th>
<th>Height of Letters</th>
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<tr>
<td>¾” to 1-1/4”</td>
<td>½”</td>
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<tr>
<td>1-1/2” to 2”</td>
<td>¾”</td>
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<tr>
<td>2-1/2” to 6”</td>
<td>1-1/4”</td>
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<tr>
<td>8” to 10”</td>
<td>2-1/2”</td>
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<tr>
<td>Over 10”</td>
<td>3-1/2”</td>
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</table>

B. Available Manufacturers: Seton, Brady, or Westline.

C. Pretensioned Pipe Labels: Precoiled, semirigid plastic formed to partially cover or cover full circumference of pipe.

D. Self-Adhesive Pipe Labels: Printed plastic with contact-type, permanent-adhesive backing.

E. Pipe Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings, and an arrow indicating flow direction.

1. Flow-Direction Arrows: Integral with piping system service lettering to accommodate both directions, or as separate unit on each pipe label to indicate flow direction.

2.4 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 and S-hook or beaded chain

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

1. Valve-tag schedule shall be included in operation and maintenance data.

2.5 WARNING TAGS

A. Warning Tags: Preprinted or partially preprinted, accident-prevention tags, of plasticized card stock with matte finish suitable for writing.
1. Size: Approximately 4 by 7 inches (100 by 178 mm).
2. Fasteners: Brass grommet and wire.
3. Nomenclature: Large-size primary caption such as "DANGER," "CAUTION," or "DO NOT OPERATE."

**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 "High-Performance Coatings."

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

1. Near each valve and control device.
2. Near each branch connection, excluding short takeoffs for fixtures and terminal units. Where flow pattern is not obvious, mark each pipe at branch.
3. Near penetrations through walls, floors, ceilings, and inaccessible enclosures.
4. At access doors, manholes, and similar access points that permit view of concealed piping.
5. Near major equipment items and other points of origination and termination.
6. Spaced at maximum intervals of 50 feet along each run. Reduce intervals to 25 feet in areas of congested piping and equipment.
7. In no case shall an exposed line enter or leave a room without being identified.
8. Secure identification markers to piping by firmly pressing markers in place, following removal of protective covering. Additionally secure by banding ends of markers in place using 1/2 inch wide aluminum bands of the type normally used to secure insulation in place.
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.

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 220700
PLUMBING INSULATION

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Insulation Materials:
   a. Calcium silicate.
   b. Cellular glass.
   c. Fiberglass.
   d. Flexible elastomeric.

2. Factory-applied jackets.
3. Field-applied cloths.
4. Field-applied jackets.
5. Adhesives.
7. Sealants.
8. Tapes.
10. Thermal Hanger-Shield Inserts

1.2 SUBMITTALS

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

B. Calculations: For insulation submitted outside of the conductivity range per the “Minimum Pipe Insulation Thickness” Table for the application listed, submit thickness calculations.

C. Shop Drawings:

1. Detail application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.
2. Detail attachment and covering of heat tracing inside insulation.
3. Detail insulation application at pipe expansion joints for each type of insulation.
4. Detail insulation application at elbows, fittings, flanges, valves, and specialties for each type of insulation.
5. Detail removable insulation at piping specialties, equipment connections, and access panels.
6. Detail application of field-applied jackets.
7. Detail application at linkages of control devices.
8. Detail field application for each equipment type.
D. Samples: For each type of insulation and jacket indicated. Identify each Sample, describing product and intended use.

1. Sample Sizes:
   b. Sheet Form Insulation Materials: 12 inches square.
   d. Sheet Jacket Materials: 12 inches square.
   e. Manufacturer's Color Charts: For products where color is specified, show the full range of colors available for each type of finish material.

E. Qualification Data: For qualified Installer.

F. 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.

G. Field quality-control reports.

1.3 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. Fire-Test-Response Characteristics: Insulation and related materials shall have fire-test-response characteristics indicated, as determined by testing identical products per 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 and inspecting 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.

1.4 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.

1.5 COORDINATION

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

1.6 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 Manufacturers:

A. Fiberglass
   2. K-Flex.
   4. Manson (Certain Teed).
   5. Owens-Corning.

B. Flexible Elastomeric
   1. Aeroflex / Aerocel EPDM
   2. Armacell / Armaflex
   3. RBX Industries / Rubatex

2.2 INSULATION MATERIALS

A. Comply with requirements in Part 3 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.
BROWARD HEALTH PHARMACY

F. Calcium Silicate:

1. 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.
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.
3. Prefabricated Fitting Covers: Comply with ASTM C 450 and ASTM C 585 for dimensions used in preforming insulation to cover valves, elbows, tees, and flanges.

G. Cellular Glass: Inorganic, incombustible, foamed or cellulated glass with annealed, rigid, hermetically sealed cells. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

1. Block Insulation: ASTM C 552, Type I.
2. Special-Shaped Insulation: ASTM C 552, Type III.
4. Factory fabricate shapes according to ASTM C 450 and ASTM C 585.

H. Fiberglass

1. Flexible glass fiber; ASTM C553 and ASTM C1290; commercial grade; 'k' value of 0.25 at 75 degrees F; 1.5 lb/cu ft minimum density; 0.002 inch foil scrim kraft facing for air ducts.
2. Rigid glass fiber; ASTM C612, Class 1; 'k' value of 0.23 at 75 degrees F; 3.0 lb/cu ft minimum density.
3. Duct liner, flexible glass fiber; ASTM C1071; Type II, 'k' value of 0.23 at 75 degrees F; 3.0 lb/cu ft minimum density; coating air side to be black, unless otherwise indicated, and rated for 4,000 feet per minute air velocity. The airstream surface must be protected with a durable polyacrylate copolymer emulsion, or approved equal, specifically formulated to:
   a. Not support the growth of fungus or bacteria, when tested in accordance with the test method for fungi resistance in ASTM D 5590 with “0” growth rating.
   b. Act as a fungicidal protective coating: water based, VOC < 50 g/l. Fungicidal coating must be EPA registered for use in HVAC duct systems.

2.3 ADHESIVES

A. Products: Subject to compliance with requirements, insulation manufacturer shall provide insulation adhesive and jacket manufacturer shall provide jacket adhesive.

B. 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.

C. Calcium Silicate Adhesive: Fibrous, sodium-silicate-based adhesive with a service temperature range of 50 to 800 deg F.
D. Cellular-Glass Adhesive: Solvent-based resin adhesive, with a service temperature range of minus 75 to plus 300 deg F.


F. PVC Jacket Adhesive: Compatible with PVC jacket.

2.4 MASTICS

A. Products: Subject to compliance with requirements, insulation manufacturer shall provide mastics.

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

C. Vapor-Barrier Mastic: Water based; suitable for indoor and outdoor use on below ambient services.
   1. Water-Vapor Permeance: ASTM E 96, Procedure B, 0.013 perm at 43-mil dry film thickness.
   2. Service Temperature Range: Minus 20 to plus 180 deg F.

D. Breather Mastic: Water based; suitable for indoor and outdoor use on above ambient services.
   1. Water-Vapor Permeance: ASTM F 1249, 3 perms at 0.0625-inch dry film thickness.
   2. Service Temperature Range: Minus 20 to plus 200 deg F.
   3. Solids Content: 63 percent by volume and 73 percent by weight.

E. Color: White.

2.5 SEALANTS

A. Products: Subject to compliance with requirements, insulation manufacturer shall provide sealants.

B. Joint Sealants for Cellular-Glass Products:
   1. Materials shall be compatible with insulation materials, jackets, and substrates.
   2. Permanently flexible, elastomeric sealant.
   3. Service Temperature Range: Minus 100 to plus 300 deg F.

C. FSK and Metal Jacket Flashing Sealants:
1. Materials shall be compatible with insulation materials, jackets, and substrates.
2. Fire- and water-resistant, flexible, elastomeric sealant.
3. Service Temperature Range: Minus 40 to plus 250 deg F.

D. ASJ Flashing Sealants, and Vinyl, PVDC, and PVC Jacket Flashing Sealants:
1. Materials shall be compatible with insulation materials, jackets, and substrates.
2. Fire- and water-resistant, flexible, elastomeric sealant.
3. Service Temperature Range: Minus 40 to plus 250 deg F.

2.6 FACTORY-APPLIED JACKETS

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

1. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C 1136, Type I.
2. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C 1136, Type I.
3. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C 1136, Type II.
4. FSP Jacket: Aluminum-foil, fiberglass-reinforced scrim with polyethylene backing; complying with ASTM C 1136, Type II.
5. PVDC Jackets
   a. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
      1) Dow Chemical Company (The); Saran 540 Vapor Retarder Film and Saran 560 Vapor Retarder Film.
   b. PVDC Jacket for Indoor Applications: 4-mil-thick, white PVDC biaxially oriented barrier film with a permeance at 0.02 perms when tested according to ASTM E 96 and with a flame-spread index of 5 and a smoke-developed index of 20 when tested according to ASTM E 84.
   c. PVDC Jacket for Outdoor Applications: 6-mil-thick, white PVDC biaxially oriented barrier film with a permeance at 0.01 perms when tested according to ASTM E 96 and with a flame-spread index of 5 and a smoke-developed index of 25 when tested according to ASTM E 84.
5. Vinyl Jacket: White vinyl with a permeance of 1.3 perms when tested according to ASTM E 96, Procedure A, and complying with NFPA 90A and NFPA 90B.
2.7 FIELD-APPLIED CLOTHS

A. Woven Glass-Fiber Fabric: Comply with MIL-C-20079H, Type I, plain weave, and presized a minimum of 8 oz./sq. yd..

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:


2.8 FIELD-APPLIED JACKETS

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

B. Metal Jacket:

   1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

      a. Childers Products, Division of ITW; Metal Jacketing Systems.
      b. PABCO Metals Corporation; Surefit.
      c. RPR Products, Inc.; Insul-Mate.


      a. Factory cut and rolled to size.
      b. Finish and thickness are indicated in field-applied jacket schedules.
      c. Factory-Fabricated Fitting Covers:

         1) Same material, finish, and thickness as jacket.
         2) Preformed 2-piece or gore, 45- and 90-degree, short- and long-radius elbows.
         3) Tee covers.
         4) Flange and union covers.
         5) End caps.
         6) Beveled collars.
         7) Valve covers.
         8) Field fabricate fitting covers only if factory-fabricated fitting covers are not available.

2.9 TAPES

A. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

   1. Avery Dennison Corporation, Specialty Tapes Division.
2. Compac Corp.
4. Venture Tape.
5. Dow Chemical Company (The).

B. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C 1136.
   1. Width: 3 inches.
   2. Thickness: 11.5 mils.
   4. Elongation: 2 percent.
   5. Tensile Strength: 40 lbf/inch in width.
   6. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.

C. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C 1136.
   1. Width: 3 inches.
   2. Thickness: 6.5 mils.
   4. Elongation: 2 percent.
   5. Tensile Strength: 40 lbf/inch in width.
   6. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.

D. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive.
   1. Width: 2 inches.
   2. Thickness: 3.7 mils.
   3. Adhesion: 100 ounces force/inch in width.
   4. Elongation: 5 percent.
   5. Tensile Strength: 34 lbf/inch in width.

2.10 SECUREMENTS

A. Bands:
   1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
      a. Childers Products; Bands.
      b. PABCO Metals Corporation; Bands.
      c. RPR Products, Inc.; Bands.
   2. Aluminum: ASTM B 209, Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch thick, 3/4 inch wide with wing or closed seal.

2.11 PIPE INSULATION HANGER SHIELDS:

A. Provide shields for hangers on all insulated pipe.
B. Insulation and shields shall consist of a 180 degree galvanized sheet steel shield. Shield lengths and minimum sheet metal gauges shall be as directed below:

<table>
<thead>
<tr>
<th>PIPE SIZE</th>
<th>SHIELD LENGTH</th>
<th>MINIMUM GAUGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/2&quot; to 8&quot;</td>
<td>12&quot;</td>
<td>16</td>
</tr>
<tr>
<td>10&quot; &amp;</td>
<td>22&quot;</td>
<td>16</td>
</tr>
<tr>
<td>Larger</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

C. Shields shall be Model CS-CW, except for pipe roller applications and where pipe hanger spacing exceeds 10 feet, then provide Model CSX-CW.

D. At the Contractor’s option, shop-fabricated galvanized metal shields may be provided based on approved shop drawings. Length and gauge of sheet metal shall be as specified above.

2.12 PREMANUFACTURED COVERS

A. Preformed manufactured PVC fitting covers with rigid one piece (half-shell) preformed rigid insulation.

PART 3 - EXECUTION

3.1 GENERAL

A. Materials shall be applied by a qualified insulation applicator/workman skilled in this trade. Insulation shall be installed in accordance with the manufacturers written instructions and in accordance with recognized industry standards. Mechanical fasteners shall be used whenever possible to assure permanent construction. Unsightly work shall be cause for rejection.

B. Materials shall be applied only after surfaces have been tested and thoroughly cleaned of all mill scale, grease and dirt.

C. Non-compressible insulation material shall be installed at hanger supports on cold piping to prevent damage to insulation and vapor barrier. All wet pipe insulation shall be replaced.

D. Insulation of cold surfaces shall be vapor-sealed to prevent condensation.

E. Minimum thickness of insulation shall be as scheduled.

F. Install Pipe Insulation Hanger Shields.

G. Where piping system insulation is specified, cover valves, strainers, unions, flanges, and fittings. Refer to Preformed fitting and valve covers.

H. Extend piping insulation without interruption through walls, floors and similar piping penetrations, there shall be no exceptions.
3.2 APPLICATION TYPES

A. Equipment

E1: Cut insulation to fit contour of equipment, and secure by means of bands or adhesives as required for each individual piece of equipment. Provide vapor barrier and finish as required for each specific application. Provide new cold surfaces of pumps with accessible boxes that easily separate coincidental with parting line of evaporator heads and pump casings. Resulting insulation joints shall be covered with a self-sealing, vapor-barrier tape. Seal all laps and penetrations in vapor barrier jacket with an approved vapor barrier mastic.

B. Piping

P1: Butt insulation together and securely tape. Install factory-furnished laps at the butt joints. Neatly bevel and finish insulation where it terminates. Use of double tape self-sealing adhesives systems will negate requirements for staples.

P2: Butt insulation together and securely tape. Install factory-furnished laps at the butt joints. Neatly bevel and finish insulation where it terminates. Seal all laps and penetrations in vapor barrier jacket with an approved vapor barrier mastic.

P3: Same as P2, except install insulation over heat trace tape. Finish with metal jacket.

3.3 INSULATION SCHEDULE KEYS

<table>
<thead>
<tr>
<th>Insulation Types Key</th>
<th>Type</th>
<th>Maximum K Factor @ 75°F</th>
<th>Temp. Limit °F</th>
<th>Density Lb. Per Cubic Foot</th>
<th>Federal Spec. Compliance</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Calcium Silicate</td>
<td>0.38</td>
<td>1200</td>
<td>14</td>
<td>HH-I-523C</td>
<td></td>
</tr>
<tr>
<td>2. Fiberglass (Rigid)</td>
<td>0.23</td>
<td>450</td>
<td>3</td>
<td>ASTM C 547 Type 1</td>
<td></td>
</tr>
<tr>
<td>3. Foamed Glass (Cellular)</td>
<td>0.36</td>
<td>850</td>
<td>9</td>
<td>HH-I-1751/3A</td>
<td></td>
</tr>
<tr>
<td>4. Foamed Plastic (Flexible)</td>
<td>0.25</td>
<td>220</td>
<td>5</td>
<td>HH-I-573</td>
<td></td>
</tr>
<tr>
<td>5. Insulating Cement</td>
<td>0.7</td>
<td>1700</td>
<td></td>
<td>SS-C-160</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Finishes Key</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>F1.</td>
<td>8-ounce glass cloth</td>
</tr>
<tr>
<td>F2.</td>
<td>Insulation cement</td>
</tr>
<tr>
<td>F3.</td>
<td>0.016 aluminum, plain, up through 12&quot; pipe size; 0.016 aluminum, corrugated, for pipe sizes 14&quot; and larger</td>
</tr>
<tr>
<td>F4.</td>
<td>White all-service jacket (vapor barrier) with self-sealing lap, or taped joints</td>
</tr>
<tr>
<td>F5.</td>
<td>Two coats vinyl lacquer type white paint</td>
</tr>
</tbody>
</table>
3.4 EQUIPMENT AND PIPING INSULATION SCHEDULES

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 unless there is a potential for personnel injury.

1. Drainage piping located in crawl spaces.
2. Underground piping.
3. Chrome-plated pipes and fittings.

C. Fitting and Valve Covers:

1. Fitting covers shall be of preformed PVC for indoor service and metal for outdoor service.
2. Insulation material shall be rigid and of the same or greater material type and thickness, density and conductivity as the adjoining pipe. Blanket inserts will not be allowed.
3. Field fabricated fitting covers of same or similar material as pipe covering with preformed rigid inserts as specified in paragraph 1 above

D. Exposed piping for ADA compliant lavatories shall be provided with premanufactured covers complying with ASTM E-84 for P-traps, waste piping and angle stop valves.
## EQUIPMENT AND PIPING INSULATION SCHEDULE

<table>
<thead>
<tr>
<th>INSULATION TYPE</th>
<th>THICKNESS</th>
<th>APPLICATION TYPE</th>
<th>INDOOR CONCEALED</th>
<th>INDOOR EXPOSED</th>
<th>OUTDOOR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Domestic cold water; bottom of roof drains and overflow drains; horizontal storm drains and overflow drains within building; waste piping conveying cooling coil condensate; waste from chilled drinking water fountains.</td>
<td>Indoor: 2</td>
<td>1&quot;</td>
<td>P2 F4</td>
<td>F4</td>
<td>--</td>
</tr>
<tr>
<td></td>
<td>Outdoor: 2</td>
<td>1&quot;</td>
<td>[P2][P3]</td>
<td>--</td>
<td>F4 &amp; F3</td>
</tr>
<tr>
<td>Domestic hot water supply &amp; recirculation.</td>
<td>Indoor: 2</td>
<td>Note 1</td>
<td>P1 F4</td>
<td>F4</td>
<td>--</td>
</tr>
<tr>
<td>Domestic water pumps.</td>
<td>Indoor: [2] [3] [4]</td>
<td>2&quot;</td>
<td>E1</td>
<td>--</td>
<td>[F1] [F2] [F3] [F5] [F3] [F5]</td>
</tr>
<tr>
<td>Domestic water storage tank</td>
<td>Indoor: 2</td>
<td>1 1/2&quot;</td>
<td>E1</td>
<td>--</td>
<td>F2 &amp; F1 F4 &amp; F3</td>
</tr>
<tr>
<td>Medical Vacuum pump exhaust piping</td>
<td>Indoor: 1</td>
<td>2&quot;</td>
<td>P1</td>
<td>--</td>
<td>F2</td>
</tr>
</tbody>
</table>

* Provide insulation where piping is heat traced.

** Refer to insulation types and finishes keys.

*** Table does not apply to factory insulated equipment.

Note 1 – See “Domestic Hot Water Pipe Insulation Thickness” table below.

### DOMESTIC HOT WATER PIPE INSULATION THICKNESS

<table>
<thead>
<tr>
<th>SUPPLY WATER TEMP °F</th>
<th>NON-CIRCULATING RUNOUTS UP TO 1&quot;</th>
<th>CIRCULATING MAINS AND BRANCHES</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>UP TO 1 1/4&quot;</td>
<td>1 1/2&quot; &amp; 2&quot;</td>
</tr>
<tr>
<td>170-180</td>
<td>1&quot;</td>
<td>1&quot;</td>
</tr>
<tr>
<td>140-160</td>
<td>1&quot;</td>
<td>1&quot;</td>
</tr>
<tr>
<td>100-130</td>
<td>1&quot;</td>
<td>1&quot;</td>
</tr>
</tbody>
</table>

**Note:**

1. The above table is only applicable to insulations in the conductivity range of 0.23 to 0.25. For insulation outside these conductivity ranges, the minimum thickness (T) shall be determined by the following calculation and the calculation submitted for approval:

\[
T = r \left( \frac{(1+t/r)^K/k - 1} \right)
\]

where

- \( T \) = Thickness
- \( r \) = Actual outside radius of pipe (in.)
- \( t \) = Insulation thickness per the above table
- \( K \) = Conductivity of alternate material
- \( k \) = Upper value of the Conductivity Range per the above table
END OF SECTION
SECTION 221116
DOMESTIC WATER PIPING

PART 1 - GENERAL

1.1 SUMMARY
A. Provide piping, valves, fittings and related products as listed on Drawings and described herein.

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

C. Related Section:
   1. Division 22 Section "Meters and Gages for Plumbing Piping" for thermometers, pressure gages, and fittings.
   2. Division 22 Section "Domestic Water Piping Specialties" for water distribution piping specialties.

1.2 PERFORMANCE REQUIREMENTS
A. Provide components and installation capable of producing domestic water piping systems with 80 psig, unless otherwise indicated.

1.3 SUBMITTALS
A. Product Data: For pipe, tube, fittings, and couplings.
C. Field quality-control test reports.

1.4 QUALITY ASSURANCE
A. Piping materials shall bear label, stamp, or other markings of specified testing agency.
B. Comply with NSF 61 and NSF 372 for potable domestic water piping and components.
1.5 PROJECT CONDITIONS

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

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

PART 2 - PRODUCTS

2.1 COPPER TUBE AND FITTINGS

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

4. Copper Unions: MSS SP-123, cast-copper-alloy, hexagonal-stock body, with ball-and-socket, metal-to-metal seating surfaces, and solder-joint or threaded ends.

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


2.2 DUCTILE-IRON PIPE AND FITTINGS

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

1. Standard-Pattern, Mechanical-Joint Fittings: AWWA C110, ductile or gray iron.

2.3 PIPING JOINING MATERIALS

A. Pipe-Flange Gasket Materials: AWWA C110, rubber, flat face, 1/8 inch thick or ASME B16.21, nonmetallic and asbestos free, unless otherwise indicated; 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. Include water-flushable flux according to ASTM B 813.

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

2.4 ENCASEMENT FOR PIPING

A. Standard: ASTM A 674 or AWWA C105.

B. Form: Sheet or Tube.

C. Material: LLDPE film of 0.008-inch minimum thickness or high-density, cross-laminated PE film of 0.004-inch minimum thickness.

D. Color: Black.

2.5 SPECIALTY VALVES

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

B. Comply with requirements in Division 22 Section "Domestic Water Piping Specialties" for balancing valves, drain valves, backflow preventers, and vacuum breakers.

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. Sleeve-Type Transition Coupling: AWWA C219.

1. Manufacturers:

   a. Cascade Waterworks Manufacturing.
   b. Dresser, Inc.; Dresser Piping Specialties.
   c. Ford Meter Box Company, Inc. (The).
   d. JCM Industries.
   e. Romac Industries, Inc.
   f. Smith-Blair, Inc; a Sensus company.
   g. Viking Johnson; c/o Mueller Co.
2.7 DIELECTRIC FITTINGS

A. General Requirements: Assembly of copper alloy and ferrous materials or ferrous material body with separating nonconductive insulating material suitable for system fluid, pressure, and temperature.

B. Dielectric Unions:

1. Manufacturers:
   a. EPCO Sales, Inc.
   c. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
   d. Zurn Plumbing Products Group; Wilkins Water Control Products.

2. Description:
   a. Pressure Rating: 150 psig at 180 deg F.
   b. End Connections: Solder-joint copper alloy and threaded ferrous.

C. Dielectric-Flange Kits:

1. Manufacturers:
   a. Advance Products & Systems, Inc.
   b. Calpico, Inc.
   c. Central Plastics Company.
   d. Pipeline Seal and Insulator, Inc.

2. Description:
   a. Nonconducting materials for field assembly of companion flanges.
   b. Pressure Rating: 150 psig (1035 kPa).
   c. Gasket: Neoprene or phenolic.
   d. Bolt Sleeves: Phenolic or polyethylene.
   e. Washers: Phenolic with steel backing washers.

D. Dielectric Couplings:

1. Manufacturers:
   a. Calpico, Inc.
   b. Lochinvar Corporation.

2. Description:
   a. Galvanized-steel coupling.
   b. Pressure Rating: 300 psig at 225 deg F.
   c. End Connections: Female threaded.
   d. Lining: Inert and noncorrosive, thermoplastic.

E. Dielectric Nipples:
1. **Manufacturers:**
   a. Perfection Corporation; a subsidiary of American Meter Company.
   b. Precision Plumbing Products, Inc.
   c. Victaulic Company.

2. **Description:**
   a. Copper-Silicon nipple complying with ASTM F 1545.
   b. Pressure Rating: 300 psig at 225 deg F (107deg C).
   c. End Connections: Male threaded or grooved.

**PART 3 - EXECUTION**

3.1 **EARTHWORK**
   A. Comply with requirements in Division 31 Section "Earth Moving" for excavating, trenching, and backfilling.

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

   B. Install copper tubing under building slab according to CDA's "Copper Tube Handbook."

   C. Install ductile-iron piping under building slab with restrained joints according to AWWA C600 and AWWA M41.

   D. Install underground ductile-iron pipe in PE encasement according to ASTM A 674 or AWWA C105.

   E. Install shutoff valve, hose-end drain valve, strainer and pressure gage inside the building at each domestic water service entrance. Comply with requirements in Division 22 Section "Meters and Gages for Plumbing Piping" for pressure gages and Division 22 Section "Domestic Water Piping Specialties" for drain valves and strainers.

   F. Install domestic water piping level with 0.25 percent slope downward toward drain and plumb.

   G. Install seismic restraints on piping. Comply with requirements in Division 22 Section "Vibration and Seismic Controls for Plumbing Piping and Equipment" for seismic-restraint devices.
H. Install piping concealed from view and protected from physical contact by building occupants unless otherwise indicated and except in equipment rooms and service areas.

I. 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.

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

K. Install piping adjacent to equipment and specialties to allow service and maintenance.

L. Install piping to permit valve servicing.

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

N. Install piping free of sags and bends.

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

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

Q. Install pressure gages on suction and discharge piping from each plumbing pump and packaged booster pump. Comply with requirements in Division 22 Section "Meters and Gages for Plumbing Piping" for pressure gages.

R. Install thermometers on inlet and outlet piping from each water heater. Comply with requirements in Division 22 Section "Meters and Gages for Plumbing Piping" for thermometers.

S. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Division 22 Section "Common Work Results for Plumbing."

T. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Division 22 Section "Common Work Results for Plumbing."

3.3 JOINT CONSTRUCTION

A. Ream ends of pipes and tubes and remove burrs.

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

C. Brazed Joints: Join copper tube and fittings according to CDA's "Copper Tube Handbook," "Brazed Joints" Chapter.
D. Soldered Joints: 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."

E. Pressure-Sealed Joints:
   1. Use manufacturer-recommended tool and procedure. Leave insertion marks on pipe after assembly.
   2. Sealing element shall be verified for the intended use.
   3. Tube ends shall be cut on a right angle (square) to the tube.
   4. Tube ends shall be reamed and chamfered, all grease, oil or dirt shall be removed from the tube end with a clean rag.
   5. Visually examine the fitting sealing element to ensure there is no damage, and it is properly seated into the fitting.
   6. Utilizing an Insertion Depth Inspection Gauge mark the tube wall, with a felt tip pen, at the appropriate location, or insert the tube fully into the fitting and mark the tube wall at the face of the fitting.
   7. Always examine the tube to ensure it is fully inserted into the fitting prior to pressing the joint.
   8. Pressure-seal fittings ½-inch thru 4-inch shall be joined using appropriate sized tools.
   9. Pressure-seal fittings shall be installed according to the most current edition of the Manufacturer's installation guidelines.

F. 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.

G. Dissimilar-Material Piping Joints: Make joints using adapters compatible with materials of both piping systems and provide Dielectric isolator.

3.4 VALVE INSTALLATION

A. General-Duty Valves: Comply with requirements in Division 22 Section "General-Duty Valves for Plumbing Piping" for valve installations.

B. Install shutoff valve close to water main on each branch and riser serving plumbing fixtures or equipment, on each water supply to equipment, and on each water supply to plumbing fixtures that do not have supply stops. Use ball valves for piping NPS 2 and smaller. Use butterfly valves for piping NPS 2-1/2 and larger.

C. Install hose end drain valves for equipment at base of each water riser, at low points in horizontal piping, and where required to drain water piping. Drain valves are specified in Division 22 Section "Domestic Water Piping Specialties."

D. Install automatic balancing valves in each hot-water circulation return branch. Comply with requirements in Division 22 Section "Domestic Water Piping Specialties" for automatic balancing valves.

E. Install automatic balancing valves with a strainer upstream and a check valve immediately downstream.
3.5 TRANSITION FITTING INSTALLATION
   A. Install transition couplings at joints of dissimilar piping.
   B. Transition Fittings in Underground Domestic Water Piping:
      1. NPS 2 and Larger: Sleeve-type coupling.

3.6 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 couplings, nipples or unions.
   C. Dielectric Fittings for NPS 2-1/2: Use dielectric flange kits.

3.7 HANGER AND SUPPORT INSTALLATION
   A. Comply with requirements in Division 22 Section "Hangers and Supports for Plumbing Piping and Equipment" for pipe hanger and support products and installation.

3.8 CONNECTIONS
   A. Drawings indicate general arrangement of piping, fittings, and specialties.
   B. Install piping adjacent to equipment and machines to allow service and maintenance.
   C. Connect domestic water piping to exterior water-service piping. Use transition fitting to join dissimilar piping materials.

3.9 IDENTIFICATION
   A. Identify system components. Comply with requirements in Division 22 Section "Identification for Plumbing Piping and Equipment" for identification materials and installation.

3.10 FIELD QUALITY CONTROL
   A. Perform tests and inspections.
   B. Piping Inspections:
      1. Do not enclose, cover, or put piping into operation until it has been inspected and approved by authorities having jurisdiction.
2. 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:
   
a. Roughing-in Inspection: Arrange for inspection of piping before concealing or closing-in after roughing-in and before setting fixtures.
   b. Final Inspection: Arrange final inspection for authorities having jurisdiction to observe tests specified below and to ensure compliance with requirements.

3. Reinspection: If authorities having jurisdiction find that piping will not pass tests or inspections, make required corrections and arrange for reinspection.

4. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.

C. Piping Tests:

1. Fill domestic water piping. Check components to determine that they are not air bound and that piping is full of water.
2. 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.
3. 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.
4. 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.
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 for corrective action required.

D. Perform the following tests on pressure-seal piping:

1. After fittings have been installed a “two step test” shall be followed.
   a. Pressurize the system with application appropriate test medium, water between 15 and 85 psi, or air/dry nitrogen between .5 and 45 psi.
   b. Check the pressure gauge for pressure loss.
   c. If the system does not hold pressure, walk the system and check for un-pressed fittings.
   d. Should an un-pressed fitting/s be identified, ensure the tube is fully inserted into the fitting, and properly marked, prior to pressing the joint.
   e. After appropriate repairs have been made, retest the system per local code, or specification requirements, not to exceed 600 psi with water.

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

F. Prepare test and inspection reports.
3.11 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. Remove plugs used during testing of piping and for temporary sealing of piping during installation.
5. Remove and clean strainer screens. Close drain valves and replace drain plugs.
6. Check plumbing specialties and verify proper settings, adjustments, and operation.

3.12 CLEANING

A. Clean and disinfect potable and 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 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. Submit water samples for testing in sterile bottles to authorities having jurisdiction. Repeat procedures if biological examination shows contamination.

3.13 PIPING SCHEDULE

A. Transition and special fittings with pressure ratings at least equal to piping rating may be used in applications below unless otherwise indicated.

B. Flanges and unions may be used for aboveground piping joints unless otherwise indicated.

C. Under-building-slab, domestic water, building-service entrance piping, NPS 8 and smaller, shall be the following:
1. Mechanical-joint, ductile-iron pipe; standard-pattern mechanical-joint fittings; and mechanical joints.

D. Under-building-slab, domestic water piping, NPS 2 and smaller, shall be the following:

1. Soft copper tube, ASTM B 88, Type k; No joints below grade.

E. Aboveground domestic water piping, NPS 2 and smaller, shall be one of the following:

1. Hard copper tube, ASTM B 88, Type L ASTM B 88; cast- or wrought- copper solder-joint fittings; and soldered joints.
2. Hard copper tube, ASTM B 88, Type L; copper pressure-seal fittings; and pressure-seal joints.

F. Aboveground domestic water piping, NPS 2 1/2 and larger, shall be one of the following:

1. Hard copper tube, ASTM B 88, Type L ASTM B 88; cast- or wrought- copper solder-joint fittings; and soldered joints.
2. Hard copper tube, ASTM B 88, Type L; grooved-joint copper-tube appurtenances; and grooved joints.

G. Non-Potable-Water Piping: Use same materials as domestic water piping

3.14 VALVE SCHEDULE

A. Drawings indicate valve types to be used. Where specific valve types are not indicated, the following requirements apply:

1. Shutoff Duty: Use ball valves for piping NPS 2 and smaller. Use butterfly valves with flanged ends for piping NPS 2-1/2 and larger.
2. Throttling Duty: Use ball valves for piping NPS 2 and smaller. Use butterfly valves with flanged ends for piping NPS 2-1/2 and larger.

B. Use check valves to maintain correct direction of domestic water flow to and from equipment.

END OF SECTION
SECTION 221119
DOMESTIC WATER PIPING SPECIALTIES

PART 1 - GENERAL

1.1 SUMMARY

A. Provide plumbing fixtures and drains as listed on Drawings and described herein.

B. This Section includes the following domestic water piping specialties:

1. Vacuum breakers.
2. Backflow preventers.
5. Thermostatic mixing valves.
7. Outlet boxes.
8. Hose bibbs.
9. Wall hydrants.
10. Ground hydrants.
11. Drain valves.
12. Water hammer arresters.
13. Air vents.
15. Electrical trap-seal primer systems.

C. Related Sections include the following:

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

1.2 PERFORMANCE REQUIREMENTS

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

1.3 SUBMITTALS

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

B. Shop Drawings: Diagram power, signal, and control wiring.

C. Field quality-control test reports.

D. Operation and Maintenance Data: For domestic water piping specialties to include operation, and maintenance manuals.
1.4 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. NSF Compliance:
   2. Comply with NSF 61, "Drinking Water System Components - Health Effects; Sections 1 through 9."
   3. NSF Compliance: NSF 61-G for valve materials for potable-water service.

PART 2 - PRODUCTS

2.1 VACUUM BREAKERS

A. Pipe-Applied, Atmospheric-Type Vacuum Breakers:
   1. Manufacturers:
      a. Conbraco Industries, Inc.
      b. FEBCO; SPX Valves & Controls.
      d. Zurn Plumbing Products Group; Wilkins Div.
   3. Size: NPS 1/4 to NPS 3, as required to match connected piping.
   5. Inlet and Outlet Connections: Threaded.
   6. Finish: Chrome plated.

B. Hose-Connection Vacuum Breakers:
   1. Manufacturers:
      a. Conbraco Industries, Inc.
      b. MIFAB, Inc.
      d. Woodford Manufacturing Company.
      e. Zurn Plumbing Products Group.
   5. Finish: Chrome or Rough bronze.

C. Pressure Vacuum Breakers:
   1. Manufacturers:
a. Conbraco Industries, Inc.
b. FEBCO; SPX Valves & Controls.
d. Zurn Plumbing Products Group; Wilkins Div.
e. Beeco, LLC.

3. Operation: Continuous-pressure applications.
4. Pressure Loss: 5 psig maximum, through middle 1/3 of flow range.
5. Accessories:
   a. Valves: Ball type, on inlet.

D. Laboratory-Faucet Vacuum Breakers:
   1. Manufacturers:
      a. Conbraco Industries, Inc.
      c. Woodford Manufacturing Company.
      d. Zurn Plumbing Products Group; Wilkins Div.

   5. End Connections: Threaded.
   6. Finish: Chrome plated.

E. Spill-Resistant Vacuum Breakers:
   1. Manufacturers:
      a. Conbraco Industries, Inc.

   3. Operation: Continuous-pressure applications.
   4. Accessories:
      a. Valves: Ball type, on inlet.

2.2 BACKFLOW PREVENTERS

A. Intermediate Atmospheric-Vent Backflow Preventers:
   1. Manufacturers:
      a. Conbraco Industries, Inc.
      b. FEBCO; SPX Valves & Controls.
      c. Honeywell Water Controls.
      e. Zurn Plumbing Products Group; Wilkins Div.
2. Standard: ASSE 1012.
3. Operation: Continuous-pressure applications.
5. End Connections: Union or solder joint.

B. Reduced-Pressure-Principle Backflow Preventers:

1. Manufacturers:
   a. Conbraco Industries, Inc.
   b. FEBCO; SPX Valves & Controls.
   d. Zurn Plumbing Products Group; Wilkins Div.
   e. Beeco, LLC.

3. Operation: Continuous-pressure applications.
4. Pressure Loss: 12 psig maximum, through middle 1/3 of flow range.
5. Body: Bronze for NPS 2 and smaller; cast iron with interior lining complying with AWWA C550 or that is FDA approved or steel with interior lining complying with AWWA C550 or that is FDA approved for NPS 2-1/2 and larger.
6. End Connections: Threaded for NPS 2 and smaller; flanged for NPS 2-1/2 and larger.
7. Configuration: Designed for horizontal, straight through flow.
8. Accessories:
   a. Valves: Ball type with threaded ends on inlet and outlet of NPS 2 and smaller; rising stem gate valve with flanged ends on inlet and outlet of NPS 2-1/2 and larger.

2.3 WATER PRESSURE-REDUCING VALVES

A. Water Pressure Regulators:

1. Manufacturers:
   a. Conbraco Industries, Inc.
   b. Honeywell Water Controls.
   d. Zurn Plumbing Products Group; Wilkins Div.
   e. Beeco, LLC.

4. Body: Bronze for NPS 2 and smaller; cast iron with interior lining complying with AWWA C550 or that is FDA approved for NPS 2-1/2 and NPS 3.
6. End Connections: Threaded for NPS 2 and smaller; flanged for NPS 2-1/2 and NPS 3.

B. Water Control Valves:

1. Manufacturers:
   a. CLA-VAL Automatic Control Valves.
   b. OCV Control Valves.
   c. Watts Industries, Inc.; Watts ACV.
   d. Zurn Plumbing Products Group; Wilkins Div.
   e. Beeco, LLC.

2. Description: Pilot-operation, 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. Pattern: Angle or Globe-valve design.
   b. Trim: Stainless steel.

5. End Connections: Threaded for NPS 2 and smaller; flanged for NPS 2-1/2 and larger.

2.4 BALANCING VALVES

A. Automatic Balancing Valves:

1. Manufacturers:
   b. Griswold Controls

2. Type: Ball valve with two readout ports and stainless steel flow regulating cartridge.


4. Size: Same as connected piping, but not larger than NPS 2.

5. Pressure Rating: 400-psig minimum CWP.


7. Seats and Seals: Replaceable.

8. End Connections: Solder joint or threaded.


10. Accuracy: plus or minus 5%

2.5 THERMOSTATIC MIXING VALVES

A. Thermostatic, Water Mixing Valves:
1. Manufacturers:
   a. Armstrong International, Inc. (RADA)
   b. Lawler Manufacturing Company, Inc.
   c. Leonard Valve Company.
   d. Powers; a Watts Industries Co.
   e. Symmons Industries, Inc.


4. Type: Exposed-mounting, thermostatically controlled water mixing valve.

5. Material: Bronze body with corrosion-resistant interior components.

6. Connections: Threaded or union inlets and outlet.

7. Accessories: Manual temperature control, check stops on hot- and cold-water supplies, and adjustable, temperature-control handle.

8. Valve Pressure Rating: 125 psig minimum, unless otherwise indicated.


B. Individual-Fixture, Water Tempering Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Leonard Valve Company.
   b. Powers.
   c. Watts; a Watts Water Technologies company.
   d. Zurn Industries, LLC.

2. Standard: ASSE 1016 and 1070, thermostatically controlled, water tempering valve.

3. Pressure Rating: 125 psig minimum unless otherwise indicated.


5. Temperature Control: Adjustable.

6. Inlets and Outlet: Threaded.

7. Finish: Rough or chrome-plated bronze.

2.6 STRainers FOR DOMESTIC WATER PIPING

A. Y-Pattern Strainers:

1. Pressure Rating: 125 psig minimum, unless otherwise indicated.

2. Body: Bronze for NPS 2 and smaller; cast iron with interior lining complying with AWWA C550 or FDA-approved, epoxy coating for NPS 2-1/2 and larger.

3. End Connections: Threaded for NPS 2 and smaller; flanged for NPS 2-1/2 and larger.

4. Screen: Stainless steel with round perforations, unless otherwise indicated.

5. Perforation Size:
   a. Strainers NPS 2 and Smaller: 0.020 inch.
   b. Strainers NPS 2-1/2 to NPS 4: 0.045 inch.
   c. Strainers NPS 5 and Larger: 0.10 inch.
6. **Drain:** Factory-installed, hose-end drain valve.

2.7 **OUTLET BOXES**

A. **Clothes Washer Outlet Boxes:**

1. **Manufacturers:**
   b. Guy Gray Manufacturing Co., Inc.
   c. IPS Corporation. (Guy Gray)
   d. Oatey.
   e. Symmons Industries, Inc.
   g. Whitehall Manufacturing; a div. of Acorn Engineering Company.
   h. Zurn Plumbing Products Group.

2. **Mounting:** Recessed.
3. **Material and Finish:** Epoxy-painted-steel 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 ball valves and NPS 1/2 copper, water tubing.
6. **Drain:** NPS 2 standpipe and P-trap for direct waste connection to drainage piping.

B. **Icemaker Outlet Boxes:**

1. **Manufacturers:**
   b. IPS Corporation. (Guy Gray)
   c. Oatey.

2. **Mounting:** Recessed.
3. **Material and Finish:** Epoxy-painted-steel box and faceplate.
4. **Faucet:** Valved fitting complying with ASME A112.18.1. Include NPS 1/2 or smaller copper tube outlet.
5. **Supply Shutoff Fitting:** NPS 1/2 ball valve and NPS 1/2 copper, water tubing.

2.8 **HOSE BIBBS**

A. **Hose Bibbs:**

1. **Standard:** ASME A112.18.1 for faucets.
2. **Body Material:** Bronze.
3. **Seat:** Bronze, replaceable.
4. **Supply Connections:** 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.
8. Refer to Plumbing Fixture Schedule on drawings for finishes.

2.9 WALL HYDRANTS

A. Nonfreeze Wall Hydrants:

1. Manufacturers:
   b. MIFAB, Inc.
   d. Tyler Pipe; Wade Div.
   e. Watts Drainage Products Inc.
   f. Woodford Manufacturing Company.
   g. Zurn Plumbing Products Group.

4. Operation: Loose key.
5. Casing and Operating Rod: Of length required to match wall thickness. Include wall clamp.
6. Inlet: NPS 3/4 [or NPS 1].
7. Outlet: Concealed, with integral vacuum breaker and garden-hose thread complying with ASME B1.20.7.
8. Box: Deep, flush mounting with cover.
10. Operating Keys(s): One with each wall hydrant.
11. Refer to Plumbing Fixture Schedule on drawings for finishes.

2.10 DRAIN VALVES

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

2. Pressure Rating: 400-psig minimum CWP.
3. Body: Copper alloy.
4. Ball: Chrome-plated brass.
5. Seats and Seals: Replaceable.
7. Inlet: Threaded or solder joint.
8. Outlet: Threaded, short nipple with garden-hose thread complying with ASME B1.20.7 and cap with brass chain.

2.11 WATER HAMMER ARRESTERS

A. Water Hammer Arresters:
1. Manufacturers:
   b. MIFAB, Inc.
   c. PPP Inc.
   d. Sioux Chief Manufacturing Company, Inc.
   e. Tyler Pipe; Wade Div.
   f. Watts Drainage Products Inc.
   g. Zurn Plumbing Products Group.

3. Type: Copper tube with piston.
4. Size: ASSE 1010, Sizes AA and A through F or PDI-WH 201, Sizes A through F.

2.12 AIR VENTS

A. Bolted-Construction Automatic Air Vents:
   1. Body: Bronze.
   2. Pressure Rating: 125-psig minimum pressure rating at 140 deg F.
   3. Float: Replaceable, corrosion-resistant metal.
   5. Inlet and Vent Outlet End Connections: Threaded.

B. Welded-Construction Automatic Air Vents:
   2. Pressure Rating: 150-psig minimum pressure rating.
   3. Float: Replaceable, corrosion-resistant metal.
   5. Inlet and Vent Outlet End Connections: Threaded.

2.13 TRAP-SEAL PRIMER VALVES

A. Supply-Type, Trap-Seal Primer Valves:
   1. Manufacturers:
      a. MIFAB, Inc.
      b. PPP Inc.
      c. Sioux Chief Manufacturing Company, Inc.
      e. Watts Industries, Inc.; Water Products Div.

   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. Distribution box as required.
8. Finish: Chrome plated, or rough bronze for units used with pipe or tube that is not chrome finished.

2.14 ELECTRIC TRAP-SEAL PRIMER SYSTEMS

A. Electric Trap-Seal Primer Systems:

1. Manufacturers:
   a. PPP Inc.
   b. MIFAB, Inc.

2. Standard: ASSE 1044,
3. Piping: NPS 3/4, ASTM B 88, Type L; copper, water tubing.
5. Electric Controls: 24-hour timer, solenoid valve, and manual switch for 120-V ac power.
7. Number Outlets: as indicated on drawings.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Refer to Division 22 Section "Common Work Results for Plumbing" for piping joining materials, joint construction, and basic installation requirements.

B. Install backflow preventers in each water supply to mechanical equipment and systems and to other equipment and water systems that may be sources of contamination. Comply with authorities having jurisdiction.

   1. Install drain for backflow preventers with atmospheric-vent drain connection with air-gap fitting, fixed air-gap fitting, or equivalent positive pipe separation of at least two pipe diameters in drain piping and pipe to floor drain. Locate air-gap device attached to or under backflow preventer. Simple air breaks are not acceptable for this application.
   2. Do not install bypass piping around backflow preventers.

C. Install water pressure regulators with inlet and outlet shutoff valves and bypass with memory-stop balancing valve. Install pressure gages on inlet and outlet.

D. Install water control valves with inlet and outlet shutoff valves and bypass with globe valve. Install pressure gages on inlet and outlet.

E. Install balancing valves in locations where they can easily be adjusted.

F. Install thermostatic mixing valves with check stops or shutoff valves and strainers on inlets and with shutoff valve on outlet.

   1. Install thermometers on inlets and outlet and water regulators if specified.
2. Install cabinet-type units recessed in or surface mounted on wall as specified.

G. Install Y-pattern strainers for water on supply side of each control valve, water pressure-reducing valve, solenoid valve, and pump.

H. Install outlet boxes recessed in wall. Install 2-by-4-inch fire-retardant-treated-wood blocking wall reinforcement between studs. Fire-retardant-treated-wood blocking is specified in Division 06 Section "Rough Carpentry."

I. Install water hammer arresters in water piping according to PDI-WH 201 and drawings.

J. Install air vents at high points of water piping. Install drain piping and discharge to floor drain.

K. 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.

L. Install electric 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. Piping installation requirements are specified in other Division 22 Sections. Drawings indicate general arrangement of piping and specialties.

B. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

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

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.
5. Pressure-reducing valves.
6. Automatic balancing valves.
7. Thermostatic mixing valves.
10. Supply-type, trap-seal primer valves.
11. Electric 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 Division 22 Section "Identification for Plumbing Piping and Equipment."

3.4 FIELD QUALITY CONTROL

A. Perform the following tests and prepare test reports:

1. Test each pressure vacuum breaker reduced-pressure-principle backflow preventer, double-check backflow-prevention assembly and vacuum breaker assembly according to authorities having jurisdiction and the device's reference standard.

B. Remove and replace malfunctioning domestic water piping specialties and retest as specified above.

3.5 ADJUSTING

A. Set field-adjustable pressure set points of water pressure-reducing valves.

B. Confirm flow rate and direction of flow for automatic balancing valves.

C. Set field-adjustable temperature set points of thermostatic mixing valves.

END OF SECTION
SECTION 221316
SANITARY WASTE AND VENT PIPING

PART 1 - GENERAL

1.1 SUMMARY
A. [Provide piping, valves, fittings and related products as listed on Drawings and described herein.
B. This Section includes the following for soil, waste, and vent piping inside the building:
   1. Pipe, tube, and fittings.
C. Related Sections include the following:
   1. Division 22 Section "Sanitary Sewerage Pumps."
   2. Division 22 Section "Chemical Waste Systems for Laboratory and Healthcare Facilities" for chemical-waste and vent piping systems.
   3. Division 31 Section "Earth Moving" for excavating, trenching, and backfilling.

1.2 DEFINITIONS
A. EPDM: Ethylene-propylene-diene terpolymer rubber.
B. LLDPE: Linear, low-density polyethylene plastic.
C. NBR: Acrylonitrile-butadiene rubber.
D. PE: Polyethylene plastic.
E. PVC: Polyvinyl chloride plastic.
F. TPE: Thermoplastic elastomer.

1.3 PERFORMANCE REQUIREMENTS
A. Components and installation shall be capable of withstanding the following minimum working pressure, unless otherwise indicated:

1.4 SUBMITTALS
A. Product Data: For pipe, tube, fittings, and couplings.
B. Shop Drawings:
   1. Sovent Drainage System: Include plans, elevations, sections, and details.
   
   C. Field quality-control inspection and test reports.

1.5 QUALITY ASSURANCE

A. Piping materials shall be American manufactured and bear label, stamp, or other markings of specified testing agency.

B. All cast iron piping and fittings shall be marked with the collective trademark of the Cast Iron Soil Pipe Institute and be listed with NSF international.

C. Comply with NSF 14, "Plastics Piping Systems Components and Related Materials," for plastic piping components. Include marking with "NSF-dwv" for plastic drain, waste, and vent piping; "NSF-drain" for plastic drain piping; "NSF-tubular" for plastic continuous waste piping; and "NSF-sewer" for plastic sewer piping.

PART 2 - PRODUCTS

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

A. Pipe and Fittings: ASTM A 74, Service and Extra-Heavy class.

B. Gaskets: ASTM C 564, rubber.

C. Calking Materials: ASTM B 29, pure lead and oakum or hemp fiber.

2.2 HUBLESS CAST-IRON SOIL PIPE AND FITTINGS

A. Pipe and Fittings: ASTM A 888 or CISPI 301.

B. Shielded Couplings: Assembly of metal shield or housing, corrosion-resistant fasteners, and rubber sleeve with integral, center pipe stop.

   1. Standard, Shielded, Stainless-Steel Couplings: CISPI 310 and ASTM C 1277, with stainless steel corrugated shield; stainless-steel bands and tightening devices; and ASTM C 564, rubber sleeve & bear the NSF Trademark.

      a. Manufacturers:

         1) ANACO.
         2) Mission Rubber Co.
         3) Tyler Pipe; Soil Pipe Div.

a. Manufacturers:
   1) Clamp-All Corp.
   2) Anaco/Husky Technologies

3. Heavy-Duty, Shielded, Cast-Iron Couplings: ASTM A 48/A 48M, two-piece, cast-iron housing; stainless-steel bolts and nuts; and ASTM C 564, rubber sleeve.
   a. Manufacturers:
      1) MG Piping Products Co.

2.3 STEEL PIPE AND FITTINGS

A. Steel Pipe: ASTM A 53/A 53M, Type E or S, Grade A or B, Standard Weight or Schedule 40, galvanized. Include ends matching joining method.

B. Drainage Fittings: ASME B16.12, threaded, cast-iron drainage pattern.

C. Pressure Fittings:

D. Grooved-Joint Systems:
   1. Manufacturers:
      a. Anvil International.
      b. Victaulic Company.
   2. Grooved-End, Steel-Piping Fittings: ASTM A 47/A 47M, malleable-iron casting; ASTM A 106, galvanized-steel pipe; or ASTM A 536, ductile-iron casting; with dimensions matching steel pipe.
   3. Grooved-End, Steel-Piping Couplings: AWWA C606, for steel-pipe dimensions. Include ferrous housing sections, gasket suitable for water, and bolts and nuts.

2.4 STAINLESS-STEEL PIPE AND FITTINGS

A. Pipe and Fittings: ASME A112.3.1, drainage pattern with socket and spigot ends.

B. Gaskets: Lip seals shaped to fit socket groove, with plastic backup ring.
1. Material: EPDM, unless NBR is indicated.

2.5 DUCTILE-IRON PIPE AND FITTINGS

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

1. Mechanical-Joint, Ductile-Iron Fittings: AWWA C110, ductile- or gray-iron standard pattern or AWWA C153, ductile-iron compact pattern.

2. Glands, Gaskets, and Bolts: AWWA C111, ductile- or gray-iron glands, rubber gaskets, and steel bolts.

B. Grooved-Joint Systems:

1. Manufacturers:
   a. Victaulic Company.


3. Grooved-End, Ductile-Iron-Piping Couplings: AWWA C606, for ductile-iron-pipe dimensions. Include ferrous housing sections, gasket suitable for water, and bolts and nuts.

C. Flanges: ASME 16.1, Class 125, cast iron.

2.6 COPPER TUBE AND FITTINGS

A. Copper DWV Tube: ASTM B 306, drainage tube, drawn temper.


B. Hard Copper Tube: ASTM B 88, Types L and M, water tube, drawn temper.


2. Copper Flanges: ASME B16.24, Class 150, cast copper with solder-joint end.

3. Copper Unions: MSS SP-123, copper-alloy, hexagonal-stock body with ball-and-socket, metal-to-metal seating surfaces, and solder-joint or threaded ends.

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

2.7 PVC PIPE AND FITTINGS

A. Solid-Wall PVC Pipe: ASTM D 2665, drain, waste, and vent.

1. PVC Socket Fittings: ASTM D 2665, socket type, made to ASTM D 3311, drain, waste, and vent patterns.

2.8 SPECIAL PIPE FITTINGS

A. Flexible, Nonpressure Pipe Couplings: Comply with ASTM C 1173, elastomeric, sleeve-type, reducing or transition pattern. Include shear ring, ends of same sizes as piping to be joined, and corrosion-resistant-metal tension band and tightening mechanism on each end.

1. Manufacturers:
   b. Fernco, Inc.
   c. Logan Clay Products Company (The).
   d. Mission Rubber Co.
   e. NDS, Inc.

2. Sleeve Materials:
   b. For Plastic Pipes: ASTM F 477, elastomeric seal or ASTM D 5926, PVC.
   c. For Dissimilar Pipes: ASTM D 5926, PVC or other material compatible with pipe materials being joined.

B. Shielded Nonpressure Pipe Couplings: ASTM C 1460, elastomeric or rubber sleeve with full-length, corrosion-resistant outer shield and corrosion-resistant-metal tension band and tightening mechanism on each end.

1. Manufacturers:
   a. Husky
   c. Mission Rubber Co.

2.9 DRIP PANS

A. Of not less than 14-gauge galvanized steel with raised sides and galvanized steel pipe nipple drains welded in place at low points.
PART 3 - EXECUTION

3.1 PIPING APPLICATIONS

A. Flanges and unions may be used on aboveground pressure piping, unless otherwise indicated.

B. PVC piping shall not be used within occupied spaces or plenums of occupied spaces.

C. Aboveground, soil and waste piping shall be any of the following:
   1. Service class, cast-iron soil pipe and fittings; gaskets; and gasketed joints.
   2. Hubless cast-iron soil pipe and fittings; heavy-duty shielded, stainless-steel couplings; and hubless-coupling joints.
   3. Steel pipe, drainage fittings, and threaded joints.
   4. Stainless-steel pipe and fittings, gaskets, and gasketed joints.
   5. Copper DWV tube, copper drainage fittings, and soldered joints.

D. Aboveground, vent piping shall be any of the following:
   1. Service class, cast-iron soil pipe and fittings; gaskets; and gasketed joints.
   2. Hubless cast-iron soil pipe and fittings; heavy-duty shielded, stainless-steel couplings; and hubless-coupling joints.
   3. Steel pipe, drainage fittings, and threaded joints.
   4. Stainless-steel pipe and fittings gaskets, and gasketed joints.
   5. Copper DWV tube, copper drainage fittings, and soldered joints.

E. Underground, soil, waste, and vent piping shall be any of the following:
   1. Extra-Heavy Service class, cast-iron soil piping; gaskets; and gasketed joints.
   2. Stainless-steel pipe and fittings, gaskets, and gasketed joints.
   3. Solid wall PVC pipe, PVC socket fittings, and solvent-cemented joints.

3.2 PIPING INSTALLATION

A. Sanitary sewer piping outside the building is specified in Division 22 Section "Facility Sanitary Sewers."

B. Basic piping installation requirements are specified in Division 22 Section "Common Work Results for Plumbing."

C. Install cleanouts at grade and extend to where building sanitary drains connect to building sanitary sewers.

D. Install cleanout fitting with closure plug inside the building in sanitary force-main piping.

E. Install underground, steel, force-main piping.

F. Install underground, ductile-iron, force-main piping according to AWWA C600.
   Install buried piping inside the building between wall and floor penetrations and
connection to sanitary sewer piping outside the building with restrained joints. Anchor pipe to wall or floor. Install thrust-block supports at vertical and horizontal offsets.

G. Install underground, copper, force-main tubing according to CDA's "Copper Tube Handbook."

H. Install underground, ductile-iron, special pipe fittings according to AWWA C600.

I. Install cast-iron sleeve with water stop and mechanical sleeve seal at each service pipe penetration through foundation wall. Select number of interlocking rubber links required to make installation watertight. Sleeves and mechanical sleeve seals are specified in Division 22 Section "Common Work Results for Plumbing."

J. Make changes in direction for soil and waste drainage and vent piping using appropriate branches, bends, and long-sweep bends. Sanitary tees and short-sweep 1/4 bends may be used on vertical stacks if change in direction of flow is from horizontal to vertical. Use long-turn, double Y-branch and 1/8-bend fittings if 2 fixtures are installed back to back or side by side with common drain pipe. Straight tees, elbows, and crosses may be used on vent lines. Do not change direction of flow more than 90 degrees. Use proper size of standard increasers and reducers if pipes of different sizes are connected. Reducing size of drainage piping in direction of flow is prohibited.

K. Lay buried building drainage piping beginning at low point of each system. Install true to grades and alignment indicated, with unbroken continuity of invert. Place hub ends of piping upstream. Install required gaskets according to manufacturer's written instructions for use of lubricants, cements, and other installation requirements. Maintain swab in piping and pull past each joint as completed.

L. Install soil and waste drainage and vent piping downward in direction of flow at the slopes required by local code or Authorities Having Jurisdiction, unless otherwise indicated on drawings.

M. Install engineered soil and waste drainage and vent piping systems as follows:

2. Reduced-Size Venting: Comply with standards of authorities having jurisdiction.

N. Sleeves are not required for cast-iron soil piping passing through concrete slabs-on-grade if slab is without membrane waterproofing.

O. Install underground PVC soil and waste drainage piping according to ASTM D 2321.

P. Do not enclose, cover, or put piping into operation until it is inspected and approved by authorities having jurisdiction.

Q. Hubless cast-iron piping 6" and larger shall be restrained at any direction change using blocks, rods, bracing or other suitable methods.
R. Provide drip pans under waste lines concealed above operating, cysto and delivery rooms, cath labs, nurseries, food preparation centers, food serving facilities, food storage areas, central services, electronic data processing areas, electric and telecommunication closets, and other sensitive areas, or as shown on the plans. Pans shall be of galvanized steel, arranged to drain outside these areas, or as noted on Drawings.

3.3  JOINT CONSTRUCTION

A. Basic piping joint construction requirements are specified in Division 22 Section "Common Work Results for Plumbing."


C. Join hubless cast-iron soil piping according to CISPI 310 and CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for hubless-coupling joints.

D. 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.

E. Grooved Joints: Assemble joint with keyed coupling, gasket, lubricant, and bolts according to coupling and fitting manufacturer's written instructions.

F. PVC Nonpressure Piping Joints: Join piping according to ASTM D 2665.

3.4  HANGER AND SUPPORT INSTALLATION

A. Pipe hangers and supports are specified in Division 22 Section "Hangers and Supports for Plumbing Piping and Equipment." Install the following:

1. Vertical Piping: MSS Type 8 or Type 42, clamps.
2. Install individual, straight, horizontal piping runs according to the following:

   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. Install supports according to Division 22 Section "Hangers and Supports for Plumbing Piping and Equipment."

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

D. Install supports for vertical cast-iron soil piping every 15 feet.

E. Install supports for vertical steel piping every 15 feet.
F. Install supports for vertical stainless-steel piping every 10 feet.

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

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

3.5 CONNECTIONS

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

B. Connect soil and waste piping to exterior sanitary sewerage piping. Use transition fitting to join dissimilar piping materials.

C. Connect drainage and vent piping to the following:
   1. Plumbing Fixtures: Connect drainage piping in sizes indicated, but not smaller than required by plumbing code.
   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. 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. Connect force-main piping to the following:
   1. Sanitary Sewer: To exterior force main or sanitary manhole.
   2. Sewage Pumps: To sewage pump discharge.

3.6 FIELD QUALITY CONTROL

A. During installation, notify authorities having jurisdiction at least 24 hours before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction.
   1. Roughing-in Inspection: Arrange for inspection of piping before concealing or closing-in after roughing-in and before setting fixtures.
   2. Final Inspection: Arrange for final inspection by authorities having jurisdiction to observe tests specified below and to ensure compliance with requirements.

B. Reinspection: If authorities having jurisdiction find that piping will not pass test or inspection, make required corrections and arrange for reinspection.

C. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.

D. Test sanitary drainage and vent piping according to procedures of authorities having jurisdiction or, in absence of published procedures, as follows:
1. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.

2. Leave uncovered and unconcealed new, altered, extended, or replaced drainage and vent piping until it has been tested and approved. Expose work that was covered or concealed before it was tested.

3. Roughing-in Plumbing Test Procedure: Test drainage and vent piping, except outside leaders, on completion of roughing-in. Close openings in piping system and fill with water to point of overflow, but not less than 10-foot head of water. From 15 minutes before inspection starts to completion of inspection, water level must not drop. Inspect joints for leaks.

4. Finished Plumbing Test Procedure: After plumbing fixtures have been set and traps filled with water, test connections and prove they are gastight and watertight. Plug vent-stack openings on roof and building drains where they leave building. Introduce air into piping system equal to pressure of 1-inch wg. Use U-tube or manometer inserted in trap of water closet to measure this pressure. Air pressure must remain constant without introducing additional air throughout period of inspection. Inspect plumbing fixture connections for gas and water leaks.

5. Repair leaks and defects with new materials and retest piping, or portion thereof, until satisfactory results are obtained.

6. Prepare reports for tests and required corrective action.

3.7 CLEANING

A. Clean interior of piping. Remove dirt and debris as work progresses.

B. Protect drains during remainder of construction period to avoid clogging with dirt and debris and to prevent damage from traffic and construction work.

C. Place plugs in ends of uncompleted piping at end of day and when work stops.

3.8 PROTECTION

A. Exposed PVC Piping: Protect plumbing vents exposed to sunlight with two coats of water-based latex paint.

END OF SECTION
PART 1 - GENERAL

1.1 SUMMARY

A. Provide plumbing fixtures and drains as listed on Drawings and described herein.

B. This Section includes the following sanitary drainage piping specialties:
   1. Cleanouts.
   2. Floor drains.
   3. Trench drains.
   4. Roof flashing assemblies.
   5. Through-penetration firestop assemblies.
   7. Flashing materials.

C. Related Sections include the following:
   1. Division 22 Section "Storm Drainage Piping Specialties" for trench drains for storm water, channel drainage systems for storm water, roof drains, and catch basins.
   2. Division 22 Section "Plumbing Fixtures" for hair interceptors.
   3. Division 22 Section "Healthcare Plumbing Fixtures" for plaster sink interceptors.
   4. Refer to Division 22 Section "Common Work Results for Plumbing" for piping joining materials, joint construction, and basic installation requirements.

1.2 DEFINITIONS

A. PVC: Polyvinyl chloride plastic.

1.3 SUBMITTALS

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

B. Shop Drawings: Show fabrication and installation details for frost-resistant vent terminals.

C. Field quality-control test reports.

D. Operation and Maintenance Data: For drainage piping specialties to include in emergency, operation, and maintenance manuals.
1.4 QUALITY ASSURANCE

A. Drainage piping specialties shall bear label, stamp, or other markings of specified testing agency.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.


1.5 COORDINATION

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

B. Coordinate size and location of roof penetrations.

PART 2 - PRODUCTS

2.1 CLEANOUTS

A. Cleanouts:

1. Basis-of-Design Product: Subject to compliance with requirements, Refer to table for area and provide the product indicated or a comparable product by one of the following:

   1) Linoleum Floors: J.R. Smith Series 4140 - round top with insert
   2) Carpeted Floors: J.R. Smith Series 4240-Y - round with carpet marker
   3) Exterior: J. R. Smith 4240 - round with cast iron cover
   4) Wall: J.R. Smith Series 4710
   5) Quarry Floor: J.R. Smith Series 4053-PB - square bronze top
   6) Ceramic Floor: J.R. Smith Series 4053-NB - square nickel bronze top
   7) Concrete Floors: J. R. Smith Series 4100 – round galvanized cast iron top.
   8) Truck/Loading Dock Areas: J. R. Smith Series 4231 – ductile iron top.

b. MIFAB, 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 for cast iron for cleanout tee.
3. **Body Material:** cast-iron as required to match connected piping.
4. **Closure:** Countersunk or raised-head, brass plug.
5. **Closure Plug Size:** Same as or not more than one size smaller than cleanout size.

### 2.2 FLOOR DRAINS AND FLOOR SINKS

**A. Floor Drains and Floor Sinks:**

1. **Manufacturers:**
   - b. MIFAB, Inc.
   - d. Tyler Pipe; Wade Div.
   - e. Watts Drainage Products Inc.
   - f. Zurn Plumbing Products Group; Light Commercial Operation.
   - g. Zurn Plumbing Products Group; Specification Drainage Operation.

2. **Standard:** ASME A112.6.3.
3. **Refer to schedule on drawings**

### 2.3 ROOF FLASHING ASSEMBLIES

**A. Roof Flashing Assemblies:**

1. **Manufacturers:** Subject to compliance with requirements, provide products by one of the following:
   - 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 8 inches from pipe, with galvanized-steel boot reinforcement and counterflashing fitting.

### 2.4 MISCELLANEOUS SANITARY DRAINAGE PIPING SPECIALTIES

**A. Hub Drain:**

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:** as indicated on drawings.
PART 3 - EXECUTION

3.1 INSTALLATION

A. Install cleanouts in aboveground piping and building drain piping according to the following, unless otherwise indicated:

1. Size same as drainage piping up to NPS 4. Use NPS 4 for larger drainage piping unless larger cleanout is indicated.
2. Locate at each change in direction of piping greater than 45 degrees.
3. Locate at minimum intervals of 50 feet for piping NPS 4 and smaller and 100 feet for larger piping.
4. Locate at base of each vertical soil and waste stack.

B. For floor cleanouts for piping below floors, install cleanout deck plates with top flush with finished floor.

C. For cleanouts located in concealed piping, install cleanout wall access covers, of types indicated, with frame and cover flush with finished wall.

D. Install floor drains/sinks at low points of surface areas to be drained. Set grates of drains flush with finished floor, unless otherwise indicated.

1. Position floor drains/sinks for easy access and maintenance.
2. Set floor drains/sinks 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/sink 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/sinks connected to sanitary building drain, unless otherwise indicated.

E. Install roof flashing assemblies on sanitary stack vents and vent stacks that extend through roof.

F. Install flashing fittings on sanitary stack vents and vent stacks that extend through roof.

G. Assemble open drain fittings and install with top of hub 1 inch above floor.

H. Install deep-seal traps on floor drains and other waste outlets, if indicated.

I. Install floor-drain/sink, 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.

J. Install air-gap fittings on draining-type backflow preventers and on indirect-waste piping discharge into sanitary drainage system.

K. Install sleeve flashing device with each riser and stack passing through floors with waterproof membrane.

L. Install wood-blocking reinforcement for wall-mounting-type specialties.

M. Install traps on plumbing specialty drain outlets. Omit traps on indirect wastes unless trap is indicated.

N. Install escutcheons at wall, floor, and ceiling penetrations in exposed finished locations and within cabinets and millwork. Use deep-pattern escutcheons if required to conceal protruding pipe fittings.

3.2 CONNECTIONS

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

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

C. Grease Interceptors: Connect inlet and outlet to unit, and connect flow-control fitting and vent to unit inlet piping. Install valve on outlet of automatic drawoff-type unit.

D. Oil Interceptors: Connect inlet, outlet, vent, and gravity drawoff piping to unit; flow-control fitting and vent to unit inlet piping; and gravity drawoff and suction piping to oil storage tank.

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.
   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.

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 counterflushing 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 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
SUMMARY

A. This Section includes the following conventional plumbing fixtures and related components:
   1. Faucets for lavatories and sinks.
   2. P-traps, Supplies and strainers.
   3. Fixture supports.
   4. Lavatories.
   5. Sinks.

B. Related Sections include the following:
   1. Division 10 Section "Toilet, Bath, and Laundry Accessories."
   2. Division 22 Section "Domestic Water Piping Specialties" for backflow preventers, floor drains, and specialty fixtures not included in this Section.
   3. Division 22 Section "Healthcare Plumbing Fixtures."
   4. Division 22 Section "Emergency Plumbing Fixtures."
   5. Division 22 Section "Drinking Fountains and Water Coolers."
   6. Division 31 Section "Facility Water Distribution Piping" for exterior plumbing fixtures and hydrants.

1.2 DEFINITIONS


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.

1.3 SUBMITTALS

A. Product Data: For each type of plumbing fixture indicated. Include selected fixture and trim, fittings, accessories, appliances, appurtenances, equipment, and supports. Indicate materials and finishes, dimensions, construction details, and flow-control rates.

B. Shop Drawings: Diagram power, signal, and control wiring.

C. Operation and Maintenance Data: For plumbing fixtures to include in emergency, operation, and maintenance manuals.

D. Warranty: Special warranty specified in this Section.

1.4 QUALITY ASSURANCE

A. Source Limitations: Obtain plumbing fixtures, faucets, and other components of each category through one source from a single manufacturer.

   1. Exception: If fixtures, faucets, or other components are not available from a single manufacturer, obtain similar products from other manufacturers specified for that category.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.


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.
10. Porcelain-Enameled, Formed-Steel Fixtures: ASME A112.19.4M.
15. Vitreous-China Fixtures: ASME A112.19.2M.
17. Water-Closet, Flushometer Tank Trim: ASSE 1037.
18. Whirlpool Bathtub Fittings: ASME A112.19.8M.

H. Comply with the following applicable standards and other requirements specified for lavatory and sink faucets:

1. Backflow Protection Devices for Faucets with Side Spray: ASME A112.18.3M.
2. Backflow Protection Devices for Faucets with Hose-Thread Outlet: ASME A112.18.3M.
5. Hose-Connection Vacuum Breakers: ASSE 1011.

I. Comply with the following applicable standards and other requirements specified for bathtub/shower faucets:

1. Backflow Protection Devices for Hand-Held Showers: ASME A112.18.3M.
2. Combination, Pressure-Equalizing and Thermostatic-Control Antiscald Faucets: ASSE 1016.

J. Comply with the following applicable standards and other requirements specified for miscellaneous fittings:
K. Comply with the following applicable standards and other requirements specified for miscellaneous components:

1. Disposers: ASSE 1008 and UL 430.
4. Floor Drains: ASME A112.6.3.
5. Grab Bars: ASTM F 446.
8. Off-Floor Fixture Supports: ASME A112.6.1M.

1.5 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: One year(s) from date of Substantial Completion.

1.6 EXTRA MATERIALS

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

1. Faucet Washers and O-Rings: Equal to 10 percent of amount of each type and size installed.
2. Faucet Cartridges and O-Rings: Equal to 5 percent of amount of each type and size installed.
3. Flushometer Valve, Repair Kits: Equal to 10 percent of amount of each type installed, but no fewer than 12 of each type.
4. Provide hinged-top wood or metal box, or individual metal boxes, with separate compartments for each type and size of extra materials listed above.
5. Water-Closet Tank, Repair Kits: Equal to 5 percent of amount of each type installed.
6. Toilet Seats: Equal to 5 percent of amount of each type installed.
7. Dry Urinal Trap-Seal Cartridges: 10 of each type installed.
8. Dry Urinal Trap-Seal Liquid: Equal to 1 gal for each urinal installed.

PART 2 - PRODUCTS

2.1 LAVATORY AND SINK FAUCETS

A. Lavatory and Sink Faucets:

1. Manufacturers:
   a. American Standard Companies, Inc.
   b. Chicago Faucets.
   c. Delta Faucet Company.
   d. Eljer.
   e. Elkay Manufacturing Co.
   f. Just Manufacturing Company.
   g. Kohler Co.
   h. Moen, Inc.
   i. Speakman Company.
   j. T & S Brass and Bronze Works, Inc.
   k. Zurn Plumbing Products Group.

2.2 BATHTUB/SHOWER FAUCETS

A. Bathtub/Shower Faucets:

1. Manufacturers:
   a. American Standard Companies, Inc.
   b. Chicago Faucets.
   c. Delta Faucet Company.
   d. Eljer.
   e. Kohler Co.
   f. Moen, Inc.
   g. Speakman Company.
   h. Symmons Industries, Inc.
   i. T & S Brass and Bronze Works, Inc.
   j. Zurn Plumbing Products Group.
2.3 FLUSHOMETERS

A. Flushometers:
   1. Manufacturers:
      a. Coyne & Delany Co.
      b. Sloan Valve Company.
      c. Zurn Plumbing Products Group.

2.4 TOILET SEATS

A. Toilet Seats:
   1. Manufacturers:
      a. American Standard Companies, Inc.
      b. Bemis Manufacturing Company.
      c. Centoco Manufacturing Corp.
      d. Church Seats.
      e. Eljer.
      f. Kohler Co.
      g. Olsonite Corp.
      h. Sperzel.

2.5 PROTECTIVE SHIELDING GUARDS

A. Protective Shielding Pipe Covers:
   1. Manufacturers:
      a. Engineered Brass Co.
      b. McGuire Manufacturing Co., Inc.
      c. TRUEBRO, Inc.
      d. Zurn Plumbing Products Group.
   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 and ASTM E-84.

2.6 P-TRAPS, SUPPLIES, STRAINERS

A. Manufacturers:
   1. McGuire Manufacturing Co., Inc.
   2. Elkay Manufacturing Co.
   3. American Standard Companies, Inc.
   4. Kohler Co.
   5. Engineered Brass Co.
2.7  FIXTURE SUPPORTS

A.  Manufacturers:
   1.  Josam Company.
   2.  MIFAB Manufacturing Inc.
   4.  Tyler Pipe; Wade Div.
   5.  Watts Drainage Products Inc.; a div. of Watts Industries, Inc.

2.8  LAVATORIES

A.  Lavatories:
   1.  Manufacturers:
      a.  American Standard Companies, Inc.
      b.  Eljer.
      c.  Kohler Co.
      d.  Zurn Plumbing Products Group.

2.9  SINKS

A.  Sinks:
   1.  Manufacturers:
      a.  Elkay Manufacturing Co.
      b.  Just Manufacturing Company.
      c.  Metal Masters Foodservice Equipment Co., Inc.

PART 3 - EXECUTION

3.1  EXAMINATION

A.  Examine roughing-in of water supply and sanitary drainage and vent piping
    systems to verify actual locations of piping connections before plumbing fixture
    installation.

B.  Examine cabinets, counters, floors, and walls for suitable conditions where fixtures
    will be installed.

C.  Proceed with installation only after unsatisfactory conditions have been corrected.
3.2 INSTALLATION

A. Assemble plumbing fixtures, trim, fittings, and other components according to manufacturers' written instructions.

B. Install off-floor supports, affixed to building substrate, for wall-mounting fixtures.
   1. Use carrier supports with waste fitting and seal for back-outlet fixtures.
   2. Use carrier supports without waste fitting for fixtures with tubular waste piping.
   3. Use chair-type carrier supports with rectangular steel uprights for accessible fixtures.

C. Install back-outlet, wall-mounting fixtures onto waste fitting seals and attach to supports.

D. Install floor-mounting fixtures on closet flanges or other attachments to piping or building substrate.

E. Install wall-mounting fixtures with tubular waste piping attached to supports.

F. Install floor-mounting, back-outlet water closets attached to building floor substrate and wall bracket and onto waste fitting seals.

G. Install counter-mounting fixtures in and attached to casework.

H. Install fixtures level and plumb according to roughing-in drawings.

I. Install water-supply piping with stop on each supply to each fixture to be connected to water distribution piping. Attach supplies to supports or substrate within pipe spaces behind fixtures. Install stops in locations where they can be easily reached for operation.
   1. Exception: Use ball valves if supply stops are not specified with fixture. Valves are specified in Division 22 Section "General-Duty Valves for Plumbing Piping."

J. Install trap and tubular waste piping on drain outlet of each fixture to be directly connected to sanitary drainage system.

K. Install tubular waste piping on drain outlet of each fixture to be indirectly connected to drainage system.

L. Install flushometer valves for accessible water closets and urinals with handle mounted on wide side of compartment. Install other actuators in locations that are easy for people with disabilities to reach.

M. Install tanks for accessible, tank-type water closets with lever handle mounted on wide side of compartment.

N. Install toilet seats on water closets.

O. Install trap-seal liquid in dry urinals.
P. Install faucet-spout fittings with specified flow rates and patterns in faucet spouts if faucets are not available with required rates and patterns. Include adapters if required.

Q. Install water-supply flow-control fittings with specified flow rates in fixture supplies at stop valves.

R. Install faucet flow-control fittings with specified flow rates and patterns in faucet spouts if faucets are not available with required rates and patterns. Include adapters if required.

S. Install shower flow-control fittings with specified maximum flow rates in shower arms.

T. Install traps on fixture outlets.
   1. Exception: Omit trap on fixtures with integral traps.
   2. Exception: Omit trap on indirect wastes, unless otherwise indicated.

U. Install disposer in outlet of each sink indicated to have disposer. Install switch where indicated or in wall adjacent to sink if location is not indicated.

V. Install dishwasher air-gap fitting at each sink indicated to have air-gap fitting. Install in sink deck. Connect inlet hose to dishwasher and outlet hose to disposer.

W. Install hot-water dispensers in back top surface of sink or in countertop with spout over sink.

X. 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."

Y. Set shower receptors in leveling bed of cement grout. Grout is specified in Division 22 Section "Common Work Results for Plumbing."

Z. 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."

3.3 CONNECTIONS

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

B. Connect fixtures with water supplies, stops, and risers, and with traps, soil, waste, and vent piping. Use size fittings required to match fixtures.

C. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."
D. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.4 FIELD QUALITY CONTROL

A. Verify that installed plumbing fixtures are categories and types specified for locations where installed.

B. Check that plumbing fixtures are complete with trim, faucets, fittings, and other specified components.

C. Inspect installed plumbing fixtures for damage. Replace damaged fixtures and components.

D. Test installed fixtures after water systems are pressurized for proper operation. Replace malfunctioning fixtures and components, then retest. Repeat procedure until units operate properly.

E. Install fresh batteries in sensor-operated mechanisms.

3.5 ADJUSTING

A. Operate and adjust faucets and controls. Replace damaged and malfunctioning fixtures, fittings, and controls.

B. Operate and adjust controls. Replace damaged and malfunctioning units and controls.

C. Adjust water pressure at faucets and flushometer valves to produce proper flow and stream.

D. Replace washers and seals of leaking and dripping faucets and stops.

E. Install fresh batteries in sensor-operated mechanisms.

3.6 CLEANING

A. Clean fixtures, faucets, and other fittings with manufacturers' recommended cleaning methods and materials. Do the following:

1. Remove faucet spouts and strainers, remove sediment and debris, and reinstall strainers and spouts.
2. Remove sediment and debris from drains.

B. After completing installation of exposed, factory-finished fixtures, faucets, and fittings, inspect exposed finishes and repair damaged finishes.
3.7 PROTECTION

A. Provide protective covering for installed fixtures and fittings.

B. Do not allow use of plumbing fixtures for temporary facilities unless approved in writing by Owner.

END OF SECTION
SECTION 224500

EMERGENCY PLUMBING FIXTURES

PART 1 - GENERAL

1.1 SUMMARY

A. Provide plumbing fixtures and drains as listed on Drawings and described herein.

B. This Section includes the following emergency plumbing fixtures:

1. Emergency showers.
2. Eyewash equipment.
3. Eye/face wash equipment.
4. Hand-held drench hoses.
5. Combination units.
6. Water-tempering equipment.

C. Related Sections include the following:

1. Division 22 Section "Sanitary Waste Piping Specialties" for floor drains.

1.2 DEFINITIONS

A. Accessible Fixture: Emergency plumbing fixture that can be approached, entered, and used by people with disabilities.

B. Plumbed Emergency Plumbing Fixture: Fixture with fixed, potable-water supply.

C. Tepid: Moderately warm.

1.3 SUBMITTALS

A. Product Data: For each type of product indicated. Include flow rates and capacities, furnished specialties, and accessories.

B. Product Certificates: Submit certificates of performance testing specified in "Source Quality Control" Article.

C. Field quality-control test reports.

D. Operation and Maintenance Data: For emergency plumbing fixtures to include in maintenance manuals.
1.4 QUALITY ASSURANCE


C. NSF Standard: Comply with NSF 61, "Drinking Water System Components--Health Effects," for fixture materials that will be in contact with potable water.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers for Emergency Showers, Eyewash Equipment, Eye/Face-wash Equipment, Hand held Drench Hoses and Combination Units:

2. Guardian Equipment Co.
4. Lab Safety Supply Inc.
5. Speakman Company.

2.2 EMERGENCY SHOWERS

A. Emergency Showers:

1. Description: Plumbed, single-shower-head [horizontal, wall-mounting] [vertical, ceiling-mounting] [freestanding] emergency shower.
   a. Capacity: Deliver potable water at rate not less than 20 gpm for at least 15 minutes.
   b. Supply Piping: NPS 1-1/4 chrome-plated brass or stainless steel with flow regulator and stay-open control valve.
   c. Control-Valve Actuator: Pull [rod] [chain].
   d. Shower Head: 8-inch minimum diameter, [chrome-plated brass or stainless steel] [plastic].

B. Emergency Showers, <DECONTAM SHOWER>:

1. Manufacturers:
   a. Guardian Equipment Co.
   b. Haws Corporation.
   c. Speakman Company.
2. Description: Plumbed, multiple-spray emergency shower with [eight] [12] small shower heads or nozzles.
   
a. Capacity: Deliver potable water at rate not less than 20 gpm for at least 15 minutes.
b. Supply Piping: NPS 1-1/4 minimum chrome-plated brass or stainless steel with flow regulator and stay-open control valve.

2.3 EYEWASH EQUIPMENT

A. Eyewash Equipment:

1. Description: Plumbed, freestanding eyewash equipment.
   
a. Capacity: Deliver potable water at rate not less than 0.4 gpm for at least 15 minutes.
b. Supply Piping: NPS 1/2 chrome-plated brass or stainless steel with flow regulator and stay-open control valve.
d. Receptor: [Chrome-plated brass or stainless-steel] [Plastic] bowl.
e. Drain Piping: NPS 1-1/4 minimum, chrome-plated brass, receptor drain, P-trap, waste to wall, and wall flange complying with ASME A112.18.2.

B. Eyewash Equipment:

1. Description: Plumbed, [accessible,] wall-mounting eyewash equipment with receptor and wall bracket.
   
a. Capacity: Deliver potable water at rate not less than 0.4 gpm for at least 15 minutes.
b. Supply Piping: NPS 1/2 chrome-plated brass or stainless steel with flow regulator and stay-open control valve.
d. Receptor: [Chrome-plated brass or stainless-steel] [Plastic] bowl.
e. Drain Piping: NPS 1-1/4 minimum, chrome-plated brass, receptor drain, P-trap, waste to wall, and wall flange complying with ASME A112.18.2.

C. Eyewash Equipment:

1. Description: Plumbed, adjacent-to-sink, swivel, counter-mounting eyewash equipment.
   
a. Capacity: Deliver potable water at rate not less than 0.4 gpm for at least 15 minutes.
b. Supply Piping: NPS 1/2 chrome-plated brass or stainless steel with flow regulator and stay-open control valve.
2.4 EYE/FACE WASH EQUIPMENT

A. Eye/Face Wash Equipment:

1. Description: Plumbed, [accessible,] wall-mounting eye/face wash equipment with receptor and wall bracket.

   a. Capacity: Deliver potable water at rate not less than 3.0 gpm for at least 15 minutes.
   b. Supply Piping: NPS 1/2 chrome-plated brass or stainless steel with flow regulator and stay-open control valve.
   d. Receptor: [Chrome-plated brass or stainless-steel] [Plastic] bowl.
   e. Drain Piping: NPS 1-1/4 minimum, chrome-plated brass, receptor drain, P-trap, waste to wall, and wall flange complying with ASME A112.18.2.

2.5 HAND-HELD DRENCH HOSES

A. Hand-Held Drench Hoses:

1. Description: Plumbed, wall-mounting, hand-held drench hose with wall bracket.

   a. Capacity: Deliver potable water at rate not less than 3.0 gpm for at least 15 minutes.
   b. Supply Piping: NPS 1/2 chrome-plated brass or stainless steel with flow regulator and stay-open control valve.
   d. Hose: Coiled, rubber or plastic.
   e. Spray Heads: [Single] [Twin].

B. Hand-Held Drench Hoses:

1. Description: Plumbed, counter-mounting, hand-held drench hose.

   a. Capacity: Deliver potable water at rate not less than 3.0 gpm for at least 15 minutes.
   b. Supply Fitting: NPS 1/2 brass with flow regulator.
   c. Hose: Rubber or plastic.
   d. Control-Valve Actuator: Hand-held squeeze valve.
   e. Spray Heads: [Single] [Twin].

2.6 COMBINATION UNITS

A. Combination Units:

1. Description: Plumbed, accessible, freestanding, with emergency shower and eye/face wash equipment.

   a. Piping: Chrome-plated brass or stainless steel.
1) Unit Supply: NPS 1-1/2 from [top] [side].
2) Unit Drain: Outlet at side near bottom.
3) Shower Supply: NPS 1 with flow regulator and stay-open control valve.
4) Eye/Face Wash Supply: NPS 1/2 with flow regulator and stay-open control valve.

b. Shower Capacity: Deliver potable water at rate not less than 20 gpm for at least 15 minutes.
   1) Control-Valve Actuator: [Pull rod] [Pull chain].
   2) Shower Head: 8-inch minimum diameter, [chrome-plated brass or stainless steel] [plastic].

c. Eye/Face Wash Equipment: With capacity to deliver potable water at rate not less than 3.0 gpm for at least 15 minutes.
   1) Control-Valve Actuator: [Paddle] [Push bar].
   2) Receptor: [Chrome-plated brass or stainless-steel] [Plastic] bowl.

2.7 WATER-TEMPERING EQUIPMENT

A. Water-Tempering Equipment:
   1. Manufacturers:
      b. Bradley Corporation.
      c. Haws Corporation.
      d. Lawler Manufacturing Co., Inc.
      e. Leonard Valve Company.
      f. Powers, a Watts Industries Co.

   2. Description: Factory-fabricated, hot- and cold-water-tempering equipment with thermostatic mixing valve.
      a. Thermostatic Mixing Valve: Designed to provide 85 deg F tepid, potable water at emergency plumbing fixtures, to maintain temperature at plus or minus 2 deg F throughout required 15-minute test period, and in case of unit failure to continue cold-water flow, with union connections, controls, metal piping, and corrosion-resistant enclosure.

2.8 SOURCE QUALITY CONTROL

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

A. Examine roughing-in for water and waste piping systems to verify actual locations of piping connections before plumbed emergency plumbing fixture installation.

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

3.2 EMERGENCY PLUMBING FIXTURE INSTALLATION

A. Assemble emergency plumbing fixture piping, fittings, control valves, and other components.

B. Install fixtures level and plumb.

C. Fasten fixtures to substrate.

D. Install shutoff valves in water-supply piping to fixtures. Use ball valve if specific type valve is not indicated. Install valves chained or locked in open position if permitted. Install valves in locations where they can easily be reached for operation. Valves are specified in Division 22 Section "General-Duty Valves for Plumbing Piping."

1. Exception: Omit shutoff valve on supply to emergency equipment if prohibited by authorities having jurisdiction.

E. Install dielectric fitting in supply piping to fixture if piping and fixture connections are made of different metals. Dielectric fittings are specified in Division 22 Section "Common Work Results for Plumbing."

F. Install thermometers in supply and outlet piping connections to water-tempering equipment. Thermometers are specified in Division 22 Section "Meters and Gages for Plumbing Piping."

G. Install trap and waste to wall on drain outlet of fixture receptors that are indicated to be directly connected to drainage system.

H. Install indirect waste piping to wall on drain outlet of fixture receptors that are indicated to be indirectly connected to drainage system. Drainage piping is specified in Division 22 Section "Sanitary Waste and Vent Piping."

I. Install escutcheons on piping wall and ceiling penetrations in exposed, finished locations. Escutcheons are specified in Division 22 Section "Common Work Results for Plumbing."

J. Install equipment nameplates or equipment markers on fixtures and equipment signs on water-tempering equipment. Identification materials are specified in Division 22 Section "Identification for Plumbing Piping and Equipment."
3.3 CONNECTIONS

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

B. Connect cold-water-supply piping to plumbed emergency plumbing fixtures not having water-tempering equipment.

C. Connect hot- and cold-water-supply piping to hot- and cold-water-tempering equipment. Connect output from water-tempering equipment to emergency plumbing fixtures.

D. Directly connect emergency plumbing fixture receptors with trapped drain outlet to sanitary drainage and vent piping.

E. Indirectly connect emergency plumbing fixture receptors without trapped drain outlet to sanitary drainage piping.

3.4 FIELD QUALITY CONTROL

A. Mechanical-Component Testing: After plumbing connections have been made, test for compliance with requirements. Verify ability to achieve indicated capacities and temperatures.

B. Repair or replace malfunctioning units. Retest as specified above after repairs or replacements are made.

C. Report test results in writing.

3.5 ADJUSTING

A. Adjust or replace fixture flow regulators for proper flow.

B. Adjust equipment temperature settings.

END OF SECTION
SECTION 230500
COMMON WORK RESULTS FOR HVAC

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following:
   1. Common terminology and requirements used throughout this Division.
   2. Requirements for Acceptance Testing Agency.
   3. Requirements for Professional Engineers responsible for Delegated Design.
   4. Piping materials and installation instructions common to most piping systems.
   5. Transition fittings.
   6. Dielectric fittings.
   7. Mechanical sleeve seals.
   8. Sleeves.
   10. Grout.
   11. HVAC demolition.
   12. Equipment installation requirements common to equipment sections.
   13. Painting and finishing.
   14. Concrete bases.
   15. Supports and anchorages.

1.2 RELATED DOCUMENTS

A. In addition to Division 01 Specification Sections, related sections include the following:
   1. Division 01 Section "Cutting and Patching"
   2. Division 02 Section "Selective Structure Demolition" for general demolition requirements and procedures.
   3. Division 03 Sections "Cast-in-Place Concrete" and "Miscellaneous Cast-in-Place Concrete".
   4. Division 05 Section "Metal Fabrications" for structural steel.
   5. Division 09 Sections "Interior Painting" and "Exterior Painting".
   6. Division 08 Section "Access Doors and Frames" for access panels and doors.

1.3 DEFINITIONS

A. This section includes the following definitions that are common to most Division 23 Specifications.
   1. Definitions found within this section, Division 23 “Common Work Results for HVAC,” are considered to generally apply to all sections unless otherwise noted.
   2. Other sections may increase or decrease the scope and usage of a particular word, phrase, or abbreviation for the section in which it appears.
B. AHJ: Authority Having Jurisdiction. This abbreviation is the general term for all agencies having oversight and/or inspection authority for a scope of work, trade, or system. AHJ includes agencies such as local and state fire marshals, city inspectors, et. al.

C. AHU: Air handling unit. This abbreviation is the general term for systems that filter and/or changes the sensible and/or latent properties of air supplied to a space. Its use is synonymous with RTU, roof top unit, irrespective of a system’s physical location.

D. Bound Material: Bound refers to materials permanently bound, as by stitching or glue, or materials securely fastened in their covers by multiple fasteners that penetrate all papers. Ring binders, spiral binders, brads and screw posts are acceptable fasteners. Loose papers clipped together or stapled at one (1) corner are not acceptable.

E. Business Day: Where this Section and other Sections of this Division use the term “Business Day” it shall mean Monday thru Friday, excluding Holidays recognized by Federal, State and Local government.

F. CAV: Constant air volume.

G. 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.

H. Concealed, Interior Installations: Concealed from view and protected from physical contact by building occupants. Examples include above ceilings and chases.

I. CPVC: Chlorinated polyvinyl chloride plastic.

J. DDC: Direct-digital controls.

K. ECM: Electrically commutated motor.

L. EPDM: Ethylene propylene diene monomer rubber.

M. Exposed, Exterior Installations: Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions. Examples include rooftop locations.

N. Exposed, Interior Installations: Exposed to view indoors. Examples include finished occupied spaces and mechanical equipment rooms.

O. 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, crawlspace, and tunnels.

P. FMS: Facility Management System. May be used interchangeably with BAS, Building Automation System.

Q. Furnish: The material, equipment, etc. to be supplied, but not installed by the supplier.
R. Manufacturers:
1. Available Manufacturers: When used, this allows any manufacturer in compliance with the requirements to be submitted and used for the system indicated, pending engineer’s approval. The list of manufacturers is intended to illustrate typical providers.
2. Basis-of-Design: The manufacturer indicated as such is required to be furnished. The Owner reserves the right to select additional manufacturers listed and adjust the bid amount up or down as is indicated on the bid form for the selected manufacturer.
3. Manufacturers: When used, restricts the list of acceptable manufacturers to only the entities indicated that comply with the requirements detailed.
   a. Where the product of a single manufacturer is mentioned by trade name or manufacturer’s name in this Division, it is the only acceptable manufacturer.
   b. Where two (2) or more manufacturers are named, only those manufacturers will be considered or approved.

S. NBR: Acrylonitrile-butadiene rubber.

T. NRTL: Nationally Recognized Testing Laboratory.

U. PE: Polyethylene plastic.

V. Products and Materials: Components and assemblies for the construction of the systems as indicated in the Documents including, but not limited to pipes, tubes, ducts, and equipment.

W. Products or Materials: See “Products and Materials”.

X. Provide: The materials and equipment described shall be furnished, installed and connected under this Division, complete for operation, unless specifically noted to the contrary. Identical to the phrase “furnish and install”.

Y. PVC: Polyvinyl chloride plastic.

Z. RTU: Rooftop unit. The abbreviations means packaged, outdoor, central station AHUs. This abbreviation may be used regardless of whether the unit is located on a roof or at grade.

AA. VAV: Variable air volume.

BB. VFD: Variable frequency drive. This may be used interchangeably with VSD (variable speed drive), VSC (variable speed controller), and VFMC (variable frequency motor controller). This technology varies the frequency of the incoming electrical signal to change the speed of driven equipment.

1.4 RELATED REQUIREMENTS

A. All conditions imposed by these documents shall be applicable to all portions of the Work under this Division. These references are intended to point out specific items
to the Contractor, but in no way relieve him of the responsibility of reading and 
complying with all relevant parts of the entire Specification.

B. The Contractor shall examine and coordinate with all Contract Drawings and 
Specifications, and all Addenda issued. Failure to comply shall not relieve them of 
responsibility. The omission of details of other portions of the Work from this Division 
shall not be used as a basis for a request for additional compensation.

C. The specific features and details for other portions of the Work related to the 
construction in progress or to the existing building(s) shall be determined by 
examination at the site.

1.5 RELATED REQUIREMENTS

A. All conditions imposed by these documents shall be applicable to all portions of the 
Work under this Division. These references are intended to point out specific items 
to the Contractor, but in no way relieve him of the responsibility of reading and 
complying with all relevant parts of the entire Specification.

1.6 ORDINANCES, PERMITS AND CODES

A. It shall be the Contractor’s duty to perform the work and provide the materials 
covered by these Specifications in conformance with all ordinances and regulations 
of all authorities having jurisdiction.

B. All work herein shall conform to all applicable laws, ordinances, and regulations of 
the local utility companies.

C. The work shall be in accordance with, but not limited to, the requirements of:
   1. National Fire Protection Association
   2. City Building Codes
   3. Florida Safety Code
   4. Florida Boiler Code
   5. Florida Department Of State Health Services

D. Codes and standards referred to are minimum standards. Where the requirements 
of these Specifications or drawings exceed those of the codes and regulations, the 
drawings, and Specifications govern.

E. The Contractor shall obtain permits, plan checks, connection and specification fees, 
inspections, and approvals applicable to the Work as required by the regulatory 
authorities.

F. Fees and costs of any nature whatsoever incidental to permits, inspections, and 
approvals shall be assumed and paid by the Contractor.

G. The pro-rata costs, if any, for utilities serving this property will be paid for by the 
Owner and shall not be included as part of this Contract.
1.7 REFERENCE STANDARDS

A. Where differences between building codes, state laws, local ordinances, industry standards, utility company regulations and the Contract Documents occur, the most stringent shall govern. The Contractor shall promptly notify the Owner's Representative in writing of any such difference.

B. Should the Contractor perform any Work that does not comply with local codes, laws and ordinances, industry standards or other governing regulations, the Work shall be corrected on noncompliance deficiencies with the Contractor bearing all costs.

C. In addition to the aforementioned ordinances, industry standards published by the following organizations shall apply:

1. AIA - AMERICAN INSTITUTE OF ARCHITECTS
2. AABC - ASSOCIATED AIR BALANCE COUNCIL
3. AASHO - AMERICAN ASSOCIATION OF STATE HIGHWAY OFFICIALS
4. ACI - AMERICAN CONCRETE INSTITUTE
5. ADC - AIR DIFFUSION COUNCIL
6. AGA - AMERICAN GAS ASSOCIATION
7. AHRI - AIR CONDITIONING HEATING & REFRIGERATION INSTITUTE
8. AISC - AMERICAN INSTITUTE OF STEEL CONSTRUCTION
9. AMCA - AMERICAN HEATING, VENTILATING, AND AIR CONDITIONING INSTITUTE
10. ANSI - AMERICAN NATIONAL STANDARDS INSTITUTE
11. API - AMERICAN PETROLEUM INSTITUTE
12. ASCE - AMERICAN SOCIETY OF CIVIL ENGINEERS
13. ASHRAE - AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR CONDITIONING ENGINEERS, INC.
14. ASME - AMERICAN SOCIETY OF MECHANICAL ENGINEERS
15. ASTM - AMERICAN SOCIETY FOR TESTING AND MATERIALS
16. AWSC - AMERICAN WELDING SOCIETY CODE
17. AWWA - AMERICAN WATER WORKS ASSOCIATION
18. CDA - COPPER DEVELOPMENT ASSOCIATION
19. CISPI - CAST IRON SOIL PIPE INSTITUTE
20. CTI - COOLING TOWER INSTITUTE
21. FGI - FACILITY GUIDELINES INSTITUTE
22. FMG - FACTORY MUTUAL GLOBAL
23. ICC - INTERNATIONAL CODE COUNCIL
24. IRI - INDUSTRIAL RISK INSURERS
25. NBS - NATIONAL BUREAU OF STANDARDS
26. NFPA - NATIONAL FIRE PROTECTION ASSOCIATION
27. OSHPD - OFFICE OF STATEWIDE HEALTH PLANNING AND DEVELOPMENT
28. PDI - PLUMBING AND DRAINAGE INSTITUTE
29. SMACNA - SHEET METAL AND AIR CONDITIONING CONTRACTORS NATIONAL ASSOCIATION
30. TDLR - TEXAS DEPARTMENT OF LICENSING AND REGULATION
31. TSDHS - TEXAS DEPARTMENT OF STATE HEALTH SERVICES
32. UL - UNDERWRITER'S LABORATORIES

D. Where the Documents exceed the above requirements, the Documents shall govern. In no case shall Work be installed contrary to or below the minimum legal standards.
1.8 DRAWINGS AND SPECIFICATIONS

A. The inter-relation of the specifications, the drawings, and the schedules are as follows:
   1. The specifications provide the written requirements for the quality, standard, nature of the materials, equipment and construction systems.
   2. The drawings establish the quantities, approximate dimensions, details and location of equipment.
   3. The schedules give the capacities, characteristics and components.

B. For any individual project, if there is conflict between the drawings and or specifications, they are equivalent in authority and priority. Should they disagree in themselves, or with each other, prices shall be based on the most expensive combination of quality and quantity of work indicated. In the event of the above mentioned disagreements the resolution shall be determined by the Architect.

C. Contractor is responsible to bring any conflicts in drawings and/or specifications to the attention of the Architect, immediately, prior to any work being done.

D. Review all construction details illustrated on the architectural and structural drawings and be guided thereby.

1.9 SUBMITTAL PROCEDURES

A. Simultaneous Action Submittals: When submittals are required and a simultaneous action is indicated, the equipment is to be coordinated across trades prior to forwarding to the Engineer.
   1. The release of mechanical equipment submittals (pumps, air handling units, chillers, fans cooling towers, etc.) is dependent on the receipt of a complete and accurate overcurrent protective device coordination study as required by Division 26.
   2. The Architect and Engineer require a full submittal review period as delineated in Division 01 Section “Submittal Procedures” to adequately review the OCPD study against the submitted electrical components prior to release of submittals for equipment procurement.
   3. The submittal schedule required by Division 01 requirements shall provide for this review time in the action submittal process.
   4. Delay claims arising due to Contractor’s failure to coordinate simultaneous action submittals will not be considered by the Owner.

B. Documents for submittal may be hard copies in a three ring binder or soft copies in an electronic file using the Portable Document Format (PDF) standard. In any case, where multiple products, trades, floors, disciplines, etc. are combined into one (1) submittal, provide tabs for binders or ‘bookmarks’ for PDF files for efficient navigation between items to be reviewed and a table of contents at the front. Documents that do not conform may be rejected.

C. Common Requirements for Product Data: Where this Section and other Sections of this Division require Product Data to be submitted, meet the requirements defined in Division 01 Section "Submittal Procedures". In addition to the requirements of Division 01 comply with the following:
1. Submit hardcopy of Product Data in the quantity as required under Division 01 Section "Submittal Procedures". Hardcopies of product data submittals shall be bound materials as defined above. Separate products under distinct subheadings that correspond to paragraphs in specification text. Divide sections in binder with labeled divider tabs.

2. In addition to hardcopies required by Division 01, submit one copy of product data in electronic format. All files shall be in Portable Document Format (.pdf).

3. Product Data shall not consist of manufacturer’s catalogs or cut sheets that contain no indication of the exact item offered. The submission on individual items shall designate the exact item offered.

D. Common Requirements for Shop Drawings: Where this Section and other Sections of this Division require Shop Drawings to be submitted, meet the requirements defined in Division 01 Section "Submittal Procedures". In addition to the requirements of Division 01 comply with the following:

1. Prepare Shop Drawings using computerized drafting software compatible with AutoDesk’s AutoCAD®.

2. Submit hardcopy of Shop Drawings in the quantity as required under Division 01 Section "Submittal Procedures". Hardcopies of Shop Drawings shall have each sheet clearly labeled with a unique sheet identification number.

3. In addition to hardcopies required by Division 01, submit one (1) copy of Shop Drawings in electronic format. Files shall include both AutoCAD® compatible source files and files printed to Portable Document Format (.pdf).

4. Shop Drawings shall be of appropriate scale based on the following:

   a. Ductwork and Piping Systems, including all underfloor work: Minimum 1/8" = 1'-0".

      1) Double-line congested areas.
      2) Double-line duct widths greater than 24”.

   b. Mechanical rooms: 1/4” = 1’ – 0”.
      1) Double-line all systems.

   c. Temperature Control Diagrams with Sequence of Operations on same drawing.

5. Shop drawings shall include the following items:

   a. Concrete pads and foundations.
   b. Equipment room layouts with actual dimensions and offsets for all systems.
   c. Roof layouts.
   d. Trench locations and sizes.
   e. Dimensioned floor drain locations.

E. Common Requirements for Coordination Drawings: Where this Section and other Sections of this Division require Coordination Drawings to be submitted, meet the requirements defined in Division 01 Section "Submittal Procedures" and Division 01 Section “Project Management and Coordination”. In addition to the requirements of Division 01 comply with the following:
1. Prepare Coordination Drawings using computerized drafting software compatible with AutoDesk’s AutoCAD®. Drawings files must be composite with multiple distinctive layers for each of the various trades.

2. Submit hardcopy of Coordination Drawings in the quantity as required under Division 01. Hardcopies of Coordination Drawings shall have each sheet clearly labeled with a unique sheet identification number.

3. In addition to hardcopies required by Division 01, submit one (1) copy of Shop Drawings in electronic format. Files shall include both AutoCAD® compatible source files and files printed to Portable Document Format (.pdf).

4. Coordination Drawings shall be of appropriate scale but shall not be smaller than a scale of 1/4-inch equals one foot.

5. [Coordination Drawings shall be multi-color prints with each system printed in a separate and unique color.]

F. Coordination Drawings: Prepare drawings showing dimensioned layout for the following:

1. Penetration and Structural Opening: Floor plans showing sleeves and formed structural penetrations. Show sleeve and formed penetration layouts and relationships between structural components and other adjacent building elements, including but not limited to pre-tensioning and post-tensioning members where used.

2. Reflected Ceiling Plans: ceiling plans, sections, and other necessary details showing dimensioned layouts for equipment located in or on the ceiling plane. Base dimensions on exact dimensioned data obtained from product submittals for products to be included in the Work. Differentiate between field measurements and assumed dimensions. Include the all items in the ceiling plane coordinated with each other, based on input from installers of the items involved.

3. Include the following items coordinated with each other, based on input from installers of the items involved:
   a. Suspended ceiling components.
   b. Structural members to which suspension systems for luminaires will be attached.
   c. Perimeter moldings, decorative ceiling elements, and Architectural features.
   d. Luminaires.
   e. HVAC Diffusers, Registers and Grilles.
   f. Speakers.
   g. Sprinklers.
   h. Fire Alarm initiating devices, including but not limited to the following:
      1) Smoke detectors.
      2) Heat detectors.
   i. Fire Alarm notification appliances.
   j. Occupancy sensors.
   k. Access panels.
   l. Security cameras and occupancy detectors.
   m. Wireless Access Points.
   n. Wiring Diagrams
   o. Short-circuit current rating of equipment assembly.

4. HVAC Layouts:
BROWARD HEALTH PHARMACY

a. Single-line drawings of duct and piping systems are satisfactory except for the following, which shall be double-lined:

1) All mechanical equipment rooms.
2) Main duct runs to and from air handling equipment rooms.
3) Ductwork and piping in congested areas.
4) Ductwork with widths 36" and greater.

b. Shop drawings shall be provided for the following:

1) Sheet Metal and Duct Systems, including all underfloor work (prepared at a minimum scale of 1/8"=1'-0")
2) Piping and equipment systems for chilled water, condenser water, refrigerant, heating water, steam and other HVAC piping systems. (Preferably at 1/4" = 1’ – 0” and not less than 1/8" = 1’ – 0”).
3) Equipment room layouts with actual equipment, piping, and duct at 1/4" = 1’ – 0” scale. Show clearances, access spaces, relative heights of piping, main ducts, outside and relief louvers. Provide at least one (1) section through each equipment room showing the same.
4) Temperature Control Diagrams with Sequence of Operations on same drawing.
5) Housekeeping and equipment concrete pads.
6) Dimensioned floor drain locations and the equipment each serves.
7) Roof layouts.
8) Trench locations and sizes.
9) Catwalk or equipment maintenance platform assemblies.

c. Equipment support locations, type of support, and weight on each support.

d. Location of structural supports for structure-supported raceways.

e. For floor mounted equipment: concrete base dimension, outline of equipment, and required clearances.

f. Location of structural supports for seismic bracing.

G. Common Requirements for Specification Compliance Certification: Where this Section and other Sections of this Division require Specification Compliance Certification to be submitted, meet the requirements defined in Division 01 Section "Submittal Procedures" for "Other Informational Submittals". In addition to the requirements of Division 01 comply with the following:

1. Prepare a line-by-line Specification Compliance Certification by marking up a copy of the Contract Document specification section in the left margin. Accompany the markup with a written report explaining all items that are not marked with "Compliance". Submit line-by-line markup, written report of deviations and alternates and a cover letter certified by Manufacturer or Installer that prepared the Specification Compliance Certification. Use the following key for preparing the line-by-line markup.

a. "C" for Compliance: By noting the term "compliance" or "C" in the margin, it shall be understood that the manufacturer is in full compliance with the item specified and will provide exactly the same with no deviations.
b. “D” for Deviation: By noting the term "deviation" or "D" in the margin, it shall be understood that the manufacturer prefers to provide a different component in lieu of that specified.

c. “A” for Alternate: By noting the term "alternate" or "A" in the margin, it shall be understood that the manufacturer proposes to provide the same operating function but prefers to do it in a different manner.

d. “N/A” for Not Applicable: By noting the term “not applicable” or “N/A” in the margin, it shall be understood that the specified item is not applicable to the project.

H. Common Requirements For Qualification Data:
1. Professional Engineer Qualifications: Where this Section and other Sections of this Division require a licensed Professional Engineer to be responsible for Delegated Design requirements; Submit Qualification data for Professional Engineer including, but not limited to, proof of licensing registration in the state where the Project is located.

2. Independent Testing and Inspecting Agency Certification: Where this Section and other Sections of this Division require an Independent Testing and Inspecting agency to be responsible for Acceptance Testing and Field Quality Control requirements; submit certification documentation for such agency that demonstrates compliance with the Quality Assurance paragraph of this Section.

I. Qualification Data: For Independent Testing and Inspecting Agency.

J. Welding certificates.

1.10 PRODUCT SUBSTITUTIONS

A. Comply with provisions of Division 01 Section “Product Substitution Procedures”.

1. If item of equipment or device offered as Substitution differs in dimension or configuration from that indicated in the Contract Documents, provide, as part of the substitution submittal, a drawing that shows that the equipment or devices proposed for Substitution can be installed in the space available without interfering with other trades or with access requirements for operations and maintenance in the completed project. Drawings shall be of appropriate scale but shall not be smaller than a scale of 1/4-inch equals one foot.

2. Where substitute equipment or devices requires different arrangement or connections from that indicated in the Contract Documents, install the equipment or devices to operate properly and in accordance with the requirements of the Contract Documents. Make incidental changes necessary in piping, ductwork or wiring which results from the inclusion of the substitute equipment or device without any additional cost to the Owner. Pay all additional costs incurred by other trades in connection with changes required by the inclusion of the substituted equipment or device in the Work.

3. When submitting a manufacturer that is not the Basis of Design, the Contractor shall provide an itemized list of all deviations from and compliances with the information detailed in both the specification section and schedule. An additional itemized list shall account for scope increase and deductions based on substitutions for the following minimum items:

a. Electrical panels, distribution, and safeties.

b. Structural modifications.
c. Civil modifications.
d. Plumbing modifications.
e. Duct and pipe connections or arrangements.
f. Space heating and cooling requirements.
g. Exhaust or ventilation modifications.
h. Seismic restraint modifications.
i. Vibration isolation requirements.

B. Manufacturers not listed are subject to design Engineer’s review and may not be acceptable. The substitute manufacturer shall submit a complete copy of the appropriate technical specification section minimum ten (10) business days prior to bid with each sub-paragraph noted with the comment, "compliance", "deviation", "alternate" or "not applicable" as described above. In the case of non-primary, vendor-supplied items, the name of the sub-vendor supplying said item, including model number, shall be indicated.

C. Where substitute products or materials requiring different arrangement or connections from that indicated are accepted by the Owner's Representative, install the equipment or devices to operate properly and in harmony with the intent of the Documents, making all incidental changes in piping, ductwork, wiring, and any other trade resulting from the substitution without any additional cost to the Owner.

D. The Owner's Representative reserves the right to call for samples of any item of product or material offered in substitution, together with a sample of the specific item when, in their opinion, the quality of the item and/or the appearance is involved, and it is deemed that an evaluation of the item may be better made by visual inspection.

E. When any request for a substitution of a product or material is submitted and rejected, the item named in the Documents shall be furnished. Repetitive submittal of substitutions for the same item will not be considered.

1.11 QUALITY ASSURANCE

A. All Work shall be performed by properly licensed technicians skilled in their respective trades. All materials, equipment and devices shall be installed in accordance with the recommendations of the manufacturer and in the best standard practice to bring about results of a first class condition.

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 in the systems they are working on and that certification is current.

D. Electrical Characteristics for HVAC Equipment:
   1. Equipment having higher electrical characteristics other than those specified should 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.

2. Where variable frequency drives are provided for equipment, whether installed separately or integral to the equipment, the VFDs shall conform to Division 26 Section, “Variable Frequency Motor Controllers”.

E. Wherever a UL standard has been established for a particular type of material, equipment or device, each item of such material, equipment or device provided on this project shall meet the requirements of the UL standard in every way, and shall be UL listed and labeled.

F. Products and materials shall be of the best quality customarily applied in quality commercial practice, and shall be by reputable manufacturers.

G. Each major component shall bear a nameplate giving the name and address of the manufacturer, and the catalog number or designation of the component.

H. Products and materials provided under this Division of the Specifications shall be essentially the standard item, unless otherwise noted, of the specified manufacturer, or where allowed, an alternate manufacturer.

I. Common Requirements for Independent Testing and Inspecting Agency Qualifications: Where this Section and other Sections of this Division call for an Independent Testing and Inspecting Agency (Testing Agency); the Testing Agency shall comply with the following requirements:
1. Have the experience and capability to conduct the testing indicated,
2. Be a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to the AHJ and the Engineer-of-Record.
3. Meet the following:
   a. Be an independent, third party entity which can function as an unbiased testing authority, professionally independent of the manufacturers, suppliers, and installers of equipment or systems being evaluated.
   b. Be regularly engaged in the testing of seismic support of HVAC equipment devices, installations, and systems.
   c. Use technicians who are regularly employed for testing services.

J. Provide Miami-Dade NOA certification for the following equipment mounted on a roof:
1. Custom AHUs
2. Fans
3. Ductwork Supports
4. Air-cooled Condensers
5. Pipe Stand Supports

1.12 DELIVERY, STORAGE, AND HANDLING

A. Deliver products and materials with factory-applied end caps or “heat shrink” wrappings to protect openings. Maintain opening protection through shipping, storage, and handling to prevent damage and the entrance of dirt, debris, and moisture.
B. Store light sensitive products and materials away from and protected against direct sunlight.

C. Support products and materials at all times to prevent sagging and bending.

D. The area provided for product and material storage at the jobsite shall be clean, dry and exposure to dust minimized.

E. Responsibility for the protection of products and materials shall extend to existing equipment, systems, and products and materials. Erect temporary sheltering structures, provide temporary bracing and supports, or cover existing equipment, systems, and products and materials to prevent damage and the entrance of dirt, debris, and moisture.

F. Failure on the part of the Contractor to comply with the above to the satisfaction of the Architect, Engineer, or either’s authorized representative shall be sufficient cause for the rejection of products and materials in question.

1.13 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.

D. Installation Drawings
   1. Prepare special drawings as called for elsewhere herein or directed by the Architect to coordinate this work with the work of other Divisions, to illustrate changes in this work to facilitate its concealment in finished spaces, to avoid obstructions, or to illustrate the installation of a substitute equipment item.
   2. Use these drawings in the field for the installation of all systems and components. Unless otherwise directed, do not submit these drawings for review, but provide 3 copies to the Architect for information.

E. ACTION SUBMITTALS
   1. Product Data: For the following:
      a. Dielectric fittings.
      b. Mechanical sleeve seals.
      c. Escutcheons.
PART 2 - PRODUCTS

2.1 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.

C. All piping and tubing shall be American manufactured, unless otherwise indicated.

2.2 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. Fiberglass Pipe Adhesive: As furnished or recommended by pipe manufacturer.

2.3 DIELECTRIC FITTINGS

A. Description: Combination fitting of copper alloy and ferrous materials with threaded, solder-joint, plain, or weld-neck end connections that match piping system materials.

B. Insulating Material: Suitable for system fluid, pressure, and temperature.
C. Dielectric Unions: Factory-fabricated, union assembly, for 250-psig minimum working pressure at 180 deg F.

D. Dielectric Flanges: Factory-fabricated, companion-flange assembly, for 150- or 300-psig minimum working pressure as required to suit system pressures.

E. Dielectric-Flange Kits: Companion-flange assembly for field assembly. Include flanges, full-face- or ring-type neoprene or phenolic gasket, phenolic or polyethylene bolt sleeves, phenolic washers, and steel backing washers.
   1. Separate companion flanges and steel bolts and nuts shall have 150- or 300-psig minimum working pressure where required to suit system pressures.

F. Dielectric Couplings: Galvanized-steel coupling with inert and noncorrosive, thermoplastic lining; threaded ends; and 300-psig minimum working pressure at 225 deg F.

G. Dielectric Nipples: Electroplated steel nipple with inert and noncorrosive, thermoplastic lining; plain, threaded, or grooved ends; and 300-psig minimum working pressure at 225 deg F.

2.4 MECHANICAL SLEEVE SEALS

A. Description: Modular sealing element unit, designed for field assembly, to fill annular space between pipe and sleeve.
   1. Manufacturers:
      a. Innerlynx.
      b. Link-Seal by PSI.
      c. Metraflex Co.
   2. Sealing Elements: EPDM for high temperature applications and NBR for all others unless otherwise indicated, interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe. Seal shall be same manufacturer as sleeve.
   3. Pressure Plates: Stainless steel. Include two (2) for each sealing element.
   4. Connecting Bolts and Nuts: Stainless steel of length required to secure pressure plates to sealing elements. Include one (1) for each sealing element.

2.5 SLEEVES

A. Steel Pipe: ASTM A 53, Type E, Grade B, Schedule 10, galvanized, plain ends.

2.6 ESCUTCHEONS

A. Description: Manufactured wall and ceiling escutcheons and floor plates, with an ID to closely fit around pipe, tube, and insulation of insulated piping and an OD that completely covers opening.

B. One-Piece, Cast-Brass Type: With set screw.
   1. Finish: Polished chrome-plated and rough brass, pending approval by Architect.
C. Split-Casting, Cast-Brass Type: With concealed hinge and set screw.
   1. Finish: Polished chrome-plated and rough brass, pending approval by Architect.

D. One-Piece, Floor-Plate Type: Cast-iron floor plate.

E. Split-Casting, Floor-Plate Type: Cast brass with concealed hinge and set screw.

2.7 GROUT
A. Description: ASTM C 1107, Grade B, nonshrink and nonmetallic, dry hydraulic-cement grout.
   2. Design Mix: 5000-psi, 28-day compressive strength.

PART 3 - EXECUTION

3.1 SCOPE OF WORK
A. Inspection of Site
   1. The accompanying drawings do not indicate existing mechanical installations other than to identify modifications of and extensions thereof. Site visits and installation inspections to ascertain the conditions to be met are included in the scope.
   2. Failure to comply with an inspection of the site shall not constitute ground for any additional payments in connection with removing or modifying any part of the existing installations and/or installing any new work under this Division.
   3. Review construction details of the existing portion of the building during the site inspection and include all work required to modify the existing mechanical installations and install new materials, comprising a part of the mechanical installation, within the present structure.
   4. Review all construction details of the new portion of the building as illustrated on the architectural and structural drawings and be guided thereby.

B. Products and Materials Description
   1. Where two (2) or more units of the same kind or class of a specific item are required, these shall be the products of a single manufacturer; however, the component parts of the item need not be the products of one (1) manufacturer.
   2. In describing the various products and materials, in general each item will be described singularly, even though there may be a multiplicity of identical items. Also, where the description is only general in nature, exact sizes, duties, space arrangements, horsepower requirements and other data shall be determined by reference to the Documents.

C. The Work shall include modifications and extensions to existing systems, and the modification of the existing structure as required accommodating the installation of the Work.
D. Refer to other Divisions of the Specifications for related Work.

E. Install, hang, support, etc. all MEP systems and equipment to satisfy all requirements of the applicable seismic zone using performance requirements and design criteria for project site as indicated by Architect.

F. It is the intent, unless otherwise indicated, that all products and materials described and specified under this Division, shall be provided for a complete working system irrespective of use of the phrases “install”, “furnish”, “furnish and install”, or “provide” as described above has been actually included.

G. The Contractor is responsible for all Work of every description in connection with this Division of the Specifications.

H. The Contractor specifically and distinctly assumes all risk for damage or injury from whatever cause to property or person used or employed on or in connection with this Work and of all damages or injury to any person or property wherever located, resulting from an action or operation under the Contract in connection with the Work, and undertake the promise to defend the Owner against all claims on account of any such damage or injury.

I. The Contractor will be held responsible for the satisfactory execution and completion of the Work in accordance with the true intent of the Documents.

J. Provide without extra charge all incidental items required as part of the Work, even though it may not be specifically indicated. If the Contractor has reason for objecting to the use of any material, equipment, device or method of construction as indicated, he shall make report of such objections to the Owner's Representative, obtain proper approval and adjustment to the Contract, and shall proceed with the Work.

K. Electrical Installation
   1. All electric wiring shall be installed under Division 26, except for such equipment items as are prewired at their point of manufacture and so delivered to the project, and except for the following:
      a. Temperature Control Wiring and Power Wiring provided by controls contractor.
   2. Prepare and submit for review wiring diagrams for all equipment furnished under this Division. Show on these diagrams all power, interlock, and control circuits. When the Architect takes no exception to these drawings, they shall become installation drawings for the Contractor.
   3. All chilled water, condenser water piping, domestic cold and hot water piping, and wet fire protection system shall be heat traced when routed external to the building or in areas susceptible to freezing conditions.

3.2 Schedule And Sequence Of Work

A. The Contractor shall meet and cooperate with the Owner and Owner's Representative to schedule and sequence Work so as to ensure meeting scheduled completion dates and avoid delaying other portions of the Work. Work requiring special sequencing shall be at no additional cost to the Owner and shall have no impact on the schedule.
B. Work schedules and completion dates as established shall be rigidly adhered to. Cooperate in establishing these schedules and perform the work under this Division at such times as directed so as to ensure meeting scheduled dates and avoid delaying any other Contractor.

C. The facility will continue to be in use throughout the construction period, and the schedule contemplates working in designated areas in the present facility while other adjacent areas are occupied. Execute work in this Division to minimize disturbance to occupants in adjacent areas.

D. When any work affects any services to any occupied area new permanent or temporary services, or a combination of both, shall be installed to enable occupied areas to function properly. Additional valves required shall be installed without added cost to the Owner.

E. Perform no work in the present facility that interferes with normal hours of occupancy, unless special permission is granted by the Owner. Included are operations which would cause objectionable noise or service interruptions. Each discipline shall coordinate their work with the established phases of construction.

F. Any work involving a service suspension shall be scheduled in advance with the Owner.

G. Should it be necessary to perform certain operations on an "overtime" basis in order not to interrupt the normal usage of the facility, include the costs of such overtime without change in the Contract amount.

3.3 TEMPORARY HEATING AND COOLING

A. Provide all temporary heating and cooling equipment for spaces that require continued use.

B. Should the work in the designated areas affect any services to areas that are to remain in use, provide temporary services as required to enable those occupied areas to function properly. Additional valves, ductwork, equipment and piping required shall be installed without added cost to the Owner.

3.4 HVAC DEMOLITION

A. 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: Drain piping and cap or plug piping with same or compatible piping material.
   3. Ducts to Be Removed: Remove portion of ducts indicated to be removed and plug remaining ducts with same or compatible ductwork material.
   4. Ducts to Be Abandoned in Place: Cap or plug ducts with same or compatible ductwork material.
   5. Equipment to Be Removed: Disconnect and cap services and remove equipment.
6. Equipment to Be Removed and Reinstalled: Disconnect and cap services and remove, clean, and store equipment; when appropriate, reinstall, reconnect, and make equipment operational.

7. Equipment to Be Removed and Salvaged: Disconnect and cap services and remove equipment and deliver to Owner.

B. 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.

3.5 SALVAGED MATERIALS

A. Reuse no salvaged material except as noted on the Drawings, specified herein, or directed by the Architect. Remove from the premises all present materials falling under this Division, which are removed from the existing building. Upon completion, leave no "dead" line or equipment installed in any portion of the area being remodeled, unless otherwise indicated.

3.6 ACCESS – COMMON REQUIREMENTS

A. Provide an access door in non-lay-in ceilings to maintain and inspect HVAC components. Components include, but are not limited to, the following:
   1. Actuators.
   2. Control Modules.
   3. Filter Boxes.
   6. Terminal boxes.
   7. Valves.

B. Unless otherwise indicated, access door shall provide a minimum clear opening of 30” x 30”.

3.7 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 Shop Drawings.

C. Install piping in concealed locations, unless otherwise indicated and except in equipment rooms and service areas.

D. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
E. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

F. Install piping to permit valve servicing.

G. Install piping at indicated slopes.

H. Install piping free of sags and bends.

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

J. Install piping to allow application of insulation.

K. Select system components with pressure rating equal to or greater than system operating pressure.

L. Install escutcheons, after Architect’s final approval of finish, for penetrations of walls, ceilings, and floors according to the following:
   1. New piping penetrations shall be one-piece escutcheons.
   2. Existing piping penetrations shall be two-piece escutcheons.
   3. All sleeved penetrations shall be deep-drawn allow flush installation between escutcheon and finished surface.

M. Install sleeves for pipes passing through concrete and masonry walls, gypsum-board rated partitions, and concrete floor and roof slabs.
   2. Cut sleeves to length for mounting flush with both surfaces, unless otherwise indicated.
      a. Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2 inches above finished floor level to prevent water entrance into sleeved hole. Vertical pipe supports must be extended to and be supported by the floor rather than the sleeve.
      b. Provide concrete pipe curb in floors of mechanical equipment areas or other wet areas 4 inches above finished floor level, minimum, in lieu of extended sleeves.
   3. Install sleeves in new walls and slabs as new walls and slabs are constructed.
   4. Install sleeves that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation. Use the following sleeve materials:
      a. Steel Pipe Sleeves: For pipes smaller than NPS 6.
      b. Steel Sheet Sleeves: For pipes NPS 6 and larger, penetrating gypsum-board partitions.
      c. Stack Sleeve Fittings: For pipes penetrating floors with membrane waterproofing. Secure flashing between clamping flanges. Install section of cast-iron soil pipe to extend sleeve to 2 inches above finished floor level. Refer to Division 07 Section "Sheet Metal Flashing and Trim" for flashing.
         1) Seal space outside of sleeve fittings with grout.
   5. Except for underground wall penetrations, seal annular space between sleeve and pipe or pipe insulation, using joint sealants appropriate for size, depth, and
location of joint. Refer to Division 07 Section "Joint Sealants" for materials and installation.

N. Exterior-Wall Pipe Penetrations: Seal penetrations using sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.
   1. Install steel pipe for sleeves smaller than 6 inches in diameter for above ground locations.
   2. Install cast-iron "wall pipes" for sleeves 6 inches and larger in diameter for above ground and all underground locations.
   3. Mechanical Sleeve Seal Installation: Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

O. Underground, Exterior-Wall Pipe Penetrations: Install cast-iron "wall pipes" for sleeves. Seal pipe penetrations using mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.
   1. Mechanical Sleeve Seal Installation: Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

P. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations.

Q. Verify final equipment locations for roughing-in.

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

3.8 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.

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. Fiberglass Bonded Joints: Prepare pipe ends and fittings, apply adhesive, and join according to pipe manufacturer's written instructions.

3.9 PIPING CONNECTIONS

A. Make connections according to the following, unless otherwise indicated:
1. Install unions, in piping NPS 2 and smaller, adjacent to each valve and at final connection to each piece of equipment.
2. Install flanges, in piping NPS 2-1/2 and larger, adjacent to flanged valves and at final connection to each piece of equipment.
3. Dry Piping Systems: Install dielectric unions and flanges to connect piping materials of dissimilar metals.

3.10 EQUIPMENT INSTALLATION - COMMON REQUIREMENTS

A. Equipment called for on the plans and not listed herein shall be provided as though it were fully described herein.

B. Equipment called for herein shall be completely provided, whether fully detailed or not on the plans, and/or scheduled.

C. All equipment as indicated on the plans and as described herein shall be installed per manufacturer's recommendations to allow for proper operation and maintenance of the equipment.

D. Install equipment to allow maximum possible headroom unless specific mounting heights are indicated.

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

G. Where any piece of equipment is too large for ingress through normal building openings, it shall be placed in its containing space before the enclosing structure is completed.

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

3.11 PAINTING

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

3.12 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 not less than 4 inches larger in both directions than supported unit.
2. Concrete bases for internally isolated AHU’s shall be 6 inches (150 mm) tall above finished floor.
3. Concrete bases for all other equipment shall be 4 inches (100 mm) tall above finished floor.

3.13 ERECTION OF METAL SUPPORTS AND ANCHORAGES

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

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

3.14 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.

3.15 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.

3.16 INSTALLATION INSPECTIONS AND CERTIFICATIONS

A. The Contractor shall obtain timely inspections of the installation by the constituted authorities. Remedy any deficiencies to the satisfaction of the inspecting authority.
B. Upon final completion of the work, obtain certificates of acceptance from the constituted authorities. Deliver the certificates to the Architect for transmission to the Owner.

3.17 OPERATION PRIOR TO COMPLETION

A. When any piece of mechanical or electrical equipment is operable and it is to the advantage of the contractor to operate the equipment, he may do so with permission of Owner, providing that he properly supervises the operation, retains full responsibility for the equipment operated, and protects against dirt accumulations during operation. The warranty period shall, however, not commence until such time as the equipment is operated for the beneficial use of the Owner or until final acceptance by the Owner.
B. Regardless of whether or not the equipment has or has not been operated, the Contractor shall properly clean the equipment, install clean filter media, and properly adjust the operation of the equipment before final acceptance by the Owner.
C. All equipment is to be maintained per the manufacturer’s instructions until Owner’s maintenance staff is responsible for operation and upkeep.

3.18 INSTRUCTION OF OWNER’S PERSONNEL

A. Provide the services of competent engineers and/or technicians acceptable to the Owner's Representative to instruct other representatives of the Owner in the complete and detailed operation of each item of equipment or device of all the various electrical systems. These instructions shall be provided for whatever periods may be necessary to accomplish the desired results.
B. Upon completion of these instructions, the Contractor shall obtain a letter of release, acknowledged by the Owner or his authorized representative, stating the dates on
which the various kinds of instruction were given, and the personnel to whom the instructions were given.

C. The Contractor shall be fully responsible for proper maintenance of equipment and systems until the instructions have been given the Owner's personnel and the letter of release acknowledged.

D. In providing the instructions to the Owner's personnel, the written operating and maintenance manuals shall be followed in all instances, and the Owner's personnel shall be familiarized with such manuals.

E. Operating and maintenance manuals used for instructions shall include wiring diagrams, manufacturer's operating and maintenance instructions, parts lists (with sources identified), and other data as appropriate for each system.

3.19 SEALANT

A. Apply sealant to penetrations of all floor and wall assemblies to maintain pressure differentials required by DSHS for all pressure sensitive rooms.

B. Pressure sensitive rooms include, but are not limited to:
   1. Pharmacy including Chemo Prep, Sterile Prep and Ante rooms.

C. Sealant materials and installation requirements are specified in Division 07 Section “Joint Sealants” and Division 09 Section “Gypsum Board Assemblies.”

END OF SECTION
SECTION 230513
COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT

PART 1 - GENERAL

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

B. Related Sections include the following:
   1. Division 26 Section "Enclosed Controllers".
   2. Division 26 Section "Variable Frequency Drives".

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

1.3 WARRANTY
A. All inverter-duty motors shall have minimum 5-year warranty.

PART 2 - PRODUCTS

2.1 MANUFACTURERS
A. MagneTek/Century
B. Lincoln
C. Marathon
D. General Electric
E. Gould
2.2 GENERAL MOTOR REQUIREMENTS

A. Comply with requirements in this Section except when stricter requirements are specified in HVAC equipment schedules or Sections.

B. Comply with NEMA MG 1 unless otherwise indicated.

C. Comply with IEEE 841 for severe-duty motors.

2.3 MOTOR CHARACTERISTICS

A. Duty: Continuous duty at ambient temperature of 40 deg C and at altitude of 3300 feet above sea level.

B. Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.

2.4 POLYPHASE MOTORS

A. Description: ¾ hp and larger NEMA MG 1, Design B, medium induction motor, unless otherwise indicated.

B. Efficiency: Provide premium efficiency type for all motors 1 HP and greater and conform to the minimum efficiencies as listed in ASHRAE 90.1-2013.

C. Service Factor: 1.15.

D. Multispeed Motors: Variable torque.

1. For motors with 2:1 speed ratio, consequent pole, single winding.
2. For motors with other than 2:1 speed ratio, separate winding for each speed.

E. Multispeed Motors: Separate winding for each speed.

F. Rotor: Random-wound, squirrel cage.

G. Bearings: Regreasable, shielded, antifriction ball bearings suitable for radial and thrust loading.

H. Temperature Rise: Match insulation rating.
I. Insulation: Class F.

J. Code Letter Designation:
   1. Motors 15 HP and Larger: NEMA starting Code F or Code G.
   2. Motors smaller than 15 HP: Manufacturer's standard starting characteristic.

K. Enclosure Material: Cast iron for motor frame sizes 324T and larger; rolled steel for motor frame sizes smaller than 324T.

L. Provide shaft grounding rings.

2.5 POLYPHASE MOTORS WITH ADDITIONAL REQUIREMENTS

A. Motors Used with Reduced-Voltage and Multispeed Controllers: Match wiring connection requirements for controller with required motor leads. Provide terminals in motor terminal box, suited to control method.

B. Motors Used with Variable Frequency Controllers: Ratings, characteristics, and features coordinated with and approved by controller manufacturer.
   1. Spike-proof inverter motor such that voltage spikes will not damage motor insulation.
   2. No distance restrictions between any inverter and motor.
   3. No frequency limitations.
   4. Inverter power conditioning equipment shall not be required to protect motor.

C. Windings: Copper magnet wire with moisture-resistant insulation varnish, designed and tested to resist transient spikes, high frequencies, and short time rise pulses produced by pulse-width modulated inverters.
   1. Energy- and Premium-Efficient Motors: Class B temperature rise; Class F insulation.
   2. Inverter-Duty Motors: Class F temperature rise; Class H insulation.
   3. Thermal Protection: Comply with NEMA MG 1 requirements for thermally protected motors.

D. Severe-Duty Motors: Comply with IEEE 841, with 1.15 minimum service factor.

2.6 SINGLE-PHASE MOTORS

A. Motors less than ¾ hp shall be one of the following to suit starting torque and requirements of specific motor application, unless noted otherwise:

B. Permanent-split capacitor.
   1. Split phase.
   2. Capacitor start, inductor run.
   3. Capacitor start, capacitor run.

C. Multispeed Motors: Variable-torque, permanent-split-capacitor type.
D. Bearings: Prelubricated, antifriction ball bearings or sleeve bearings suitable for radial and thrust loading.

E. Motors 1/20 HP and Smaller: Shaded-pole type.

F. Thermal Protection: Internal protection to automatically open power supply circuit to motor when winding temperature exceeds a safe value calibrated to temperature rating of motor insulation. Thermal-protection device shall automatically reset when motor temperature returns to normal range.

2.7 MOTOR ENCLOSURES

A. Provide motor enclosures according to the following list as a minimum, unless recommended by the manufacturer for the given application or unless indicated otherwise.

1. Indoor Service: ODP type.
2. Outdoor Service: TEFC type.
3. Inside an Air Stream: For fan motors installed in the air stream by the fan manufacturer the motor enclosure shall be TEAO unless indicated otherwise by the manufacturer.
4. Hazardous Service: For NEC hazardous locations motor enclosures shall be rated for the division, class, and group indicated or required.

PART 3 - EXECUTION

3.1 STARTER AND MOTOR CONTROLS

A. Provide a suitable NEMA rated starter, one per motor, for control of each motor furnished under this Division. All motors 3/4 horsepower and larger require magnetic or electronic starters, no exceptions. All motors of any size that are automatically controlled require "Hand-Auto" or "Hand-off-Auto" magnetic or electronic starters, no exceptions. All magnetic and electronic starters shall have H-O-A switches.

B. Provide each motor that does not require a starter, a manual starting switch with thermal overload protection with identifying nameplate, green pilot light and stainless steel cover plate equal to Westinghouse Type MS. Switches installed on finished walls shall be flush type.

C. Starter shall have overload protection on all phases. This will require three overload relays for three phase motors and one overload relay for one phase/line voltage motor. Provide NEMA 1B control voltage transformer, "on" green pilot light, and 1-normally open and 2-normally closed auxiliary contacts on each starter, unless otherwise noted.

D. Certain starters and motor controls for motors furnished under this Division are scheduled on the Drawings to be elements of motor control centers provided under Division 26. Except for those scheduled starters, provide a suitable starter for control of each motor furnished under this Division.
E. Each starter shall have a capacity rating within the required limits of the motor which it serves; it shall have overload elements selected to provide protection for the motor.

F. Where a combination starter and disconnect switch or starter and circuit breaker in a common enclosure is scheduled, provide auxiliary contacts on the switch or breaker as required to assure that, when the disconnecting means is open, there are no "live" contact points on the starter.

G. Where a holding coil voltage differs from line voltage, install a transformer with secondary fusing in the starter enclosure.

H. Unless otherwise indicated, furnish starters mounted indoors with NEMA Type 1 enclosures; and furnish those exposed to the weather with NEMA Type 3R enclosures.

I. Where starters are not installed in heated and cooled spaces, the heater elements shall be of the ambient temperature-compensated, bimetallic type.

END OF SECTION
SECTION 230519

METERS AND GAUGES FOR HVAC PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Thermometers.
   2. Gauges.
   3. Test plugs.
   4. Flowmeters.

B. Related Sections:
   1. Division 23 Section "Steam and Condensate Heating Piping" for steam and condensate meters.
   2. Division 23 Section "Facility Natural-Gas Piping" for gas meters.

1.2 DEFINITIONS

A. CR: Chlorosulfonated polyethylene synthetic rubber.

B. EPDM: Ethylene propylene diene monomer rubber.

1.3 ACTION SUBMITTALS

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

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

C. Shop Drawings: Schedule for thermometers, gauges, and flowmeters indicating manufacturer's number, scale range, and location for each.

1.4 INFORMATIONAL SUBMITTALS

A. Product Certificates: For each type of thermometer, gauge, and flowmeters signed by product manufacturer.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For meters and gauges to include in operation and maintenance manuals.
1.6 EXTRA MATERIALS

A. Provide a PT measurement kit with thermometers and gauges chosen to indicate system pressures and temperatures at mid-scale. Provide multiple of each as mid-scale measurement dictates.

PART 2 - PRODUCTS

2.1 THERMOMETERS

A. Digital Vari-angle Thermometer, self-powered and within 1% accuracy, Equal to Weiss Model DVU35.

1. Case: Hi-impact ABS
2. Range: -40/300 °F (-40/150 °C)
3. Display: 3/8” LCD digits, wide ambient formula
4. Accuracy: 1% of reading or 1° whichever is greater
5. Resolution: 1/10° between -19.9/199.9 °F (-28/93 °C)
6. Recalibration: Internal potentiometer
7. Lux Rating: 10 Lux (one foot-candle)
8. Update Rate: 10 seconds
9. Ambient Operating Range: -30/140 °F (-35/60 °C)
10. Ambient Temp. Error: Zero
11. Humidity: 100%
12. Sensor: Glass passivated thermistor
13. Connector: Adjustable Angle

2.2 THERMOWELLS

A. Manufacturers: Same as manufacturer of thermometer being used.

B. Description: Pressure-tight, socket-type 304 Stainless Steel fitting made for insertion into piping and of type, diameter, and length required to hold thermometer.

2.3 PRESSURE GAUGES

A. Manufacturers:

1. Ernst Gauge Co.
2. Miljoco Corp.
3. Trerice, H. O. Co.
4. Weiss Instruments, Inc.
5. Weksler Instruments Operating Unit; Dresser Industries; Instrument Div.
6. Dwyer Instruments, Inc.

B. Direct-Mounting, Dial-Type Pressure Gauges: Indicating-dial type complying with ASME B40.100.
1. Case: Liquid-filled type, cast aluminum, 4-1/2-inch diameter.
2. Pressure-Element Assembly: Bourdon tube, unless otherwise indicated.
3. Pressure Connection: Brass, NPS 1/4, bottom-outlet type unless back-outlet type is indicated.
4. Movement: Mechanical, with link to pressure element and connection to pointer.
6. Pointer: Red or Black metal.
7. Window: Glass.
9. Accuracy: Grade B, plus or minus 1/2 percent of middle half scale.
10. Vacuum-Pressure Range: 30-in. Hg of vacuum to 50 psig of pressure.
11. Range for Fluids under Pressure: Two times operating pressure.

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

1. Case: Dry type, cast aluminum, 4-1/2-inch diameter.
2. Pressure-Element Assembly: Bourdon tube, unless otherwise indicated.
3. Pressure Connection: Brass, NPS 1/4, bottom-outlet type unless back-outlet type is indicated.
4. Movement: Mechanical, with link to pressure element and connection to pointer.
6. Pointer: Red or Black metal.
7. Window: Glass.
9. Accuracy: Grade B, plus or minus 2 percent of middle half scale.
10. Vacuum-Pressure Range: 0 to 50 psig of pressure.
11. Range for Fluids under Pressure: Two times operating pressure.

D. Pressure-Gauge Fittings:

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

2.4 TEST PLUGS

A. Manufacturers:

1. Flow Design, Inc.
2. MG Piping Products Co.
4. Peterson Equipment Co., Inc.
5. Sisco Manufacturing Co.
6. Trerice, H. O. Co.
B. Description: Corrosion-resistant brass or stainless-steel body with core inserts and gasketed and threaded cap, with extended stem for units to be installed in insulated piping.

C. Minimum Pressure and Temperature Rating: 500 psig at 200 deg F.

D. Core Inserts: One or two self-sealing rubber valves.

1. Insert material for air, water, oil, or gas service at 20 to 200 deg F shall be CR.
2. Insert material for air or water service at minus 30 to plus 275 deg F shall be EPDM.

2.5 VENTURI FLOWMETERS

A. Manufacturers:

1. Armstrong Pumps, Inc.
2. Badger Meter, Inc.; Industrial Div.
5. Hyspan Precision Products, Inc.
6. Victaulic Co. of America.

B. Description: Differential-pressure design for installation in piping; with calibrated flow-measuring element, separate flowmeter, hoses or tubing, valves, fittings, and conversion chart compatible with flow-measuring element, flowmeter, and system fluid.

C. Construction: Bronze, brass, or factory-primed steel; with brass fittings and attached tag with flow conversion data.

D. Pressure Rating: 250 psig.

E. Temperature Rating: 250 deg F.

F. End Connections for NPS 2 and Smaller: Threaded.

G. End Connections for NPS 2-1/2 and Larger: Flanged or welded.

H. Range: Flow range of flow-measuring element and flowmeter shall cover operating range of equipment or system served.

I. Portable Indicators: Differential-pressure type calibrated for connected flowmeter element and having two 12-foot hoses in carrying case.

1. Scale: Gallons per minute.
2. Accuracy: Plus or minus 2 percent between 20 and 80 percent of range.

J. Operating Instructions: Include complete instructions with each flowmeter.
2.6 TURBINE FLOWMETERS

1. Turbine flowmeters can be used with a transmitter to send signals to a remote meter terminal.

B. Manufacturers:

2. Bailey-Fischer & Porter Co.
3. Data Industrial Corp.
4. Fischer, George Inc.
5. ONICON Incorporated.

C. Description: Insertion type for inserting turbine into piping and measuring flow directly in gallons per minute.

D. Construction: Bronze or stainless-steel body; with plastic turbine or impeller and integral direct-reading scale.

E. Pressure Rating: 150 psig minimum.

F. Temperature Rating: 180 deg F minimum.

G. Display: Visual instantaneous rate of flow, with register to indicate total volume in gallons.

H. Accuracy: Plus or minus 2-1/2 percent.

PART 3 - EXECUTION

3.1 THERMOMETER APPLICATIONS

A. Install digital thermometers in the following locations:

1. Inlet and outlet of each hydronic zone.
2. Inlet and outlet of each hydronic boiler and chiller.
3. Inlet and outlet of each hydronic coil in air-handling units and built-up central systems.
4. Inlet and outlet of each hydronic heat exchanger.

B. Install thermometers in separable sockets at each additional location indicated on the Drawings or specified elsewhere herein, and/or as a standard.

C. Provide the following temperature ranges for thermometers, unless otherwise indicated:

1. Heating Hot Water: 30 to 240 deg F, with 2-degree scale divisions
2. Condenser Water: 0 to 160 deg F, with 2-degree scale divisions.
3. Chilled Water: 0 to 100 deg F, with 2-degree scale divisions.
4. Steam and Condensate: 50 to 400 deg F, with 5-degree scale divisions.
3.2 GAUGE COCK APPLICATIONS

A. Install test plugs adjacent to all control sensors (except Insertion Type Flow Meters) installed in piping systems.

B. Valved pressure gauge connections shall be installed in each location indicated on the Drawings and/or specified elsewhere herein.

C. Install each gauge cock on a nipple of sufficient length so that the cock handle will be free of the pipe insulation. Position each cock so that a 4-1/2” diameter dial gauge may be easily read and screwed into and out of the cock.

D. On pumps use a single pressure gauge connected by ball valves and metal tubing to the inlet and discharge flanges as well as the suction diffuser inlet flange, if applicable.

E. Install gauge cocks at each pump as close to pump suction and discharge connections as practicable. Use any gauge connections provided in the pump casing.

3.3 GAUGE APPLICATIONS

A. Install dry-case-type pressure gauges at the following locations:

1. Discharge of each pressure-reducing valve.
2. At each steam connection to a heat exchanger in the mechanical equipment rooms.

B. Install liquid-filled-case-type pressure gauges at chilled- and condenser-water inlets and outlets of chillers.

C. On pumps use a single pressure gauge connected by ball valves and metal tubing to the inlet and discharge flanges as well as the suction diffuser inlet flange, if applicable.

D. Furnish and install calibrated pressure gauges at each location indicated on the Drawings, specified elsewhere herein, and/or as a standard.

3.4 INSTALLATIONS

A. Install thermometers and adjust vertical and tilted positions.

B. Install thermowells with socket extending one-third of diameter of pipe and in vertical position in piping tees where thermometers are indicated. Install thermowells using thermally conductive grease.

C. Install direct-mounting pressure gauges in piping tees with pressure gauge located on pipe at most readable position.

D. Install ball-valve and snubber or syphon fitting in piping for each pressure gauge for fluids (except steam).
E. Install needle-valve and siphon fitting in piping for each pressure gauge for steam.

F. Assemble and install connections, tubing, and accessories between flow-measuring elements and flowmeters as prescribed by manufacturer's written instructions.

G. Install flowmeter elements in accessible positions in piping systems.

H. Install flowmeter elements with at least (10) pipe diameters minimum straight lengths of pipe upstream and (5) pipe diameters downstream from element as prescribed by manufacturer's written instructions.

I. Install flowmeters at discharge of hydronic system pumps and at inlet of hydronic air coils, as indicated.

J. Install test plugs adjacent to all gauges and control sensors (except insertion type flow meters) installed in piping systems.

3.5 CONNECTIONS

A. Install meters and gauges adjacent to machines and equipment to allow service and maintenance for meters, gauges, machines, and equipment.

B. Connect flowmeter-system elements to meters.

C. Connect flowmeter transmitters to meters.

D. Install test plugs adjacent to the temperature sensing device used for controls for simultaneous reading with test instrument for calibration purposes.

3.6 ADJUSTING

A. Calibrate meters according to manufacturer's written instructions, after installation.

END OF SECTION
SECTION 230523

GENERAL-DUTY VALVES FOR HVAC PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Retain the reference to Ferguson Enterprises for HCA projects only.

NO OTHER PROJECT SHOULD INCLUDE THIS REFERENCE.

B. This Section includes the following general-duty valves:

1. Bronze angle valves.
2. Cast-iron angle valves.
3. Copper-alloy ball valves.
4. Ferrous-alloy ball valves.
5. Ductile-iron butterfly valves.
6. High-pressure butterfly valves.
7. Bronze check valves.
8. Cast-iron swing check valves.
11. Cast-iron gate valves.
13. Cast-iron globe valves.
15. Resilient-seated, cast-iron, eccentric plug valves.

C. Related Sections include the following:

1. Division 21 fire-suppression piping and fire pump Sections for fire-protection valves.
2. Division 23 Sections for specialty valves applicable to specific services only.
3. Division 23 Section "Identification for HVAC Piping and Equipment" for valve tags and charts.
4. Division 23 Section "Instrumentation and Control for HVAC" for actuators in control valve applications.
5. Division 23 Section “Hydronic Piping” for additional valves and fittings.

1.2 DEFINITIONS

A. CWP: Cold working pressure.

B. EPDM: Ethylene-propylene-diene terpolymer rubber.

C. HPS: High-pressure Steam. Any system pressure above 15 psig is HPS.
D. LPS: Low-pressure Steam. Any system pressure less than or equal to 15 psig is LPS.

E. NRS: Nonrising stem.

F. OS&Y: Outside screw and yoke.

G. PTFE: Polytetrafluoroethylene plastic.

H. Single Flange: Any valve design where lugs are evenly spaced around the circumference of the valve face and attach to adjoining piping using full length bolts.

I. Spring-loaded, Lift-disc Check Valve: Non-slam check valve.

J. SWP: Steam working pressure.

K. TFE: Tetrafluoroethylene plastic.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of valve indicated. Include body the following:
   1. Seating, and trim materials
   2. Valve design
   3. Pressure and temperature classifications
   4. End connections
   5. Arrangement
   6. Dimensions
   7. Required clearances.
   8. Include list indicating valve and its application by system and size.
   9. Include rated capacities
   10. Shipping, installed, and operating weights
   11. Furnished specialties
   12. Accessories.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For each valve include operation and maintenance manuals.

1.5 QUALITY ASSURANCE

A. ASME Compliance: ASME B31.1 for power piping valves and ASME B31.9 for building services piping valves.

B. ASME Compliance for Ferrous Valves: ASME B16.10 and ASME B16.34 for dimension and design criteria.
1.6 DELIVERY, STORAGE, AND HANDLING

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

B. Use the following precautions during storage:
   1. Maintain valve end protection.
   2. Store valves indoors and maintain at higher than ambient dew-point temperature. If outdoor storage is necessary, store valves off the ground in watertight enclosures.

C. Use sling to handle large valves; rig sling to avoid damage to exposed parts. Do not use handwheels or stems as lifting or rigging points.

PART 2 - PRODUCTS

2.1 VALVES, GENERAL

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

B. Copper-alloy Valves: NPS 2 and smaller with threaded ends, unless otherwise indicated. All valves shall comply with recognized industry standards such as MSS SP-80 and SP-110.

C. Ferrous Valves: NPS 2-1/2 and larger with flanged ends, unless otherwise indicated.

D. Valve Pressure and Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.

E. Valve Sizes: Same as upstream pipe, unless otherwise indicated.

F. Valve Actuators:
   1. Chainwheel: For attachment to valves, of size and mounting height, as indicated in the "Valve Installation" Article in Part 3.
   2. Gear Drive: Enclosed worm gear.
   3. Handwheel: For valves other than quarter-turn types.
   4. Lever Handle: Clamp lock.
   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. Valves in Insulated Piping: Valves shall have 3-inch stem extensions and the following features:
1. **Gate Valves**: Shall be rising-stem type.

2. **Ball Valves**: Shall have extended operating handle of non-thermal-conductive material, protective sleeve that allows operation of valve without breaking the vapor seal or disturbing insulation, and memory stops that are fully adjustable after insulation is applied.
   
   
   b. Jamesbury, Inc.
   
   c. Kitz Insulated Stem Extension Model #ISE 1 thru 4
   
   d. NIBCO Nib-seal handle extension

3. **Butterfly Valves**: Shall have extended necks.

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. Use solder with melting point below 840 deg F for angle, check, gate, and globe valves; below 421 deg F for ball valves.

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

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

2.2 **BRONZE ANGLE VALVES**

A. **Bronze Angle Valves, General**: MSS SP-80, with silicon bronze stem, non-asbestos packing and malleable-iron handwheel.

B. **Class 150, Bronze Angle Valves**: ASTM B 62 bronze body with TFE disc, union-ring bonnet, threaded ends, and having 300-psig CWP rating.
   
   1. Crane Co.; Crane Valve Group; Crane Valves.
   
   2. NIBCO Model T-335-Y
   

C. **Class 300, Bronze Angle Valves with Stainless-Steel Disc**: ASTM B 61 bronze body with stainless-steel plug and renewable seat, union-ring bonnet, threaded ends, and having 600-psig CWP rating.
   
   1. Crane Co.; Crane Valve Group; Crane Valves.
   
   2. NIBCO Model T-376-AP
   
2.3 CAST-IRON ANGLE VALVES

A. Cast-Iron Angle Valves, General: MSS SP-85, Type II; having ASTM A 126, Class B cast-iron body and bolted bonnet; bronze mounted, non-asbestos packing and gaskets; and flanged-end connections.

B. Class 125, Cast-Iron, Standard Angle Valves: 200-psig CWP rating.
   1. Crane Co.; Crane Valve Group; Crane Valves.
   2. NIBCO Model F-818-B

C. Class 250, Cast-Iron, Stop-Check Angle Valves: Stop-check design with non-asbestos packing and gaskets, and having 500-psig (3450-kPa) CWP rating.
   1. Crane Co.; Crane Valve Group; Crane Valves.
   2. NIBCO Model NIBCO Model F-869-B

2.4 COPPER ALLOY BALL VALVES

A. Brass Ball Valves, General: MSS SP-110 and have a brass body complying with ASTM B 283.

B. Bronze Ball Valves, General: MSS SP-110 and have a copper alloy body complying with ASTM B 584, except for Class 250 which shall comply with ASTM B 61, full-depth ASME B1.20.1 threaded or solder ends, and blowout-proof stems.

C. Two-Piece, Full-Port, Copper Alloy Ball Valves with Copper Alloy Trim: Chrome-plated copper alloy ball and copper alloy stem and; reinforced TFE seats; threaded body packnut design, blow-out proof stems, with adjustable stem packing, solder or threaded ends; and 150 psig (1034 kPa) SWP 600-psig (4140-kPa)CWP rating.
   2. Jamesbury, Inc.
   3. Kitz Model #68 or #69
   4. NIBCO Model S-585-70 or T-585-70

D. Two-Piece, Full-Port, Copper Alloy Ball Valves with Stainless-Steel Trim: Type 316 stainless-steel vented ball and stem, reinforced TFE seats, threaded body packnut design, blow-out proof stems, with adjustable stem packing, soldered or threaded ends; 150 psig SWP and 600-psig CWP ratings.
   2. Jamesbury, Inc.
   3. Kitz Model #68M or #69M
   4. NIBCO Model S-585-70-66 or T-585-70-66

E. Two-Piece, Full-Port, 250 psig SWP, Copper Alloy Ball Valves with Stainless-Steel Trim: Type 316 stainless-steel vented ball and stem, carbon-filled TFE seats, threaded body packnut design, blow-out proof stems, with adjustable stem packing, threaded ends; 250 psig SWP and 600-psig CWP ratings.
2. Jamesbury, Inc.
3. Kitz Model #68PM
4. NIBCO Model T-585-70-66-ST

F. Three-Piece, Full Port, Copper Alloy Ball Valves with Stainless-Steel Trim: Type 316 stainless-steel vented ball and stem, threaded body packnut, blow-out proof stems, with adjustable stem packing, stainless nuts and bolts on valve body, soldered or threaded ends; 150 psig SWP and 600-psig CWP rating.

2. Jamesbury, Inc.
3. Kitz Model #62M or #63M

2.5 FERROUS-ALLOY BALL VALVES

A. Ferrous-Alloy Ball Valves, General: MSS SP-72, with ASTM A-216 Type WCB, carbon-steel body; ASTM A-351, Type CF8M vented stainless-steel ball; and ASTM A-276, Type 316 stainless-steel stem; fire rated according to API 607 (4th edition); and having flanged ends and blowout-proof stem.

B. Class 150, Full-Port, Ferrous-Alloy Ball Valves: Split-body construction, carbon-filled TFE seats; 285 psig CWP rating.

2. Jamesbury, Inc.
3. Kitz 150SCTDZM-FS BZM-FS(C)
4. NIBCO Model F-515-CS-F-66-FS

C. Class 300, Full-Port, Ferrous-Alloy Ball Valves: Split-body construction, carbon-filled TFE seats; 720 psig CWP rating.

2. Jamesbury, Inc.
3. Kitz 300SCTDZM-FS BZM-FS(C)
4. NIBCO Model F-535-CS-F-66-FS

2.6 FERROUS-ALLOY BUTTERFLY VALVES

A. Ferrous-Alloy Butterfly Valves, General: MSS SP-67, for bubble-tight shutoff, extended-neck for insulation, disc and lining suitable for potable water, unless otherwise indicated, and with the following features:

1. Full lug, grooved and flanged valves shall be suitable for bi-directional dead end service at full rated pressure without the use or need of a downstream flange. Valves NPS 12 and smaller shall not have exposed stem to disc fasteners and no exterior mounted fasteners to hold the liner.
2. Valve sizes NPS 2 through NPS 6 shall have lever lock operator; valve sizes NPS 8 and larger shall have weatherproof gear operator.
B. Single-Flange, 150-psig CWP Rating, Aluminum-Bronze Disc, EPDM Seat, Ferrous-Alloy Butterfly Valves: Full-lug type with ductile-iron body, one- or two-piece Type 416 stainless-steel stem, bronze bushing, aluminum-bronze disc, and phenolic-backed EPDM seat (liner) attached to the body.

1. Cooper Cameron Corp.; Cooper Cameron Valves Div.
2. DeZURIK; SPX Corporation
3. Kitz Model #6123EG
4. NIBCO Model LD-1000-5

C. Single-Flange, 200-psig CWP Rating, Aluminum-Bronze Disc, EPDM Seat, Ferrous-Alloy Butterfly Valves: Full-lug type with ductile-iron body, one- or two-piece, Type 410 or 416 stainless-steel stem, copper bushing, fasteners and pins shall not be used to attach stem to disc, no pins or fasteners in waterway, aluminum-bronze disc, and molded-in EPDM seat (liner).

1. Cooper Cameron Corp.; Cooper Cameron Valves Div.
2. DeZURIK; SPX Corporation
3. Kitz Model #6123EL or #6123EG
4. NIBCO Model LD-2000-3/5

D. Grooved-End, Ferrous-Alloy Butterfly Valves with EPDM-Encapsulated Ductile-Iron Disc: Ductile-iron with grooved or shouldered ends, polyamide coating inside and outside, two-piece Type 416 stainless-steel stem, PTFE bronze sintered on steel bushing, fasteners and pins shall not be used to attach stem to disc, no pins or fasteners in waterway, and 300-psig CWP Rating for Valves NPS 2 through NPS 8, 200 psig CWP Rating for Valves NPS 10 through NPS 12.

1. Anvil International, Inc.
2. Grinnell Mechanical Products.
3. NIBCO Model GD-4765-3/5
4. Victaulic Co. of America.

2.7 HIGH-PRESSURE BUTTERFLY VALVES

A. High-Pressure Butterfly Valves, General: MSS SP-68 API 609 seat pressure and temperature ratings, ANSI B1634A body pressure and temperature ratings, ANSI B16.5 flange dimensions, ISO 5211, EN 12116 actuator mounting top works, capable of bi-directional dead-end service at full-rated pressure without use of downstream flange, carbon-steel body, offset design, extended-neck for insulation, permanently lubricated 300-series stainless-steel bushings with graphite and modified PTFE seats, graphite packing and gasket, one-piece duplex stainless-steel stem, and stainless-steel disc. Maximum steam rating of 50 psig. Valves NPS 6 and smaller shall have lever-lock operator; valves NPS 8 and larger shall have weatherproof gear operator.

B. Single-Flange, Full-Lug, 285 psig CWP Rating, High-Pressure Butterfly Valves:

1. Jamesbury, Inc.
2. NIBCO Model LCS6822-3/5
3. Xomox Corporation.
C. Single-Flange, Full-Lug, 720 psig CWP Rating, High-Pressure Butterfly Valves:
   1. Jamesbury, Inc.
   2. NIBCO Model LCS7822-3/5
   3. Xomox Corporation.

2.8 BRONZE CHECK VALVES

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

B. Class 125, Bronze, Lift Check Valves with TFE Disc: ASTM B-584 bronze body and integral seat with soldered or threaded end connections, and having 250-psig CWP rating.
   1. Crane Co.; Crane Valve Group; Crane Valves.
   2. Kitz Model #26 or #36
   3. NIBCO Model S-480-Y or T-480-Y
   4. Powell, Wm. Co.

C. Class 125, Bronze, Swing Check Valves with TFE Disc: ASTM B-62 bronze body and seat with TFE disc in bronze seat holder, Y-pattern design, soldered or threaded end connections, and having 200 psig CWP rating.
   1. Crane Co.; Crane Valve Group; Crane Valves.
   2. Kitz Model #23T or #22T
   3. NIBCO Model S-413-Y or T-413-Y
   4. Powell, Wm. Co.

D. Class 150, Bronze, Swing Check Valves with TFE Disc: ASTM B-62 bronze body and seat with TFE disc in bronze seat holder, Y-pattern design, soldered or threaded end connections, and having 300 psig CWP rating.
   1. Crane Co.; Crane Valve Group; Crane Valves.
   2. Kitz #30T or #29T
   3. NIBCO Model S-433-Y or T-433-Y
   4. Powell, Wm. Co.

E. Class 300, Bronze, Swing Check Valves with Bronze Disc: ASTM B-61 bronze body and seat with regrinding-type bronze disc, Y-pattern design, threaded end connections, and having 600 psig CWP rating.
   1. Crane Co.; Crane Valve Group; Crane Valves.
   2. Kitz Model #19
   3. NIBCO Model T-473-B
   4. Powell, Wm. Co.

2.9 IRON SWING CHECK VALVES

B. Class 125, Gray-Iron, Standard Swing Check Valves: ASTM A-126, Class B cast-iron body and bolted bonnet with flanged end connections; non-asbestos synthetic-fiber gaskets; bronze disc and seat; and having 200 psig CWP rating.

1. Crane Co.; Crane Valve Group; Crane Valves.
2. Kitz Model #78
3. NIBCO Model F-918-B
4. Powell, Wm. Co.

C. Class 250, Gray-Iron, Swing Check Valves: ASTM A-126, Class B cast-iron body and bolted bonnet with flanged end connections; non-asbestos synthetic-fiber gaskets; and bronze disc and seat; and having 500 psig CWP rating.

1. Crane Co.; Crane Valve Group; Crane Valves.
2. NIBCO Model F-968-B

D. Grooved-End, Swing Check Valves: Ductile-iron body with grooved or shouldered ends; nonasbestos, synthetic-fiber gaskets; rubber seats; and having 250-psig CWP Rating.

1. Anvil International, Inc.
2. Grinnell Mechanical Products
3. NIBCO Model G-917-W
4. Victaulic Co. of America

2.10 SPRING-LOADED, CENTER-GUIDED LIFT-DISC, IRON CHECK VALVES

A. Lift-Disc Check Valves, General: FCI 74-1 and MIL-V-18436F, with spring-loaded, center-guided bronze disc and seat.

B. Class 125, Globe, Flanged Lift-Disc Check Valves: Globe style with cast-iron body and flanged ends, and having 200 psig CWP rating.

1. NIBCO Model F-910-B
2. Kitz #7022 (wafer)
3. Metraflex Co.

C. Class 250, Globe, Flanged Lift-Disc Check Valves: Globe style with cast-iron body and flanged ends, and having 400 psig CWP rating.

1. NIBCO Model F-960-B
2. Metraflex Co.

2.11 BRONZE GATE VALVES

A. Bronze Gate Valves, General: MSS SP-80, with malleable-iron handwheel.
B. Class 150, Rising-Stem, Union-Ring Bonnet, Bronze Gate Valves: ASTM B-62 bronze body, bonnet, and wedge, copper-silicone bronze stem, union-ring bonnet, soldered or threaded end connections; and having 300 psig CWP rating.

1. Crane Co.; Crane Valve Group; Crane Valves.
2. Kitz Model #43 or #42T
3. NIBCO Model S-134 or T-134
4. Powell, Wm. Co.

C. Class 300, Rising-Stem, Stainless-Steel Wedge, Bronze Gate Valves: ASTM B-61 bronze body, bonnet and seat, stainless-steel wedge and seat, copper-silicone bronze stem, union-ring bonnet, and threaded end connections; and having 600 psig CWP rating.

1. Crane Co.; Crane Valve Group; Crane Valves.
2. NIBCO Model T-174-SS

2.12 CAST-IRON GATE VALVES

A. Cast-Iron Gate Valves, General: MSS SP-70, Type I with bolted bonnet, flanged end connections, and non-asbestos packing and gasket.

B. Class 125, OS&Y, Bronze-Mounted, Cast-Iron Gate Valves: ASTM A-126, Class B cast-iron body and bonnet with bronze trim, and solid-wedge disc; and having 200 psig CWP rating.

1. Crane Co.; Crane Valve Group; Crane Valves.
2. Kitz Model #72
3. NIBCO Model F-617-O
4. Powell, Wm. Co.

C. Class 250, OS&Y, Bronze-Mounted, Cast-Iron Gate Valves: ASTM A-126, Class B cast-iron body and bonnet with bronze trim, and solid-wedge disc; and having 500 psig CWP rating.

1. Crane Co.; Crane Valve Group; Crane Valves.
2. NIBCO Model F-667-O

2.13 BRONZE GLOBE VALVES

A. Bronze Globe Valves, General: MSS SP-80, with malleable-iron handwheel.

B. Class 150, TFE Disc, Bronze Globe Valves: ASTM B-62 bronze body, bonnet, and seat, TFE disc, copper-silicone bronze stem, union-ring bonnet, soldered or threaded end connections; and having 300 psig CWP rating.

1. Crane Co.; Crane Valve Group; Crane Valves.
2. Kitz Model #10 or #9
3. NIBCO Model S-235-Y or T-235-Y
4. Powell, Wm. Co.

C. Class 300, Stainless-Steel Disc, Bronze Globe Valves: ASTM B-61 bronze body and bonnet, stainless-steel disc and seat, copper-silicone bronze stem, union-ring bonnet, threaded end connections; and having 600 psig CWP rating.

1. Crane Co.; Crane Valve Group; Crane Valves.
2. Kitz Model #17S
3. NIBCO Model T-276-AP
4. Powell, Wm. Co.

2.14 CAST-IRON GLOBE VALVES

A. Cast-Iron Globe Valves, General: MSS SP-85 with bolted bonnet, flanged end connections, and non-asbestos packing and gasket.

B. Class 125, Metal Seat, Cast-Iron Globe Valves: ASTM A-126, Class B cast-iron body and bonnet with bronze trim and having 200 psig CWP rating.

1. Crane Co.; Crane Valve Group; Crane Valves.
2. Kitz Model #76
3. NIBCO Model F-718-B
4. Powell, Wm. Co.

C. Class 250, Metal Seat, Cast-Iron Globe Valves: ASTM A-126, Class B cast-iron body and bonnet with bronze trim and having 500 psig CWP rating.

1. Crane Co.; Crane Valve Group; Crane Valves.
2. NIBCO Model F-768-B

2.15 CAST-IRON PLUG VALVES

A. Available Manufacturers:

1. Lubricated-Type, Cast-Iron Plug Valves:
   a. Milliken Valve Co., Inc.
   b. Nordstrom Valves, Inc.
   c. Olson Technologies; Homestead Div.
   e. Walworth Co.

2. Nonlubricated-Type, Cast-Iron Plug Valves:
   a. General Signal; DeZurik Unit.
   b. Grinnell Corporation.
   e. Wheatley Gaso, Inc.
   f. Xomox Corporation.
B. Cast-Iron Plug Valves, General: MSS SP-78.
C. Class 125 or 150, lubricated-type, cast-iron plug valves.
D. Class 250 or 300, lubricated-type, cast-iron plug valves.
E. Class 125 or 150, nonlubricated-type, cast-iron plug valves.
F. Class 250, nonlubricated-type, cast-iron plug valves.

2.16 RESILIENT-SEATED, CAST-IRON, ECCENTRIC PLUG VALVES
A. Available Manufacturers:
   1. General Signal; DeZurik Unit.
   3. Olson Technologies; Homestead Div.
   4. Pratt, Henry Company.
B. Resilient-Seated, Cast-Iron, Eccentric Plug Valves, NPS 2-1/2 and Smaller: Design
   similar to MSS SP-108, and rated for 175-psig minimum CWP.
C. Resilient-Seated, Cast-Iron, Eccentric Plug Valves, NPS 3 and Larger: MSS SP-108,
   and rated for 175-psig minimum CWP.

2.17 CHAINWHEEL ACTUATORS
A. Manufacturers:
   1. Babbitt Steam Specialty Co.
   2. Roto Hammer Industries, Inc.
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. Chilled-Water Piping:

1. Ball Valves, NPS 2 and Smaller: Two-piece, full port, stainless-steel trim, copper alloy.
2. Ball Valves, NPS 2-1/2 and Larger: Class 150, full-port, ferrous alloy.
8. Lift Check Valves, NPS 2 and Smaller: Class 125, non-slam type, bronze with TFE disc.
9. Swing Check Valves, NPS 2 and Smaller: Class 150, bronze with TFE disc.
10. Swing Check Valves, NPS 2-1/2 and Larger: Class 125, non-slam type, cast-iron, standard.
12. Spring-Loaded, Center-Guided Lift-Disc Check Valves, NPS 2-1/2 and Larger: Class 125, flanged end, iron.
13. Plug Valves, NPS 2 and Larger: Class 125 or 150, 250 or 300, lubricated nonlubricated-type, cast iron.

B. Heating Water Piping:
1. Ball Valves, NPS 2 and Smaller: Two-piece, full port, stainless-steel trim, copper alloy.
2. Ball Valves, NPS 2-1/2 and Larger: Class 150, full-port, ferrous alloy.
8. Lift Check Valves, NPS 2 and Smaller: Class 125, bronze with TFE disc.
9. Swing Check Valves, NPS 2 and Smaller: Class 150, bronze with TFE disc.
10. Swing Check Valves, NPS 2-1/2 and Larger: Class 125, cast iron, standard.
12. Spring-Loaded, Center-Guided, Lift-Disc Check Valves, NPS 2-1/2 and Larger: Class 125, flanged end, iron.
13. Gate Valves, NPS 2 and Smaller: Class 150, bronze.
14. Gate Valves, NPS 2-1/2 and Larger: Class 125, cast iron.

C. Select valves, with the following end connections:

1. For Copper Tubing, NPS 2 and Smaller: Solder-joint or threaded ends, for chilled or condenser water piping systems only.
2. For Copper Tubing, NPS 2-1/2 and Larger: Flanged ends.
3. For Steel Piping, NPS 2 and Smaller: Threaded ends.
4. For Steel Piping, NPS 2-1/2 and Larger: Flanged ends.
5. For Grooved-End, Copper Tubing and Steel Piping: Valve ends may be grooved. Do not use for steam or steam condensate piping.

3.3 VALVE INSTALLATION

A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.

C. For shut-off service of hydronic systems, use

1. Up to NPS 2: Ball type.
2. NPS 2-1/2 and greater: Butterfly type.

D. Locate valves for easy access and provide separate support where necessary.

E. Install valves in horizontal piping with stem at or above center of pipe.

F. Install valves in position to allow full stem movement.
G. Provide clamp lock lever handle for all valves, other than plug type, NPS 4 or smaller.

H. Provide hand wheel for all valves, other than plug type, NPS 6 and greater.

I. Install chainwheel operators on valves NPS 4 and larger and more than 78 inches above floor. Extend chains to 60 inches above finished floor elevation.

J. 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 23 Section "Common Work Results for HVAC" 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
1.1 SUMMARY

A. This Section includes the following hangers and supports for HVAC system piping and equipment:
   1. Steel 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 include the following:
   1. Division 05 Section "Metal Fabrications" for structural-steel shapes and plates for trapeze hangers for pipe and equipment supports.
   2. Division 21 Section "Water-Based Fire-Suppression Systems" for pipe hangers for fire-protection piping.
   3. Division 23 Section "Expansion Fittings and Loops for HVAC Piping" for pipe guides and anchors.
   4. Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment" for vibration isolation devices.
   5. Division 23 Sections "Metal Ducts" and "Nonmetal Ducts" for duct hangers and supports.

1.2 DEFINITIONS

A. MFMA: Metal Framing Manufacturers Association.

B. MSS: Manufacturers Standardization Society of the Valve and Fittings Industry Inc.

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

1.3 PERFORMANCE REQUIREMENTS

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

1.4 ACTION SUBMITTALS

A. Product Data: For the following:
   1. Steel pipe hangers and supports.
   2. Fiberglass pipe hangers.
   3. Thermal-hanger shield inserts.
   4. Powder-actuated fastener systems.

B. Shop Drawings: Signed and sealed by a qualified professional engineer. Show fabrication and installation details and include calculations for the following:
   1. Trapeze pipe hangers. Include Product Data for components.
   2. Metal framing systems. Include Product Data for components.
   3. Fiberglass strut systems. Include Product Data for components.
   4. Pipe stands. Include Product Data for components.
   5. Equipment supports.

C. Delegated-Design Submittal: For trapeze hangers indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
   1. Detail fabrication and assembly of trapeze hangers.
   2. Design Calculations: Calculate requirements for designing trapeze hangers.

1.5 INFORMATIONAL SUBMITTALS

A. Welding certificates.

1.6 QUALITY ASSURANCE


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

C. Pipe hangers and supports shall conform to the recommendations of ASHRAE, ASPE, ANSI, and MSS, unless otherwise indicated.
D. Ensure anchors are acceptable per ICC for use in cracked concrete.

E. Furnish and install hangers and supports that conform to the requirements of the following codes and standards:

1. Metal Framing Manufacturers Association
   a. MFMA-4, Metal Framing Standards Publication.
   b. MFMA-103, Guidelines for the Use of Metal Framing.

**PART 2 - PRODUCTS**

**2.1 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. Available Manufacturers:

1. AAA Technology & Specialties Co., Inc.
2. Anvil.
5. Carpenter & Paterson, Inc.
6. Empire Industries, Inc.
7. ERICO/Michigan Hanger Co.
8. Globe Pipe Hanger Products, Inc.
9. Grinnell Corp.
10. GS Metals Corp.
12. PHD Manufacturing, Inc.
13. PHS Industries, Inc.
15. Tolco Inc.

C. Galvanized, Metallic Coatings: Pregalvanized or hot dipped.

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

E. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion for support of bearing surface of piping.

**2.2 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.
2.3 METAL FRAMING SYSTEMS

A. Description: MFMA-3, shop- or field-fabricated pipe-support assembly made of steel channels and other components.

B. Available Manufacturers:

2. ERICO/Michigan Hanger Co.; ERISTRUT Div.
3. GS Metals Corp.
5. Thomas & Betts Corporation.
6. Tolco Inc.
7. Unistrut Corp.; Tyco International, Ltd.

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

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

2.4 FASTENER SYSTEMS

A. Mechanical-Expansion Anchors: Insert-wedge-type or threaded-anchor-type zinc-coated or 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. Available Manufacturers:
   b. Empire Industries, Inc.
   c. Hilti, Inc.
   d. ITW Ramset/Red Head.
   e. MKT Fastening, LLC.
   f. Powers Fasteners.

2. Concrete Inserts: Steel or malleable-iron, slotted support system units similar to MSS Type 18; complying with MFMA-4 or MSS SP-58.
3. Clamps for Attachment to Steel Structural Elements: MSS SP-58, type suitable for attached structural element.
4. Through Bolts: Structural type, hex head, and high strength. Comply with ASTM A 325.
5. Toggle Bolts: All-steel springhead type.

2.5 PIPE STAND FABRICATION

A. Pipe Stands, General: 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.

1. Manufacturers:
   a. ERICO/Michigan Hanger Co.
   b. MIRO Industries.

C. Low-Type, Single-Pipe Stand: One-piece plastic or stainless-steel base unit with plastic roller, for roof installation without membrane penetration.

1. Manufacturers:
   a. MIRO Industries.
   b. Portable Pipe Hangers.

D. High-Type, Single-Pipe Stand: Assembly of base, vertical and horizontal members, and pipe support, for roof installation without membrane penetration.

1. Manufacturers:
   a. ERICO/Michigan Hanger Co.
   b. MIRO Industries.
   c. Portable Pipe Hangers.

2. Base: Plastic or stainless steel.
3. Vertical Members: Two or more cadmium-plated-steel or stainless-steel, continuous-thread rods.
4. Horizontal Member: Cadmium-plated-steel or stainless-steel rod with plastic or stainless-steel, roller-type pipe support.

E. High-Type, Multiple-Pipe Stand: Assembly of bases, vertical and horizontal members, and pipe supports, for roof installation without membrane penetration.

1. Manufacturers:
   a. Portable Pipe Hangers.

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-Mounting-Type Pipe Stands: Shop- or field-fabricated pipe support made from structural-steel shape, continuous-thread rods, and rollers for mounting on permanent stationary roof curb.

1. Available Manufacturers:
   a. Curb Technologies.
   b. Pate.
   c. Thy Curb.
1) Models:
   a) TC-1 for insulated roof decks.
   b) TC-2 for un-insulated and existing roof decks.
   c) TC-3 for Bulb-T roof decks.

2. Pipe curbs and rails with covers shall be all welded 18 gauge galvanized steel shell and baseplate, wood nailer, and TP-1 Duro EPDM cover or TP-2 pipe cover, as detailed on the drawings, for pipe penetration(s).

2.6 EQUIPMENT SUPPORTS

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

1. Available Manufacturers:
   a. Curb Technologies.
   b. Pate.
   c. Thy Curb.

1) Models:
   a) TEMS-1 for insulated roof decks.
   b) TEMS-2 for un-insulated and existing roof decks.
   c) TEMS-3 for single-ply roof systems.

2. Equipment supports shall be all welded 18 gauge galvanized steel shell, baseplate and counterflashing with internal bulkhead re-enforcement and wood nailer.

2.7 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, nonshrink and nonmetallic grout; suitable for interior and exterior applications.

2. Design Mix: 5000-psi, 28-day compressive strength.
PART 3 - EXECUTION

3.1 PREPARATION

A. Proceed with installation of hangers, supports and anchors only after required building structural work has been completed in areas where the work is to be installed. Correct inadequacies including, but not limited to proper placement of inserts, anchors and other building structural attachments.

3.2 HANGER AND SUPPORT APPLICATIONS

A. Use only one type hangers and supports, by one manufacturer, for each piping service.

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

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

D. Use galvanized steel, painted, or cadmium plated components in hangers and supports unless otherwise indicated.

E. Use nonmetallic coatings on attachments for electrolytic protection where attachments are in direct contact with copper tubing or provide copper-plated hangers and supports for copper piping systems where hangers are in contact with bare pipe.

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

G. Horizontal-Piping Hangers and Supports: Select size of hangers and supports to exactly fit pipe size for bare piping, and around piping insulation with saddle or shield for insulated piping. 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 120 to 450 deg F pipes, NPS 4 to NPS 16, requiring up to 4 inches of insulation.
3. Carbon- or Alloy-Steel, Double-Bolt Pipe Clamps (MSS Type 3): For suspension of pipes, NPS 3/4 to NPS 24, requiring clamp flexibility and up to 4 inches of insulation.
4. Steel Pipe Clamps (MSS Type 4): For suspension of cold and hot pipes, NPS 1/2 to NPS 24, if little or no insulation is required.
5. Pipe Hangers (MSS Type 5): For suspension of pipes, NPS 1/2 to NPS 4, to allow off-center closure for hanger installation before pipe erection.
6. Adjustable, Swivel Split- or Solid-Ring Hangers (MSS Type 6): For suspension of 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 2.
10. Split Pipe-Ring with or without Turnbuckle-Adjustment Hangers (MSS Type 11): For suspension of non-insulated stationary pipes, NPS 3/8 to NPS 8.
11. Extension Hinged or 2-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 Slide and Slide Plate (MSS Type 35): For support of piping where horizontal movement due to expansion and contraction may occur, and where a low coefficient of friction is desired. Support system shall include guided plate mounted on a concrete pedestal or structural steel support.
15. 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.
16. 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.
17. 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.
18. Single Pipe Rolls (MSS Type 41): For suspension of pipes, NPS 1 to NPS 30, from 2 rods if longitudinal movement caused by expansion and contraction might occur.
19. Adjustable Roller Hangers (MSS Type 43): For suspension of pipes, NPS 2-1/2 to NPS 20, from single rod if horizontal movement caused by expansion and contraction might occur.
20. 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.
21. 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.
22. 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.

H. Vertical-Piping Clamps: Select size of vertical piping clamps to exactly fit pipe size of bare pipe. 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.

I. Hanger-Rod Attachments: Select size of hanger rod attachments to suit hanger rods. 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.

J. Building Attachments: Select size of building attachments to suit hanger rods. 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.

K. 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.

L. Spring Hangers and Supports: Select spring hangers and supports to suit pipe size and loading. Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Restraint-Control Devices (MSS Type 47): Where indicated to control piping movement.
2. Spring Cushions (MSS Type 48): For light loads if vertical movement does not exceed 1-1/4 inches.
3. Spring-Cushion Roll Hangers (MSS Type 49): For equipping Type 41 roll hanger with springs.
4. Spring Sway Braces (MSS Type 50): To retard sway, shock, vibration, or thermal expansion in piping systems.
5. Variable-Spring Hangers (MSS Type 51): Preset to indicated load and limit variability factor to 25 percent to absorb expansion and contraction of piping system from hanger.
6. Variable-Spring Base Supports (MSS Type 52): Preset to indicated load and limit variability factor to 25 percent to absorb expansion and contraction of piping system from base support.
7. Variable-Spring Trapeze Hangers (MSS Type 53): Preset to indicated load and limit variability factor to 25 percent to absorb expansion and contraction of piping system from trapeze support.
8. Constant Supports: For critical piping stress and if necessary to avoid transfer of stress from one support to another support, critical terminal, or connected equipment. Include auxiliary stops for erection, hydrostatic test, and load-adjustment capability. These supports include the following types:
   a. Horizontal (MSS Type 54): Mounted horizontally.
   b. Vertical (MSS Type 55): Mounted vertically.
   c. Trapeze (MSS Type 56): Two vertical-type supports and one trapeze member.

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

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

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

3.3 HANGER AND SUPPORT INSTALLATION

A. Steel Pipe Hanger Installation: Comply with MSS SP-58 and MSS SP-69 for construction standards and applications. Install hangers, supports, clamps, and attachments as required by the following table 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 fabricated from ASTM A 36/A 36M, steel shapes selected for loads being supported. Weld steel according to AWS D1.1.**
3. Neither wire nor perforated metal shall be used to support piping, unless otherwise indicated or approved.
4. Do not support piping from other piping, unless otherwise indicated.

### 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 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-Mounting Type: Assemble components and mount on smooth roof surface. Do not penetrate roof membrane.
2. Curb-Mounting-Type Pipe Stands: Assemble components or fabricate pipe stand and mount on permanent, stationary roof curb. Refer to Division 07 Section "Roof Accessories" for curbs.

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


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

J. 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 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 so maximum pipe deflections allowed by ASME B31.1 (for power piping) and ASME B31.9 (for building services piping) are not exceeded.

N. Insulated Piping: Comply with Division 23 Section "HVAC Insulation – Duct, Equipment, and Piping" and the following:

1. Attach clamps and spacers to piping.
   a. Piping Operating above Ambient Air Temperature: Clamp may project through insulation.
   b. Piping Operating below Ambient Air Temperature: Use thermal-hanger shield insert with clamp sized to match OD of insert.
   c. Do not exceed pipe stress limits according to ASME B31.1 for power piping and 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.
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.
b. Shield Dimensions for Pipe: Not less than the following:
   1) Pipes NPS 8 and Larger: Include wood inserts.
   2) Insert Material: Length at least as long as protective shield.
c. Thermal-Hanger Shields: Install with insulation same thickness as piping insulation.

3.4 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.

3.5 METAL FABRICATIONS

A. Cut, drill, and fit miscellaneous metal fabrications for trapeze pipe hangers and equipment supports, as required, unless otherwise indicated.

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

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

3.6 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 inch.

3.7 PAINTING

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

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

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

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

END OF SECTION
SECTION 230548
VIBRATION AND SEISMIC CONTROLS FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following:

1. Delegated Design requirements for system design.
2. Isolation pads.
3. Freestanding and restrained spring isolators.
4. Elastomeric hangers.
5. Spring hangers.
7. Pipe riser resilient supports.
8. Resilient pipe guides.
10. Restraining braces and cables.
11. Steel and inertia, vibration isolation equipment bases.

B. Related Sections:

1. Division 23 Section "Common Work Results" for description of concrete bases used as vibration isolation.
2. Division 23 Section "Hangers and Supports for HVAC Piping and Equipment" for installation locations of pipe saddles at pipe hangers.

1.2 DEFINITIONS


1.3 PERFORMANCE REQUIREMENTS

A. Wind-Restraint Loading:

1. Basic Wind Speed: Refer to Structural Engineer and FBC for wind load requirements of project area.
2. Building Classification Category: II.
3. Minimum 10 lb/sq. ft. multiplied by the maximum area of the HVAC component projected on a vertical plane that is normal to the wind direction, and 45 degrees either side of normal.
1.4 ACTION SUBMITTALS

A. Submit product data and shop drawings in accordance with Division 01 and Division 23 Section “Common Work Results for HVAC” for products specified under PART 2 – PRODUCTS.

B. Product Data: For the following:

1. Include rated load, rated deflection, and overload capacity for each vibration isolation device.

C. Delegated-Design Submittal: For vibration isolation details indicated to comply with performance requirements and design criteria.

1. Design Calculations: Calculate static and dynamic loading due to equipment weight and operation, wind forces required to select vibration isolators, wind restraints, and for designing vibration isolation bases.
   a. Coordinate design calculations with wind load calculations required for equipment mounted outdoors. Comply with requirements in other Division 23 Sections for equipment mounted outdoors.

2. Riser Supports: Include riser diagrams and calculations showing anticipated expansion and contraction at each support point, initial and final loads on building structure, spring deflection changes. Include certification that riser system has been examined for excessive stress and that none will exist.

3. Vibration Isolation Base Details: Detail overall dimensions, including anchorages and attachments to structure and to supported equipment. Include auxiliary motor slides and rails, base weights, equipment static loads, power transmission, component misalignment, and cantilever loads.

4. Indicate materials and dimensions and identify hardware, including attachment and anchorage devices.

5. Field-fabricated supports.

6. Wind-Restraint Details:
   a. Design Analysis: To support selection and arrangement of wind restraints. Include calculations of combined tensile and shear loads.
   b. Details: Indicate fabrication and arrangement. Detail attachments of restraints to the restrained items and to the structure. Show attachment locations, methods, and spacings. Indicate association with vibration isolation devices.
   c. Coordinate vibration isolation details with wind-restraint details required for equipment mounted outdoors. Comply with requirements in other Division 23 Sections for equipment mounted outdoors.
   d. Preapproval and Evaluation Documentation: By an agency acceptable to authorities having jurisdiction, showing maximum ratings of restraint items and the basis for approval (tests or calculations).
1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings:
   1. Submit approval from Structural Engineer where supports are directly connected to structure.

B. Welding certificates.

C. Common Requirements For Qualification Data:

D. Qualification Data: For professional engineer.

E. Air-Mounting System Performance Certification: Include natural frequency, load, and damping test data.

F. Field quality-control test reports.

1.6 QUALITY ASSURANCE

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

B. Comply with NFPA 70.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Vibration Isolation and Control
   1. Amber/Booth Company, Inc.
   2. California Dynamics Corporation.
   3. ISAT
   5. Korfund Company.
   7. Vibro-Acoustics

2.2 VIBRATION ISOLATORS

A. Pads: Arranged in single or multiple layers of sufficient stiffness for uniform loading over pad area, molded with a non-slip pattern and galvanized-steel base plates, and factory cut to sizes that match requirements of supported equipment.
   1. Resilient Material: Oil- and water-resistant neoprene.

B. Spring Isolators: Freestanding, laterally stable, open-spring isolators.
1. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
2. Minimum Additional Travel: 50 percent of the required deflection at rated load.
3. Minimum Lateral Stiffness: $K_x/K_y = 1.0$.
4. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
5. Base plates: Factory drilled for bolting to structure and bonded to 1/4-inch-thick, rubber isolator pad attached to base plate underside. Base plates shall limit floor load to 100 psig.
6. Top Plate and Adjustment Bolt: Threaded top plate with adjustment bolt and cap screw to fasten and level equipment.

C. Restrained Spring Isolators: Freestanding, steel, open-spring isolators with seismic or limit-stop restraint.

1. Housing: Steel with resilient vertical-limit stops to prevent spring extension due to weight being removed; factory-drilled base plate bonded to 1/4-inch-thick, neoprene or rubber isolator pad attached to base plate underside; and adjustable equipment mounting and leveling bolt that acts as blocking during installation.
2. Restraint: Seismic or limit stop as required for equipment and authorities having jurisdiction.
3. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
4. Minimum Additional Travel: 50 percent of the required deflection at rated load.
5. Minimum Lateral Stiffness: $K_x/K_y = 1.0$.
6. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

D. Elastomeric Hangers: Single or double-deflection type, fitted with molded, oil-resistant elastomeric isolator elements bonded to steel housings with threaded connections for hanger rods. Color-code or otherwise identify to indicate capacity range.

E. Spring Hangers: Combination coil-spring and elastomeric-insert hanger with spring and insert in compression.

1. Frame: Steel, fabricated for connection to threaded hanger rods and to allow for a maximum of 30 degrees of angular hanger-rod misalignment without binding or reducing isolation efficiency.
2. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
3. Minimum Additional Travel: 50 percent of the required deflection at rated load.
4. Minimum Lateral Stiffness: $K_x/K_y = 1.0$.
5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
6. Elastomeric Element: Molded, oil-resistant rubber or neoprene. Steel-washer-reinforced cup to support spring and bushing projecting through bottom of frame.
7. Self-centering hanger rod cap to ensure concentricity between hanger rod and support spring coil.

F. Spring Hangers with Vertical-Limit Stop: Combination coil-spring and elastomeric-insert hanger with spring and insert in compression and with a vertical-limit stop.

1. Frame: Steel, fabricated for connection to threaded hanger rods and to allow for a maximum of 30 degrees of angular hanger-rod misalignment without binding or reducing isolation efficiency.
2. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
3. Minimum Additional Travel: 50 percent of the required deflection at rated load.
4. Minimum Lateral Stiffness: $K_x/K_y = 1.0$.
5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
6. Elastomeric Element: Molded, oil-resistant rubber or neoprene.
7. Adjustable Vertical Stop: Steel washer with neoprene washer "up-stop" on lower threaded rod.
8. Self-centering hanger rod cap to ensure concentricity between hanger rod and support spring coil.

G. Pipe Riser Resilient Support: All-directional, acoustical pipe anchor consisting of 2 steel tubes separated by a minimum of 1/2-inch-thick neoprene. Include steel and neoprene vertical-limit stops arranged to prevent vertical travel in both directions. Design support for a maximum load on the isolation material of 500 psig and for equal resistance in all directions.

H. Resilient Pipe Guides: Telescopic arrangement of 2 steel tubes or post and sleeve arrangement separated by a minimum of 1/2-inch-thick neoprene. Where clearances are not readily visible, a factory-set guide height with a shear pin to allow vertical motion due to pipe expansion and contraction shall be fitted. Shear pin shall be removable and reinsertable to allow for selection of pipe movement. Guides shall be capable of motion to meet location requirements.

2.3 RESTRAINED VIBRATION ISOLATION ROOF-CURB RAILS

A. General Requirements for Restrained Vibration Isolation Roof-Curb Rails: Factory-assembled, fully enclosed, insulated, air- and watertight curb rail designed to resiliently support equipment and to withstand wind forces.

B. Lower Support Assembly: Formed sheet-metal section containing adjustable and removable steel springs that support upper frame. Upper frame shall provide continuous support for equipment and shall be captive to resiliently resist wind forces. Lower support assembly shall have a means for attaching to building structure and a wood nailer for attaching roof materials, and shall be insulated with a minimum of 2 inches of rigid, glass-fiber insulation on inside of assembly.

C. Spring Isolators: Adjustable, restrained spring isolators shall be mounted on 1/4-inch-thick, elastomeric vibration isolation pads and shall have access ports, for level adjustment, with removable waterproof covers at all isolator locations. Isolators
shall be located so they are accessible for adjustment at any time during the life of the installation without interfering with the integrity of the roof.

1. Restrained Spring Isolators: Freestanding, steel, open-spring isolators with wind restraint.
   a. Housing: Steel with resilient vertical-limit stops and adjustable equipment mounting and leveling bolt.
   b. Outside 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. Minimum Lateral Stiffness: $K_x/K_y = 1.0$.
   e. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

2. Pads: Oil and water resistant neoprene arranged in single or multiple layers of sufficient stiffness for uniform loading over pad area, molded with a nonslip pattern and galvanized-steel base plates, and factory cut to sizes that match requirements of supported equipment.

D. Snubber Bushings: All-directional, elastomeric snubber bushings at least 1/4 inch thick.

E. Water Seal: Galvanized sheet metal with EPDM seals at corners, attached to upper support frame, extending down past wood nailer of lower support assembly, and counterflushed over roof materials.

2.4 VIBRATION ISOLATION EQUIPMENT BASES

A. Housekeeping Pads: Reinforced concrete 4” or 6” tall with 1” chamfer on all top edges.

B. Steel Base: Factory-fabricated, welded, structural-steel bases and rails.
   1. Design Requirements: Lowest possible mounting height with not less than 1-inch clearance above the floor. Include equipment anchor bolts and auxiliary motor slide bases or rails.
      a. Include supports for suction and discharge elbows for pumps.
   2. Structural Steel: Steel shapes, plates, and bars complying with ASTM A 36/A 36M. Bases shall have shape to accommodate supported equipment.
   3. Support Brackets: Factory-welded steel brackets on frame for outrigger isolation mountings and to provide for anchor bolts and equipment support.

1. Design Requirements: Lowest possible mounting height with not less than 1-inch clearance above the floor. Include equipment anchor bolts and auxiliary motor slide bases or rails.
   a. Include supports for suction and discharge elbows for pumps.
   b. The weight of each inertial block shall not be less than 150% of supported equipment.
   c. Extend block minimum 4” beyond equipment base.
   d. Chamfer edges minimum 1”.

2. Structural Steel: Steel shapes, plates, and bars complying with ASTM A 36/A 36M. Channels shall be minimum 6” deep. Bases shall have shape to accommodate supported equipment.

3. Support Brackets: Factory-welded steel brackets on frame for outrigger isolation mountings and to provide for anchor bolts and equipment support.

4. Fabrication: Fabricate steel templates to hold equipment anchor-bolt sleeves and anchors in place during placement of concrete. Obtain anchor-bolt templates from supported equipment manufacturer.

2.5 FACTORY FINISHES

A. Finish: Manufacturer's standard paint applied to factory-assembled and -tested equipment before shipping.

1. Powder coating on springs and housings.
2. All hardware shall be galvanized. Hot-dip galvanize metal components for exterior use.
3. Baked enamel or powder coat for metal components on isolators for interior use.
4. Color-code or otherwise mark vibration isolation wind-control devices to indicate capacity range.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and equipment to receive vibration isolation and wind control devices for compliance with requirements for installation tolerances and other conditions affecting performance.

B. Examine roughing-in of reinforcement and cast-in-place anchors to verify actual locations before installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.
3.2 APPLICATIONS

A. Base: Roof Curbs or Rails.

1. Equipment:
   a. Roof Exhaust Fans.
   b. Air Cooled Condensing Units.
   c. Factory Fabricated AHUs without internal isolation.

2. Isolator:
   a. Pad integral with curb.
   b. Restrained, open spring type with 1” deflection.

B. Miscellaneous Systems

1. Factory Fabricated, Internally Isolated, AHUs.
   a. Base:
      1) 6” Housekeeping pad.
      2) Factory fabricated, sound attenuating curb.
   b. Isolator: Pad.

3.3 VIBRATION-CONTROL DEVICE INSTALLATION

A. Comply with requirements in Division 07 Section "Roof Accessories" for installation of roof curbs, equipment supports, and roof penetrations.

B. Secure pipes to trapeze member with clamps approved for application by an agency acceptable to authorities having jurisdiction.

C. Install spring isolators for the closest three hangers for all piping attached to rotating equipment.

D. Equipment Restraints:

1. Install snubbers on HVAC equipment mounted on vibration isolators. Locate snubbers as close as possible to vibration isolators and bolt to equipment base and supporting structure.
2. Install resilient bolt isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inch.

E. Piping Restraints:

1. Comply with requirements in MSS SP-127.
2. Space lateral supports a maximum of 40 feet o.c., and longitudinal supports a maximum of 80 feet o.c.
3. Brace a change of direction longer than 12 feet.

F. Install cables so they do not bend across edges of adjacent equipment or building structure.

G. Install bushing assemblies for anchor bolts for floor-mounted equipment, arranged to provide resilient media between anchor bolt and mounting hole in concrete base.

H. Install bushing assemblies for mounting bolts for wall-mounted equipment, arranged to provide resilient media where equipment or equipment-mounting channels are attached to wall.

I. Strength of Support Assemblies: Select sizes of components so strength will be adequate to carry present and future static loads within specified loading limits.

J. Drilled-in Anchors:
   1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcing or embedded items during coring or drilling. Notify the structural engineer if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid pre-stressed tendons, electrical and telecommunications conduit, and gas lines.
   2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
   3. Wedge Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
   4. Adhesive Anchors: Clean holes to remove loose material and drilling dust prior to installation of adhesive. Place adhesive in holes proceeding from the bottom of the hole and progressing toward the surface in such a manner as to avoid introduction of air pockets in the adhesive.
   5. Set anchors to manufacturer's recommended torque, using a torque wrench.
   6. Install zinc-coated steel anchors for interior and stainless-steel anchors for exterior applications.

3.4 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Perform tests and inspections.

C. Tests and Inspections:
   1. Provide evidence of recent calibration of test equipment by a testing agency acceptable to authorities having jurisdiction.
   2. Schedule test with Owner, through Architect, before connecting anchorage device to restrained component (unless postconnection testing has been approved), and with at least seven days' advance notice.
4. Test at least four of each type and size of installed anchors and fasteners selected by Architect.
5. Test to 90 percent of rated proof load of device.
7. Measure isolator deflection.
8. Verify snubber minimum clearances.
9. If a device fails test, modify all installations of same type and retest until satisfactory results are achieved.

D. Remove and replace malfunctioning units and retest as specified above.
E. If a device fails test, modify all installations of same type and retest until satisfactory results are achieved.
F. Prepare a report that identifies unit components and devices checked and describes results. Include notation of deficiencies detected, remedial action taken, and observations and test results after remedial action.

3.5 ADJUSTING
A. Adjust isolators after piping system is at operating weight.
B. Adjust limit stops on restrained spring isolators to mount equipment at normal operating height. After equipment installation is complete, adjust limit stops so they are out of contact during normal operation.
C. Adjust active height of spring isolators.
D. Adjust restraints to permit free movement of equipment within normal mode of operation.

END OF SECTION
PART 1 - GENERAL

1.1 SUMMARY

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

1.2 ACTION SUBMITTALS

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

1.3 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. Plastic Labels for Equipment:

1. Material and Thickness: Multilayer, multicolor, laminated phenolic with a black surface and white substrate for mechanical engraving, 1/16 inch minimum thickness, beveled edges, and having predrilled holes for attachment hardware.
4. Maximum Temperature: Able to withstand temperatures up to 160 deg F.
5. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
7. Fasteners: Stainless-steel rivets or self-tapping screws.
8. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

B. Label Content: Include equipment's Drawing designation or unique equipment number as directed by owner. Secondary lettering shall indicate date of installation.

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.

D. Punched plastic tape for labels is not acceptable.

2.2 WARNING SIGNS AND LABELS

A. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16 inch minimum thickness, and having predrilled holes for attachment hardware.


C. Background Color: Red.

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

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

F. Minimum Letter Size: 1 inch for name of units. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
G. Fasteners: Stainless-steel rivets or self-tapping screws.

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

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

2.3 PIPE LABELS

A. General Requirements for Manufactured Pipe Labels: Preprinted, color-coded, with lettering indicating service, and showing flow direction. Labels shall conform to ANSI A13.1 and the following table:

<table>
<thead>
<tr>
<th>Outside Diameter of Pipe or of Covering</th>
<th>Height of Letters</th>
</tr>
</thead>
<tbody>
<tr>
<td>¾” to 1-1/4”</td>
<td>½”</td>
</tr>
<tr>
<td>1-1/2” to 2”</td>
<td>¾”</td>
</tr>
<tr>
<td>2-1/2” to 6”</td>
<td>1-1/4”</td>
</tr>
<tr>
<td>8” to 10”</td>
<td>2-1/2”</td>
</tr>
<tr>
<td>Over 10”</td>
<td>3-1/2”</td>
</tr>
</tbody>
</table>

B. Available Manufacturers: Seton, Brady, or Westline.

C. Pretensioned Pipe Labels: Precoiled, semirigid plastic formed to partially cover or cover full circumference of pipe.

D. Self-Adhesive Pipe Labels: Printed plastic with contact-type, permanent-adhesive backing.

E. Pipe Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings, and an arrow indicating flow direction. For steam systems, also include line pressure on label.

1. Flow-Direction Arrows: Integral with piping system service lettering to accommodate both directions, or as separate unit on each pipe label to indicate flow direction.

2.4 DUCT LABELS

A. Material and Thickness: Multicolor, plastic labels having adhesive for attachment.

B. Service:

1. Non-hazardous
   
   a. Supply
   b. Return
   c. Outside air
   d. Relief
   e. General Exhaust
2. Hazardous
   a. Isolation Exhaust
   b. Nuclear Medicine Exhaust
   c. Laboratory Exhaust
   d. Pharmacy Exhaust
   e. Other air streams as indicated

C. Letter Color:
   1. Non-hazardous Service: Black
   2. Hazardous Service: Black

D. Background Color:
   1. Non-hazardous Service: White
   2. Hazardous Service: Orange

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

F. Minimum Label Size: Length and width vary for required label content.

G. Minimum Letter Size: 2-1/2 inch for name of service.

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

I. Duct Label Contents: Include identification of duct service using same designations or abbreviations as used on Drawings and an arrow indicating flow direction.
   1. Flow-Direction Arrows: Integral with duct system service lettering to accommodate both directions or as separate unit on each duct label to indicate flow direction.

2.5 VALVE TAGS

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

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

A. Provide identification for all fire damper or smoke damper access openings.

B. Stencils: Prepared with letter sizes according to ASME A13.1 for piping; minimum letter height of 1-1/4 inches for ducts; and minimum letter height of 3/4 inch for access panel and door labels, equipment labels, and similar operational instructions.

   1. Stencil Material: Fiberboard or metal.
   2. Stencil Paint: Exterior, gloss, acrylic enamel red 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.

C. Labels

   1. Material and Thickness: Multilayer, multicolor, laminated phenolic with a red surface and white substrate for mechanical engraving, 1/16 inch (1.6 mm) minimum thickness, beveled edges, and having predrilled holes for attachment hardware.
   4. Maximum Temperature: Able to withstand temperatures up to 160 deg F (71 deg C).
   5. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch (64 by 19 mm).
   6. Minimum Letter Size: 1 inch (25.4 mm) for name of units. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
   7. Fasteners: Stainless-steel rivets or self-tapping screws.
   8. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

D. Fire Damper and Smoke Damper Stencil and Labels Contents

   1. "FIRE DAMPER" or "SMOKE DAMPER" as appropriate for each device.

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 using fasteners or adhesives.
B. Locate equipment labels where accessible and visible.

3.3 PIPE LABEL INSTALLATION

A. Piping Color-Coding:

1. Painting of piping is specified in Division 09 Section "High-Performance Coatings."
2. Provide color coding of all pipe services, either paint or PVC wrap, in the following:
   a. Boiler Rooms
   b. Central Plants / Power Houses
   c. Mechanical Rooms

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

1. Near each valve and control device.
2. Near each branch connection, excluding short takeoffs for fixtures and terminal units. Where flow pattern is not obvious, mark each pipe at branch.
3. Near penetrations through walls, floors, ceilings, and inaccessible enclosures.
4. At access doors, manholes, and similar access points that permit view of concealed piping.
5. Near major equipment items and other points of origination and termination.
6. Spaced at maximum intervals of 20 feet along each run. Reduce intervals to 10 feet in areas of congested piping and equipment.
7. In no case shall a line enter or leave a room without being identified.
8. Secure identification markers to piping by firmly pressing markers in place, following removal of protective covering. Additionally secure by banding ends of markers in place using 1/2 inch wide aluminum bands of the type normally used to secure insulation in place.

3.4 DUCT LABEL INSTALLATION

A. Install self-adhesive duct labels with permanent adhesive on the outermost surface of an installed air ducts system.

B. Locate labels near points where ducts enter into concealed spaces and at maximum intervals of 50 feet in each space where ducts are exposed or concealed by removable ceiling system.

3.5 VALVE-TAG INSTALLATION

A. Install tags on valves and control devices in piping systems except:

1. Check valves
2. Valves within factory-fabricated equipment.
3. Shutoff valves directly adjacent to equipment
4. Faucets
5. Convenience and lawn-watering hose connections
6. HVAC terminal devices

B. Emergency shut-off valves: Provide permanent equipment label with minimum 1” high lettering. These valves include valves 2” and larger for the following services:

1. Domestic cold water.
2. Domestic hot water.
3. Chilled water.
4. Heating water.
5. Steam.
6. Steam condensate.
7. Natural gas.

C. Mark ceiling grid with colored marker in style and material as required by Owner indicating valve locations above ceiling.

D. List tagged valves in a valve schedule and provide to Owner with floor plans indicating location.

3.6 FIRE DAMPER AND SMOKE DAMPER LABEL INSTALLATION

A. Stencil the words "FIRE DAMPER" or "SMOKE DAMPER" on access doors that are in sheet metal ducts. Ensure overspray of stencil medium is cleaned, removed, or covered from adjacent piping, walls, and as otherwise indicated.

B. Install tags on access doors that are in walls or ceilings where such doors conceal fire damper access plates, or on the T-bars of removable ceilings immediately below the location of fire damper access openings above.

END OF SECTION
SECTION 230593
TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes TAB to produce design objectives for the following:

1. Air Systems:
   a. Constant-volume air systems.

2. Hydronic Piping Systems:
   a. Constant-flow systems.
   b. Variable-flow systems.

3. HVAC equipment quantitative-performance settings.
4. Exhaust hood airflow balancing.
5. Space pressurization testing and adjusting.
6. Existing systems TAB.
7. Verifying that automatic control devices are functioning properly.
8. Reporting results of activities and procedures specified in this Section.

1.2 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 submains, 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. NC: Noise criteria.

F. Procedure: An approach to and execution of a sequence of work operations to yield repeatable results.

G. RC: Room criteria.

H. Report Forms: Test data sheets for recording test data in logical order.
I. Smoke-Control System: An engineered system that uses fans to produce airflow and pressure differences across barriers to limit smoke movement.

J. Smoke-Control Zone: A space within a building that is enclosed by smoke barriers and is a part of a zoned smoke-control system.

K. 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.

L. 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.

M. Suction Head: The height of fluid surface above the centerline of the pump on the suction side.

N. System Effect: A phenomenon that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system.

O. 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.

P. TAB: Testing, adjusting, and balancing.

Q. Terminal: A point where the controlled medium, such as fluid or energy, enters or leaves the distribution system.

R. Test: A procedure to determine quantitative performance of systems or equipment.

S. Testing, Adjusting, and Balancing (TAB) Firm: The entity responsible for performing and reporting TAB procedures.

1.3 INFORMATIONAL SUBMITTALS

A. Qualification Data: Within 30 days from Contractor's Notice to Proceed, submit 6 copies of evidence that TAB firm and this Project's TAB team members meet the qualifications specified in "Quality Assurance" Article.


D. System Readiness Checklists: Within 30 days of Contractor's Notice to Proceed, submit system readiness checklists as specified in "Preparation" Article.
E. Examination Report: Submit a summary report of the examination review based on system readiness reports and pre-functional check lists.

F. Certified TAB Reports: Submit two copies of reports prepared, as specified in this Section, on approved forms certified by TAB firm.

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.

1.4 QUALITY ASSURANCE

A. The TAB firm shall be organized to provide independent professional testing and balancing services. The firm shall have a minimum of one (1) Professional Engineer licensed in the project's state, in good standing with the board and have a current registration.

B. All personnel used on the job site shall be either TAB engineers or TAB technicians, who shall have been permanent, full-time employees of the Tab firm for a minimum of six (6) months prior to working on the project.

C. Upon request, the TAB Firm shall submit the following to the Architect/Engineer and/or Owner for approval prior to commencing services:
   1. Name and biographical data of the Professional Engineer and all personnel to be assigned to this project.
   2. Proof of company operation for minimum of five (5) years.

D. TAB Firm Qualifications: Engage a TAB firm certified by AABC.

E. TAB Conference: Meet with Owner's and Architect's representatives on approval of TAB strategies and procedures plan to develop a mutual understanding of the details. Ensure the participation of TAB team members, equipment manufacturers' authorized service representatives, HVAC controls installers, and other support personnel. Provide seven days' advance notice of scheduled meeting time and location.

   1. Agenda Items: As a minimum, include the following:
      a. Submittal distribution requirements.
      c. TAB plan.
      d. Work schedule and Project-site access requirements.
      e. Coordination and cooperation of trades and subcontractors.
f. Coordination of documentation and communication flow.
g. Coordinate submission of FMS sequence and schematics for review by TAB firm.

F. 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.

G. TAB Report Forms: Use standard forms from AABC's "National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems."

H. Instrumentation Type, Quantity, and Accuracy: As described in AABC's "National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems."

I. 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.

1.5 PROJECT CONDITIONS

A. Owner Occupancy: Owner may occupy the completed areas of the site and existing building prior to substantial completion. Cooperate with Owner during TAB operations to minimize conflicts with Owner's operations.

1.6 COORDINATION

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

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

C. The Contractor shall start up and test all materials and equipment which normally require testing. All piping, etc., shall be tested to meet code requirements or the specification requirements, whichever is the more stringent. All equipment shall operate a sufficient length of time at the Contractor's expense to prove to the Architect/Engineer and/or Owner that the equipment is free from mechanical defects, runs smoothly and quietly and performs satisfactorily to meet the requirements set forth in the mechanical plans and specifications.

D. In order that all HVAC systems can be properly tested, adjusted and balanced, the Contractor shall operate the HVAC systems at his expense for the length of time necessary to properly verify their completion and readiness for TAB, and shall further operate and pay all costs of operation during the TAB period. Operating
expenses to be paid for by the Contractor will include, but not necessarily be limited to, the following:

1. Utility costs; electrical, water, gas, etc.
2. Personnel costs to start, operate and stop all HVAC equipment.
3. All start-up labor and material costs.
4. All maintenance costs.

E. The plans and specifications have indicated valves, dampers and miscellaneous adjustment devices for the purpose of testing and balancing the HVAC systems to obtain optimum operating conditions. The Contractor shall install these devices in a manner that will leave them accessible and readily adjustable. Should any such device not be readily accessible, the Contractor shall provide access as required.

F. The Contractor shall provide and coordinate services to repair or replace any and all deficient items or conditions found before and during the TAB period.

G. As a part of this Project Contract, the Contractor shall make any changes in the sheaves, belts, motors, dampers and valves or the addition of dampers and/or valves as required to correctly balance the HVAC systems as required at no additional cost.

H. Provide sufficient time in Project Contract completion schedule to permit the completion of TAB services prior to Owner occupancy of the Project.

I. The Contractor shall furnish without charge to the TAB Firm:

1. One set of mechanical specifications and all addenda.
2. All pertinent change orders.
3. Complete set of mechanical plans with latest revisions.
4. “As-installed” drawings.
5. Approved control diagrams and submittals.
6. Approved manufacturer's submittals for all HVAC equipment.

1.7 WARRANTY

A. National Project Performance Guarantee: Provide a guarantee on AABC's "National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems" forms stating that AABC will assist in completing requirements of the Contract Documents if TAB firm fails to comply with the Contract Documents. Guarantee includes the following provisions:

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.
   1. Contract Documents are defined in the General and Supplementary
      Conditions of Contract.
   2. Verify that balancing devices, such as test ports, gage cocks, thermometer
      wells, flow-control devices, balancing valves and fittings, and manual volume
      dampers, are required by the Contract Documents. Verify that quantities and
      locations of these balancing devices are accessible and appropriate for
      effective balancing and for efficient system and equipment operation.
   3. Based on examination of the Contract Documents, to 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. Examine approved submittal data of HVAC systems and equipment.

C. Examine Project Record Documents described in Division 01 Section "Project
   Record Documents."

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 equipment performance data including fan and pump curves. 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. Calculate system effect factors to reduce performance
   ratings of HVAC equipment when installed under conditions different from those
   presented when the equipment was performance tested at the factory. To calculate
   system effects for air systems, use tables and charts found in AMCA 201, "Fans and
   Systems," Sections 7 through 10; or in SMACNA's "HVAC Systems--Duct Design,
   Sections 5 and 6. Compare this data with the design data and installed conditions.

F. Examine system and equipment installations to verify that they are complete and
   that testing, cleaning, adjusting, and commissioning specified in individual Sections
   have been performed.

G. Examine system and equipment test reports.

H. Examine HVAC system and equipment installations to verify that indicated
   balancing devices, such as test ports, gage cocks, thermometer wells, flow-control
   devices, balancing valves and fittings, and manual volume dampers, are properly
   installed, and that their locations are accessible and appropriate for effective
   balancing and for efficient system and equipment operation.
I. Examine systems for functional deficiencies that cannot be corrected by adjusting and balancing.

J. Examine terminal units, such as variable-air-volume boxes, to verify that they are accessible and their controls are connected and functioning.

K. Examine three-way valves for proper installation for their intended function of diverting or mixing fluid flows.

L. Examine heat-transfer coils for correct piping connections and for clean and straight fins.

M. Examine system pumps to ensure absence of entrained air in the suction piping.

N. Examine equipment for installation and for properly operating safety interlocks and controls.

O. Examine control system components to verify the following:
   1. Dampers, valves, and other controlled devices are operated by the intended controller.
   2. Dampers and valves are in the position indicated by the controller.
   3. Integrity of valves and dampers for free and full operation and for tightness of fully closed and fully open positions. This includes dampers in multizone units, mixing boxes, and variable-air-volume terminals.
   4. Automatic modulating and shutoff valves, including two-way valves and three-way mixing and diverting valves, are properly connected.
   5. Thermostats and humidistats are located to avoid adverse effects of sunlight, drafts, and cold walls.
   6. Sensors are located to sense only the intended conditions.
   7. Sequence of operation for control modes is according to the Contract Documents.
   8. Controller set points are set at indicated values.
   9. Interlocked systems are operating.
   10. Changeover from heating to cooling mode occurs according to indicated values.

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. 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. Prepare a TAB plan that includes strategies and step-by-step procedures.

C. The Contractor shall complete system readiness checks, prepare system readiness reports, and prefuctional tests including the following:
1. Permanent electrical power wiring is complete.
2. Hydronic systems are filled, clean, and free of air.
3. Control systems are operational.
4. Equipment and duct access doors are securely closed.
5. Balance, smoke, and fire dampers are open.
6. Isolating and balancing valves are open and control valves are operational.
7. Ceilings are installed in critical areas where air-pattern adjustments are required and access to balancing devices is provided.
8. Windows and doors can be closed so indicated conditions for system operations can be met.

3.3 GENERAL PROCEDURES FOR TESTING AND BALANCING

A. TAB firm shall coordinate with Contractor to gather all required system points and data without voiding manufacturers' warranties. Facility personnel and factory-authorized service representatives may also be required.

B. Perform testing and balancing procedures on each system according to the procedures contained in AABC's "National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems" and this Section.

C. Cut insulation, penetrate pipes, and equipment cabinets for installation of test probes to the minimum extent necessary to allow adequate performance of procedures. After testing and balancing, close probe holes and patch insulation with new materials identical to those removed. Restore vapor barrier and finish according to insulation Specifications for this Project.

D. Mark equipment and balancing device settings with paint or other suitable, permanent identification material, including damper-control positions, valve position indicators, fan-speed-control levers, and similar controls and devices, to show final settings.

E. Take and report testing and balancing measurements in inch-pound (IP) units.

3.4 GENERAL PROCEDURES FOR BALANCING AIR SYSTEMS

A. Prepare test reports for both fans and outlets. Obtain manufacturer's outlet factors and recommended testing procedures. Crosscheck the summation of required outlet volumes with required fan volumes.

B. Provide a marked-up set of mechanical plans or "as-built" duct layouts of systems that includes numbering of each HVAC device that corresponds to the respective item in the TAB report.

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. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.
F. Verify that motor starters are equipped with properly sized thermal protection.

G. Check dampers for proper position to achieve desired airflow path.

H. Check for airflow blockages.

I. Check condensate drains for proper connections and functioning.

J. Check for proper sealing of air-handling unit components.

K. Check for proper sealing of air duct system.

3.5 GENERAL PROCEDURES FOR HYDRONIC SYSTEMS

A. Prepare test reports for pumps, coils, and heat exchangers. Obtain approved submittals and manufacturer-recommended testing procedures. Crosscheck the summation of required coil and heat exchanger flow rates with pump design flow rate.

B. Prepare schematic diagrams of systems' "as-built" piping layouts.

C. In addition to requirements in "Preparation" Article, prepare hydronic systems for testing and balancing as follows:
   1. Check liquid level in expansion tank.
   2. Check highest vent for adequate pressure.
   3. Check flow-control valves for proper position.
   4. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.
   5. Verify that motor starters are equipped with properly sized thermal protection.
   6. Check that air has been purged from the system.

3.6 GENERAL PROCEDURES FOR DOMESTIC HOT WATER SYSTEMS

A. Balance domestic hot water recirculation, to ensure proper flow through all mains and branches. Tune system until hot water is delivered to the most remote fixture within the allowable time as required by the AHJ.

3.7 PROCEDURES FOR SPACE PRESSURIZATION MEASUREMENTS AND ADJUSTMENTS

A. Pressure testing shall be limited to the following room types:
   1. Pharmacy.

B. Before testing for space pressurization, observe the space to verify the integrity of the space boundaries. Verify that windows and doors are closed and applicable safing, gaskets, and sealants are installed. Report deficiencies and postpone testing until after the reported deficiencies are corrected.
C. Measure, adjust, and record the pressurization of each room, each zone, and each building by adjusting the supply, return, and exhaust airflows to achieve the indicated conditions.

D. Measure space pressure differential where pressure is used as the design criteria, and measure airflow differential where differential airflow is used as the design criteria for space pressurization.

1. For pressure measurements, measure and record the pressure difference between the intended spaces at the door with all doors in the space closed. Record the high-pressure side, low-pressure side, and pressure difference between each adjacent space.
2. For applications with cascading levels of space pressurization, begin in the most critical space and work to the least critical space.
3. Test room pressurization first, then zones, and finish with building pressurization.

E. To achieve indicated pressurization, set the supply airflow to the indicated conditions and adjust the exhaust and return airflow to achieve the indicated pressure or airflow difference.

F. For spaces with pressurization being monitored and controlled automatically, observe and adjust the controls to achieve the desired set point.

1. Compare the values of the measurements taken to the measured values of the control system instruments and report findings.
2. Check the repeatability of the controls by successive tests designed to temporarily alter the ability to achieve space pressurization. Test overpressurization and underpressurization, and observe and report on the system's ability to revert to the set point.
3. For spaces served by variable-air-volume supply and exhaust systems, measure space pressurization at indicated airflow and minimum airflow conditions.

G. In spaces that employ multiple modes of operation, such as normal mode and emergency mode or occupied mode and unoccupied mode, measure, adjust, and record data for each operating mode.

H. Record indicated conditions and corresponding initial and final measurements. Report deficiencies.

3.8 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.

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.

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. 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, filter, and coil face velocity.
2. Verify that the indicated airflows of the renovated work result in filter and coil face velocities and fan speeds that are within the acceptable limits defined by equipment manufacturer.
3. If calculations increase or decrease the airflow and water flow rates by more than 5 percent, make equipment adjustments to achieve the calculated airflow and water flow rates. If 5 percent or less, equipment adjustments are not required.
4. Air balance each air outlet.

3.9 TEMPERATURE-CONTROL VERIFICATION

A. Verify that controllers are calibrated and commissioned.

B. Check transmitter and controller locations and note conditions that would adversely affect control functions.

C. Record controller settings and note variances between set points and actual measurements.

D. Check the operation of limiting controllers (i.e., high- and low-temperature controllers).

E. Check free travel and proper operation of control devices such as damper and valve operators.

F. Check the sequence of operation of control devices. Note air pressures for systems with pneumatic components and device positions and correlate with airflow and water flow measurements.

G. Check the interaction of electrically operated switch transducers.
H. Check the interaction of interlock and lockout systems.

I. For pneumatic systems, check main control supply-air pressure and observe compressor and dryer operations.

J. Note operation of electric actuators using spring return for proper fail-safe operations.

3.10 TOLERANCES

A. Set HVAC system airflow and water flow rates within the following tolerances:

1. Supply, Return, and Exhaust Fans and Equipment with Fans:
   a. Up to 5000 cfm: 0 to plus 10 percent.
   b. Larger than 5000 cfm: 0 to plus 5 percent.

2. Air Devices
   a. Exhaust: 0 to -10 percent.
   b. Return: +/-5 percent.
   c. Supply: 0 to +10 percent.

3. Hydronic Flow Rates
   a. Pumps: 0 to +10 percent.
   b. Equipment: 0 to +5 percent.

3.11 REPORTING

A. Status Reports: As Work progresses, prepare 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.

3.12 FINAL REPORT

A. General: Typewritten, or computer printout in letter-quality font, on standard bond paper, in three-ring binder, tabulated and divided into sections by tested and balanced systems.

B. Include a certification sheet in front of binder signed and sealed by the certified testing and balancing engineer.

   1. Include a list of instruments used for procedures, along with proof of calibration.

C. 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, but do not include Shop Drawings and Product Data.

D. General Report Data: In addition to form titles and entries, include the following data in the final report, as applicable:

1. Title page.
2. Name and address of TAB firm.
3. Project name.
4. Project location.
5. Architect's name and address.
6. Engineer's name and address.
7. Contractor's name and address.
9. Signature of TAB firm 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, type size, and fittings.
14. Notes to explain why certain final data in the body of reports varies from indicated values.

E. Provide a marked-up set of mechanical plans or “as-built” layouts of systems that include numbering of each HVAC device that corresponds to the respective item in the TAB report.

1. Quantities of outside, 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.

F. 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 wg.
   e. Filter static-pressure differential in inches wg.
   f. Filter condition.
   g. Preheat coil static-pressure differential in inches wg.
   h. Cooling coil static-pressure differential in inches wg.
   i. Heating coil static-pressure differential in inches wg.
   j. Outside airflow in cfm.
   k. Return airflow in cfm.
   l. Outside-air damper position.
   m. Return-air damper position.
   n. Fan drive settings including VFD settings and percentage of maximum pitch diameter.
   o. Settings for supply-air static-pressure controller.

G. Apparatus-Coil Test Reports:

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

H. Electric-Coil Test Reports: For electric furnaces, duct coils, and electric coils installed in central-station air-handling units, include the following:

1. Unit Data:
   a. System identification.
   b. Location.
   c. Coil identification.
   d. Capacity in 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 deg F.
   e. Leaving-air temperature in deg F.
   f. Voltage at each connection.
   g. Amperage for each phase.

I. Fan Test Reports: For supply, return, and exhaust fans, include the following:

1. Fan Data:
   a. System identification.
   b. Location.
   c. Make and type.
   d. Model number and size.
   e. Manufacturer's serial number.
f. Arrangement and class.
g. Sheave make, size in inches, 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 wg.
   c. Fan rpm.
   d. Discharge static pressure in inches wg.
   e. Suction static pressure in inches wg.

J. Round, Flat-Oval, and Rectangular Duct Traverse Reports: Include a diagram with a grid representing the duct cross-section and record the following:

1. Report Data:
   a. System and air-handling unit number.
   b. Location and zone.
   c. Traverse air temperature in deg F.
   d. Duct static pressure in inches wg.
   e. Duct size in inches.
   f. Duct area in sq. ft..
   g. Indicated airflow rate in cfm.
   h. Indicated velocity in fpm.
   i. Actual airflow rate in cfm.
   j. Actual average velocity in fpm.
   k. Barometric pressure in psig.

K. 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.

L. System-Coil Reports: For reheat coils and water coils of terminal units, include the following:

   1. Unit Data:
      a. System and air-handling unit identification.
      b. Location and zone.
      c. Room or riser served.
      d. Coil make and size.
      e. Flowmeter type.

   2. Test Data (Indicated and Actual Values):
      a. Airflow rate in cfm.
      b. Entering-water temperature in deg F.
      c. Leaving-water temperature in deg F.
      d. Water pressure drop in feet of head or psig.
      e. Entering-air temperature in deg F.
      f. Leaving-air temperature in deg F.

M. Instrument Calibration Reports:

   1. Report Data:
      a. Instrument type and make.
      b. Serial number.
      c. Application.
      d. Dates of use.
      e. Dates of calibration.

3.13 INSPECTIONS

A. Initial Inspection:

   1. After testing and balancing are complete, operate each system and randomly check measurements to verify that the system is operating according to the final test and balance readings documented in the Final Report.

   2. Randomly 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. Measure sound levels at two locations.
e. Measure space pressure of at least 10 percent of locations.
f. Verify that balancing devices are marked with final balance position.
g. Note deviations to the Contract Documents in the Final Report.

B. Final Inspection:

1. After initial inspection is complete and evidence by random checks verifies that testing and balancing are complete and accurately documented in the final report, request that a final inspection be made by Owner.
2. TAB firm test and balance engineer shall conduct the inspection in the presence of Owner.
3. Owner shall randomly select measurements documented in the final report to be rechecked. The rechecking shall be limited to either 10 percent of the total measurements recorded, or the extent of measurements that can be accomplished in a normal 8-hour business day.
4. If the rechecks yield measurements that differ from the measurements documented in the final report by more than the tolerances allowed, the measurements shall be noted as "FAILED."
5. If the number of "FAILED" measurements is greater than 10 percent of the total measurements checked during the final inspection, the testing and balancing shall be considered incomplete and shall be rejected.
6. 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.
7. Request a second final inspection. If the second final inspection also fails, Owner shall contract the services of another TAB firm to complete the testing and balancing in accordance with the Contract Documents and deduct the cost of the services from the final payment.

3.14 ADDITIONAL TESTS

A. Within 90 days of completing TAB, perform additional testing and balancing 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 testing, inspecting, and adjusting during near-peak summer and winter conditions.
SECTION 230700

HVAC INSULATION – DUCT, EQUIPMENT, AND PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Insulation Materials:
   a. Calcium silicate.
   b. Cellular glass.
   c. Fiberglass.
   d. Flexible elastomeric.
   e. Mineral or glass fiber.
   f. Phenolic.
   g. Polyolefin.

2. Fire-rated insulation systems.
3. Factory-applied jackets.
4. Field-applied cloths.
5. Field-applied jackets.
6. Adhesives.
7. Mastics.
8. Lagging adhesives.
10. Tapes.
11. Securements.

B. Related Sections:

1. Division 21 Section "Fire-Suppression Systems Insulation."
2. Division 22 Section "Plumbing Insulation."
3. Division 23 Section "Metal Ducts" for duct liners.
4. Division 23 Section "Hangers and Supports for HVAC Piping and Equipment" for installation locations of pipe saddles at pipe hangers.
5. Division 33 Section "Underground Hydronic Energy Distribution" for loose-fill pipe insulation in underground piping outside the building.
6. Division 33 Section "Underground Steam and Condensate Distribution Piping" for loose-fill pipe insulation in underground piping outside the building.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include thermal conductivity, thickness, and jackets (both factory and field applied, if any).
B. Calculations: For insulation submitted outside of the conductivity range per the “Minimum Pipe Insulation Thickness” Table for the application listed, submit thickness calculations.

C. Shop Drawings:
   1. Detail application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.
   2. Detail attachment and covering of heat tracing inside insulation.
   3. Detail insulation application at pipe expansion joints for each type of insulation.
   4. Detail insulation application at elbows, fittings, flanges, valves, and specialties for each type of insulation.
   5. Detail removable insulation at piping specialties, equipment connections, and access panels.
   6. Detail application of field-applied jackets.
   7. Detail application at linkages of control devices.
   8. Detail field application for each equipment type.

1.3 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified Installer.

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

C. Field quality-control reports.

1.4 QUALITY ASSURANCE

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

B. Fire-Test-Response Characteristics: Insulation and related materials shall have fire-test-response characteristics indicated, as determined by testing identical products per ASTM E84, 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 and inspecting 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 size and location of supports, hangers, and insulation shields specified in Division 23 Section "Hangers and Supports for HVAC Piping and Equipment."

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

C. Coordinate installation and testing of heat tracing.

1.7 SCHEDULING

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

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

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Fiberglass

2. K-Flex.
4. Manson (Certain Teed).
5. Owens-Corning.

B. Flexible Elastomeric

1. Aeroflex / Aerocel EPDM
2. Armacell / Armaflex
3. RBX Industries / Rubatex

C. Phenolic
1. Polyguard Products
2. Resolco / Insul-Phen

D. Polyisocyanurate
   1. Dow / Trymer

E. Polyolefin
   1. Nomaco/ IMCOA Imcolock

2.2 INSULATION MATERIALS

A. Comply with requirements in Part 3 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. 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.
   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.
   3. Prefabricated Fitting Covers: Comply with ASTM C 450 and ASTM C 585 for dimensions used in preforming insulation to cover valves, elbows, tees, and flanges.

G. Cellular Glass: Inorganic, incombustible, cellular or cellulated glass with annealed, rigid, hermetically sealed cells. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
   1. Block Insulation: ASTM C 552, Type I.
   2. Special-Shaped Insulation: ASTM C 552, Type III.
   3. Board Insulation: ASTM C 552, Type IV.
   4. Preformed Pipe Insulation without Jacket: Comply with ASTM C 552, Type II, Class 1.
   5. Preformed Pipe Insulation with Factory-Applied ASJ: Comply with ASTM C 552, Type II, Class 2.
   6. Factory fabricate shapes according to ASTM C 450 and ASTM C 585.
H. Fiberglass

1. Flexible glass fiber; ASTM C553 and ASTM C1290; commercial grade; 'k' value of 0.25 at 75 degrees F; 1.5 lb/cu ft minimum density; 0.002 inch foil scrim kraft facing for air ducts.
2. Rigid glass fiber; ASTM C612, Class 1; 'k' value of 0.23 at 75 degrees F; 3.0 lb/cu ft minimum density.
3. Duct liner, flexible glass fiber; ASTM C1071; Type II, 'k' value of 0.23 at 75 degrees F; 3.0 lb/cu ft minimum density; coating air side to be black, unless otherwise indicated, and rated for 4,000 feet per minute air velocity. The airstream surface must be protected with a durable polyacrylate copolymer emulsion, or approved equal, specifically formulated to:
   a. Not support the growth of fungi or bacteria, when tested in accordance with the test method for fungi resistance in ASTM D 5590 with “0” growth rating.
   b. Act as a fungicidal protective coating: water based, VOC < 50 g/l. Fungicidal coating must be EPA registered for use in HVAC duct systems.

I. Flexible Elastomeric: Closed-cell, sponge- or expanded-rubber materials with a built-in vapor barrier. Comply with ASTM C 534, Type I for tubular materials and Type II for sheet materials.


K. Mineral-Fiber Board Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 612, Type IA or Type IB. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

L. Mineral Wool: ASTM C 547; preformed, high temperature insulation; 'k' value of 0.35 at 300 degrees F.

M. Phenolic:

1. Preformed pipe insulation of rigid, expanded, closed-cell structure. Comply with ASTM C 1126, Type III, Grade 1.
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.

N. 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.
2.3 FIRE-RATED INSULATION SYSTEMS

A. Fire-Rated Blanket: High-temperature, flexible, blanket insulation with FSK jacket that is tested and certified to provide a 2-hour fire rating by a NRTL acceptable to authority having jurisdiction.

1. Products: Subject to compliance with requirements, provide one of the following:
   a. CertainTeed Corp.; FlameChek.
   b. Johns Manville; Firetemp Wrap.
   c. 3M; Fire Barrier Wrap Products.
   d. Unifrax Corporation; FyreWrap.

2.4 THERMAL-HANGER SHIELD INSERTS

A. Description: 100-psig-minimum, compressive-strength insulation insert encased in sheet metal shield.

B. Available Manufacturers:
   1. Carpenter & Paterson, Inc.
   2. ERICO/Michigan Hanger Co.
   3. PHS Industries, Inc.
   4. Pipe Shields, Inc.
   5. Rilco Manufacturing Company, Inc.
   6. Value Engineered Products, Inc.

C. Insulation-Insert Material for Cold Piping: Water-repellent treated, ASTM C 533, Type I calcium silicate or ASTM C 552, Type II cellular glass with vapor barrier.

D. Insulation-Insert Material for Hot Piping: Water-repellent treated, ASTM C 533, Type I calcium silicate or ASTM C 552, Type II cellular glass.

E. For Trapeze or Clamped Systems: Insert and shield shall cover entire circumference of pipe.

F. For Clevis or Band Hangers: Insert and shield shall cover lower 360 degrees of pipe.

G. Insert Length: Extend 2 inches beyond sheet metal shield for piping operating below ambient air temperature.

2.5 ADHESIVES

A. Products: Subject to compliance with requirements, insulation manufacturer shall provide insulation adhesive and jacket manufacturer shall provide jacket adhesive.

B. 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.
C. Calcium Silicate Adhesive: Fibrous, sodium-silicate-based adhesive with a service temperature range of 50 to 800 deg F.

D. Cellular-Glass and Phenolic Adhesive: Solvent-based resin adhesive, with a service temperature range of minus 75 to plus 300 deg F.

E. Flexible Elastomeric and Polyolefin Adhesive: Comply with MIL-A-24179A, Type II, Class I.

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.

G. PVC Jacket Adhesive: Compatible with PVC jacket.

2.6 MASTICS

A. Products: Subject to compliance with requirements, insulation manufacturer shall provide mastics.

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

C. Vapor-Barrier Mastic: Water based; suitable for indoor and outdoor use on below ambient services.
   1. Water-Vapor Permeance: ASTM E 96, Procedure B, 0.013 perm at 43-mil dry film thickness.
   2. Service Temperature Range: Minus 20 to plus 360 deg F.

D. Breather Mastic: Water based; suitable for indoor and outdoor use on above ambient services.
   1. Water-Vapor Permeance: ASTM F 1249, 3 perms at 0.0625-inch dry film thickness.
   2. Service Temperature Range: Minus 20 to plus 200 deg F.
   3. Solids Content: 63 percent by volume and 73 percent by weight.

2.7 LAGGING ADHESIVES

A. Products: Subject to compliance with requirements, insulation manufacturer shall provide lagging adhesives.

B. Description: Comply with MIL-A-3316C Class I, Grade A and shall be compatible with insulation materials, jackets, and substrates.
   1. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over duct, equipment, and pipe insulation.
2. Service Temperature Range: Minus 50 to plus 360 deg F.

2.8 SEALANTS

A. Products: Subject to compliance with requirements, insulation manufacturer shall provide sealants

B. Joint Sealants for Cellular-Glass, and Phenolic Products:
   1. Materials shall be compatible with insulation materials, jackets, and substrates.
   2. Permanently flexible, elastomeric sealant.
   3. Service Temperature Range: Minus 100 to plus 300 deg F.

C. FSK and Metal Jacket Flashing Sealants:
   1. Materials shall be compatible with insulation materials, jackets, and substrates.
   2. Fire- and water-resistant, flexible, elastomeric sealant.
   3. Service Temperature Range: Minus 40 to plus 250 deg F.

D. ASJ Flashing Sealants, and Vinyl, PVDC, and PVC Jacket Flashing Sealants:
   1. Materials shall be compatible with insulation materials, jackets, and substrates.
   2. Fire- and water-resistant, flexible, elastomeric sealant.
   3. Service Temperature Range: Minus 40 to plus 250 deg F.

2.9 INSULATING CEMENT

A. ASTM C 195; hydraulic setting mineral fiber thermal insulating cement with dry density of no more than 38 lb/ft3 thermal conductivity of 0.96 at 400°F mean temperature, and service temperature to 1200°F.

B. Acceptable manufacturers: RAMCO or approved equal.

2.10 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 Jackets
   a. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
      1) Dow Chemical Company (The); Saran 540 Vapor Retarder Film and Saran 560 Vapor Retarder Film.
   b. PVDC Jacket for Indoor Applications: 4-mil-thick, white PVDC biaxially oriented barrier film with a permeance at 0.02 perms when tested according to ASTM E 96 and with a flame-spread index of 5 and a smoke-developed index of 20 when tested according to ASTM E 84.
   c. PVDC Jacket for Outdoor Applications: 6-mil-thick, white PVDC biaxially oriented barrier film with a permeance at 0.01 perms when tested according to ASTM E 96 and with a flame-spread index of 5 and a smoke-developed index of 25 when tested according to ASTM E 84.

6. Vinyl Jacket: White vinyl with a permeance of 1.3 perms when tested according to ASTM E 96, Procedure A, and complying with NFPA 90A and NFPA 90B.

2.11 FIELD-APPLIED CLOTHS

A. Woven Glass-Fiber Fabric: Comply with MIL-C-20079H, Type I, plain weave, and presized a minimum of 8 oz./sq. yd..

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

2.12 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, available products that may be incorporated into the Work include, but are not limited to, the following:
   a. Johns Manville; Zeston.
   c. Proto PVC Corporation; LoSmoke.
   d. Speedline Corporation; SmokeSafe.

2. Adhesive: As recommended by jacket material manufacturer.


4. Factory-fabricated fitting covers to match jacket if available; otherwise, field fabricate.
   a. Shapes: 45- and 90-degree, short- and long-radius elbows, tees, valves, flanges, unions, reducers, end caps, and mechanical joints.

5. Factory-fabricated tank heads and tank side panels.

C. Metal Jacket:

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
   a. Childers Products, Division of ITW; Metal Jacketing Systems.
   b. PABCO Metals Corporation; Surefit.
   c. RPR Products, Inc.; Insul-Mate.

   a. Factory cut and rolled to size.
   b. Finish and thickness are indicated in field-applied jacket schedules.
   c. Factory-Fabricated Fitting Covers:
      1) Same material, finish, and thickness as jacket.
      2) Preformed 2-piece or gore, 45- and 90-degree, short- and long-radius elbows.
      3) Tee covers.
      4) Flange and union covers.
      5) End caps.
      6) Beveled collars.
      7) Valve covers.
      8) Field fabricate fitting covers only if factory-fabricated fitting covers are not available.

3. Stainless-Steel Jacket: ASTM A 167 or ASTM A 240/A 240M.
   a. Factory cut and rolled to size.
   b. Material, finish, and thickness are indicated in field-applied jacket schedules.
   c. Factory-Fabricated Fitting Covers:
1) Same material, finish, and thickness as jacket.
2) Preformed 2-piece or gore, 45- and 90-degree, short- and long-radius elbows.
3) Tee covers.
4) Flange and union covers.
5) End caps.
6) Beveled collars.
7) Valve covers.
8) Field fabricate fitting covers only if factory-fabricated fitting covers are not available.

D. PVDC Jackets:

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
   a. Dow Chemical Company (The), Saran 540 Vapor Retarder Film.

2. PVDC Jacket for Indoor Applications: 4-mil-thick, white PVDC biaxially oriented barrier film with a permeance at 0.02 perms when tested according to ASTM E 96 and with a flame-spread index of 5 and a smoke-developed index of 20 when tested according to ASTM E 84.

3. PVDC Jacket for Outdoor Applications: 6-mil-thick, white PVDC biaxially oriented barrier film with a permeance at 0.01 perms when tested according to ASTM E 96 and with a flame-spread index of 5 and a smoke-developed index of 25 when tested according to ASTM E 84.


2.13 TAPES

A. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

1. Avery Dennison Corporation, Specialty Tapes Division.
2. Compac Corp.
4. Venture Tape.
5. Dow Chemical Company (The).

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

1. Width: 3 inches.
2. Thickness: 11.5 mils.
4. Elongation: 2 percent.
5. Tensile Strength: 40 lbf/inch in width.
6. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.
C. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C 1136.

1. Width: 3 inches.
2. Thickness: 6.5 mils.
4. Elongation: 2 percent.
5. Tensile Strength: 40 lbf/inch in width.
6. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.

D. PVC Tape: White vapor-retarder tape matching field-applied PVC jacket with acrylic adhesive. Suitable for indoor and outdoor applications.

1. Width: 2 inches.
2. Thickness: 6 mils.
3. Adhesion: 64 ounces force/inch in width.
4. Elongation: 500 percent.
5. Tensile Strength: 18 lbf/inch in width.

E. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive.

1. Width: 2 inches.
2. Thickness: 3.7 mils.
3. Adhesion: 100 ounces force/inch in width.
4. Elongation: 5 percent.
5. Tensile Strength: 34 lbf/inch in width.

F. PVDC Tape for Indoor Applications: White vapor-retarder PVDC tape with acrylic adhesive.

1. Width: 3 inches.
2. Film Thickness: 4 mils.
3. Adhesive Thickness: 1.5 mils.
4. Elongation at Break: 145 percent.
5. Tensile Strength: 55 lbf/inch in width.

G. PVDC Tape for Outdoor Applications: White vapor-retarder PVDC tape with acrylic adhesive.

1. Width: 3 inches.
2. Film Thickness: 6 mils.
3. Adhesive Thickness: 1.5 mils.
4. Elongation at Break: 145 percent.
5. Tensile Strength: 55 lbf/inch in width.

2.14 SECUREMENTS

A. Bands:

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
a. Childers Products; Bands.
b. PABCO Metals Corporation; Bands.
c. RPR Products, Inc.; Bands.

2. Stainless Steel: ASTM A 167 or ASTM A 240/A 240M, Type 304 or Type 316; 0.015 inch thick, 3/4 inch wide with wing or closed seal.

3. Aluminum: ASTM B 209, Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch thick, 3/4 inch wide with wing or closed seal.

B. Insulation Pins and Hangers:

a. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

   1) AGM Industries, Inc.
   2) GEMCO.
   3) Midwest Fasteners, Inc.

2. Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, minimum 0.106-inch-diameter shank, length to suit depth of insulation indicated.

3. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, minimum 0.106-inch-diameter shank, length to suit depth of insulation indicated with integral 1-1/2-inch galvanized carbon-steel washer.

4. Metal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:

   a. Baseplate: Perforated, galvanized carbon-steel sheet, 0.030 inch thick by 2 inches square.
   b. Spindle: Match ductwork material, fully annealed, 0.106-inch-diameter shank, length to suit depth of insulation indicated.
   c. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.

5. Self-Sticking-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:

   a. Baseplate: Galvanized carbon-steel sheet, 0.030 inch thick by 2 inches square.
   b. Spindle: Match ductwork material, fully annealed, 0.106-inch-diameter shank, length to suit depth of insulation indicated.
   c. Adhesive-backed base with a peel-off protective cover.
6. Insulation-Retaining Washers: Self-locking washers 0.016-inch-thick, Match pin material, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.
   a. Protect ends with capped self-locking washers incorporating a spring steel insert to ensure permanent retention of cap in exposed locations.

2.15 PIPE INSULATION HANGER SHIELDS
   A. Where hangers are placed outside the jackets of pipe insulation, provide shields or equivalent by Elcen Metal Products Company.
   B. Insulation and shields shall consist of a 360 degree insert of high-density, 100 psi, waterproof calcium silicate, encased in a 360 degree galvanized sheet steel shield. Insert shall be same thickness as adjoining pipe insulation, and shall extend 1-inch beyond sheet metal shield in each direction. Shield lengths and minimum sheet metal gauges shall be as directed below:

<table>
<thead>
<tr>
<th>PIPE SIZE</th>
<th>SHIELD LENGTH</th>
<th>MINIMUM GAUGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/2&quot; to 8&quot;</td>
<td>12&quot;</td>
<td>16</td>
</tr>
<tr>
<td>10&quot; &amp; 22&quot;</td>
<td></td>
<td>16</td>
</tr>
</tbody>
</table>

   C. Insulation and shields for Phenolic type insulation shall consist of a 360 degree insert of high-density (minimum 5 lbs/cu.ft.) phenolic insulation by the same manufacturer, encased in a 360 degree galvanized sheet steel shield. Insert shall be same thickness as adjoining pipe insulation, and shall extend 1-inch beyond sheet metal shield in each direction. Shield length and gauge per above table.
   D. Shields shall be Model A1000 – A9000, except for pipe roller applications and where pipe hanger spacing exceeds 10 feet, then provide Model CSX-CW.
   E. At the Contractor's option, shop-fabricated galvanized metal shields may be provided based on approved shop drawings. Length and gauge of sheet metal shall be as specified above.

2.16 PREMANUFACTURED COVERS
   A. Preformed manufactured PVC fitting covers with rigid one piece (half-shell) preformed rigid insulation.

PART 3 - EXECUTION

3.1 GENERAL
   A. Materials shall be applied by a qualified insulation applicator/workman skilled in this trade. Insulation shall be installed in accordance with the manufacturers written instructions and in accordance with recognized industry standards. Mechanical
fasteners shall be used whenever possible to assure permanent construction. Unsightly work shall be cause for rejection.

B. Prior to installation of any insulation materials to ferrous piping systems, the piping surfaces shall be thoroughly cleaned of all mill scale, grease and dirt and passed pressure testing.

C. Non-compressible insulation material shall be installed at hanger supports on cold piping to prevent damage to insulation and vapor barrier. All wet duct and pipe insulation shall be replaced.

D. Insulation of cold surfaces shall be vapor-sealed to prevent condensation.

E. Minimum thickness of insulation shall be as scheduled unless alternate thicknesses can be shown to meet energy performance and approved by the Engineer.

F. Where piping system insulation is specified, cover valves, strainers, unions, flanges, and fittings with pre-manufactured valve and fitting covers.

G. Install pipe insulation hanger shields.

H. Extend piping insulation without interruption through walls, floors and similar piping penetrations, there shall be no exceptions.

I. Duct insulation shall terminate at fire/smoke damper sleeves. A separate strip of insulation shall be provided around the sleeve and sealed at the wall.

J. Miscellaneous Applications
   1. Refrigerant suction lines within air cooled condensing units, heat pumps and chillers.

K. Unless indicated otherwise, insulate pipe and equipment that operates:
   1. 10 degrees or lower than ambient space temperature.
   2. 10 degrees of higher than ambient space temperature.

L. All steam valves and regulators at and below an elevation of 7' - 0" A.F.F. shall be insulated with removable asbestos free insulation jackets with Velcro fasteners to allow easy installation and removal.

3.2 APPLICATION TYPES

A. Equipment
   E1: Cut insulation to fit contour of equipment, and secure by means of bands, stick-clips, weld-pins and lugs or adhesives as required for each individual piece of equipment. Provide vapor barrier and finish as required for each specific application. Provide new cold surfaces of pumps with accessible boxes that easily separate coincidental with parting line of evaporator heads and pump casings. Resulting insulation joints shall be covered with a self-sealing, vapor-barrier
tape. Seal all laps and penetrations in vapor barrier jacket with an approved vapor barrier mastic.

B. Piping


P2: Butt insulation together and securely tape. Install factory-furnished laps at the butt joints. Neatly bevel and finish insulation where it terminates. Seal all laps and penetrations in vapor barrier jacket with an approved vapor barrier mastic.

P3: Same as P2, except install insulation over heat trace tape. Finish with metal jacket.

C. Ductwork

D1: Apply fiberglass board insulation to ducts with mechanical fasteners such as stick-clips or weld-pins (with tape and mastic) spaced as required to install full pieces of board insulation. Space on 12" centers (maximum) on the bottom of each duct and plenum. Cover joints and seams in vapor barrier facings with 3" wide matching tape, or with vapor-barrier mastic reinforced with 3" glass mesh reinforcement. Provide an additional layer of insulation board where duct-standing seams exceed the insulation thickness. Seal all laps and penetrations in vapor barrier jacket with an approved vapor barrier mastic.

D2: Wrap flexible fiberglass insulation around ducts and secure. Additionally, ducts 24 inches wide and larger shall secure insulation with stick clips on 18" centers. Lap insulation a minimum of four (4) inches and seal with an approved vapor barrier mastic. Reinforce lap with a three (3) inch wide band of either glass mesh reinforcement or foil/vapor-barrier tape. Seal raw glass to duct where insulation terminates. Seal all laps and penetrations in vapor barrier jacket with an approved vapor barrier mastic.
3.3 INSULATION SCHEDULE KEYS

<table>
<thead>
<tr>
<th>Insulation Types Key</th>
<th>Type</th>
<th>Maximum K Factor @ 75°F</th>
<th>Temp. Limit °F</th>
<th>Density Lb. Per Cubic Foot</th>
<th>Federal Spec. Compliance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1.</td>
<td>Calcium Silicate</td>
<td>0.38</td>
<td>1200</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td>2.</td>
<td>Fiberglass (Rigid)</td>
<td>0.23</td>
<td>450</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>3.</td>
<td>Fiberglass Flexible Duct Wrap</td>
<td>0.25</td>
<td>250</td>
<td>1.5</td>
</tr>
<tr>
<td></td>
<td>4.</td>
<td>Foamed Glass (Cellular)</td>
<td>0.36</td>
<td>850</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>5.</td>
<td>Foamed Plastic (Flexible)</td>
<td>0.25</td>
<td>220</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>6.</td>
<td>High Temperature Fiberglass</td>
<td>0.23</td>
<td>850</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>7.</td>
<td>Insulating Cement</td>
<td>0.7</td>
<td>1700</td>
<td></td>
</tr>
<tr>
<td></td>
<td>8.</td>
<td>Phenolic</td>
<td>0.13</td>
<td>250</td>
<td>2.5</td>
</tr>
<tr>
<td></td>
<td>9.</td>
<td>Flexible Elastomeric</td>
<td>0.27</td>
<td>220</td>
<td></td>
</tr>
<tr>
<td></td>
<td>10.</td>
<td>Polyolefin</td>
<td>0.25</td>
<td>200</td>
<td>2</td>
</tr>
</tbody>
</table>

Finishes Key

<table>
<thead>
<tr>
<th>Finishes Key</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>F1</td>
<td>8-ounce glass cloth</td>
</tr>
<tr>
<td>F2</td>
<td>Insulation cement</td>
</tr>
<tr>
<td>F3</td>
<td>0.016 aluminum, plain, up through 12&quot; pipe size; 0.016 aluminum, corrugated, for pipe sizes 14&quot; and larger</td>
</tr>
<tr>
<td>F4</td>
<td>15-mil PVC</td>
</tr>
<tr>
<td>F5</td>
<td>Foil/reinforced/kraft jacket (vapor barrier)</td>
</tr>
<tr>
<td>F6</td>
<td>1/4-inch weatherproof mastic with glass mesh reinforcement</td>
</tr>
<tr>
<td>F7</td>
<td>1/16&quot; vapor barrier mastic (0.05 perm rating) with glass mesh reinforcement</td>
</tr>
<tr>
<td>F8</td>
<td>White all-service jacket (vapor barrier) with self-sealing lap, or taped joints</td>
</tr>
<tr>
<td>F9</td>
<td>Two coats vinyl lacquer type white paint</td>
</tr>
</tbody>
</table>

3.4 DUCT AND PLENUM INSULATION

A. Outside Air Ducts and Plenums in Concealed or Exposed Locations

2. Insulation Materials:
   a. Rigid Fiberglass.
   b. Cellular Glass
   c. Phenolic
3. Application Type: D1.
5. Outdoor Finish: F1 and F2.

B. Supply Air Ducts and Plenums in Concealed Locations

3. Application Type: D2.
5. Outdoor Finish: F1 and F2.

C. Supply Air Ducts and Plenums in Exposed Locations

2. Insulation Materials:
   a. Rigid Fiberglass.
   b. Cellular Glass
   c. Phenolic
3. Application Type: D1.
5. Outdoor Finish: F1 and F2.

D. Return, Exhaust Ducts, and Plenums, and Air Devices in Concealed Locations Under an Exposed Roof.

3. Application Type: D2.
5. Outdoor Finish: F1 and F2.

E. Return, Exhaust Ducts, and Plenums, and Air Devices in Exposed Locations Under an Exposed Roof.

2. Insulation Materials:
   a. Rigid Fiberglass.
   b. Cellular Glass
   c. Phenolic
3. Application Type: D1.
5. Outdoor Finish: F1 and F2.

F. Additional Duct Installations

1. Where Noted on the Plans, Relief Air Ducts, Recirculated Air Ducts, Mixed Air Ducts and Return Air Duct shall be Internally Lined.
2. Items Not Insulated:
   a. Fibrous-glass ducts.
   b. Metal ducts with duct liner of sufficient thickness to comply with energy code and ASHRAE/IESNA 90.1.
   c. Factory-insulated flexible ducts.
   d. Factory-insulated plenums and casings.
   e. Flexible connectors.
f. Vibration-control devices.
g. Factory-insulated access panels and doors.

3. Where duct is exposed outdoors, protect the ductwork with one of the following:
   a. F9 with color as chosen by Architect.
   b. F3 where duct is externally insulated.

3.5 PIPING INSULATION

A. Minimum insulation thicknesses are scheduled below.

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

C. Items Not Insulated: Unless otherwise indicated, do not install insulation on the following unless there is a potential for personnel injury.
   1. Drainage piping located in crawl spaces.
   2. Underground piping.

D. Fitting and Valve Covers:
   1. Fitting covers shall be of preformed PVC for indoor service and metal for outdoor service.
   2. Insulation material shall be rigid and of the same or greater material type and thickness, density and conductivity as the adjoining pipe. Blanket inserts will not be allowed.
   3. Fittings on fiberglass pipe insulation shall be mitered insulation up to 2″ diameter and molded fittings for 2½″ and larger.
   4. Insulation on steam control valves, pressure reducing valves, calibrated balance valves and triple duty valves shall be provided with a manufactured removable insulation cover. Insulated covers shall be heavy canvas type, filled with insulating material and leather laces or straps to secure cover around valve or fitting.

E. Chilled Water, Cooling Condensate, and Refrigerant Piping Indoors, Concealed or Exposed.
   1. Insulation Materials:
      a. Cellular Glass, with mitered section fittings only.
      b. Phenolic.
   2. Application Type: P2.
   3. Finish:
      b. For Foam Glass only:
         1) No finish required for concealed installations above ceilings and within shafts.
2) Only field applied ASJ shall be used.

F. Hot Water, Indoors, Concealed or Exposed.
1. Insulation Material: Rigid Fiberglass.
2. Application Type: P2.

G. Chilled Water, Heating Hot Water, Cooling Condensate, Domestic Water, Refrigerant Piping Outdoors, Concealed or Exposed.
1. Insulation Material: Cellular Glass, with mitered section fittings only and field applied ASJ.
2. Application Type: P2.

### MINIMUM PIPE INSULATION THICKNESS

<table>
<thead>
<tr>
<th>FLUID TEMP. (°F)</th>
<th>Insulation Conductivity</th>
<th>Nominal Pipe or Tube Size (in.)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Conductivity</td>
<td>Mean Rating</td>
</tr>
<tr>
<td></td>
<td>Btu*/in.(/h*ft°F)</td>
<td>Temp. °F</td>
</tr>
<tr>
<td>Heating Systems (Steam, Steam Condensate, and Hot Water)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt;350 (Includes HPS)</td>
<td>0.32-0.34</td>
<td>250</td>
</tr>
<tr>
<td>251-350 (Includes HPR, BF)</td>
<td>0.29-0.32</td>
<td>200</td>
</tr>
<tr>
<td>201-250 (Includes LPS, LPR)</td>
<td>0.23</td>
<td>150</td>
</tr>
<tr>
<td>141-200 (Includes HS, HR)</td>
<td>0.23</td>
<td>125</td>
</tr>
<tr>
<td>105-140</td>
<td>0.23</td>
<td>100</td>
</tr>
<tr>
<td>Cooling Systems (Chilled Water, Brine, and Refrigerant)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>≥40</td>
<td>0.36</td>
<td>100</td>
</tr>
<tr>
<td>&lt;40</td>
<td>0.36</td>
<td>100</td>
</tr>
</tbody>
</table>

**Notes:**

1. The above table is applicable to insulations in the conductivity ranges stated only. For insulation outside these conductivity ranges, the minimum thickness (T) shall be determined by the following calculation and the calculation submitted for acceptance:

\[
T = r \left( \frac{1+t}{r} \right)^{K/k} - 1
\]

where T = Thickness
r = Actual outside radius of pipe (in.)
t = Insulation thickness per the above table
K = Conductivity of alternate material
k = Upper value of the Conductivity Range per the above table

**END OF SECTION**
SECTION 230900
INSTRUMENTATION AND CONTROL FOR HVAC

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes control equipment for HVAC systems and components, including control components for terminal heating and cooling units not supplied with factory-wired controls.

B. Related Sections include the following:

1. Division 23 Section "Meters and Gages for HVAC Piping" for measuring equipment that relates to this Section.
2. Division 23 Section “Custom Central Station AHUs” for additional requirements.

1.2 DEFINITIONS

A. Analog: A continuously varying signal value, such as current, flow, pressure, or temperature.

B. BACnet Specific Definitions:

2. BACnet Interoperability Building Blocks (BIBBs): BIBB defines a small portion of BACnet functionality that is needed to perform a particular task. BIBBs are combined to build the BACnet functional requirements for a device.
3. BACnet/IP: Defines and allows using a reserved UDP socket to transmit BACnet messages over IP networks. A BACnet/IP network is a collection of one or more IP subnetworks that share the same BACnet network number.
5. PICS (Protocol Implementation Conformance Statement): Written document that identifies the particular options specified by BACnet that are implemented in a device.

C. Binary: Two-state signal where a high signal level represents "ON" or "OPEN" condition and a low signal level represents "OFF" or "CLOSED" condition. "Digital" is sometimes used interchangeably with "Binary" to indicate a two-state signal.

D. Controller: Generic term for any standalone, microprocessor-based, digital controller residing on a network, used for local or global control. Three types of
controllers are indicated: Network Controller, Programmable Application Controller, and Application-Specific Controller.

E. Control System Integrator: An entity that assists in expansion of existing enterprise system and support of additional operator interfaces to I/O being added to existing enterprise system.

F. DDC: Direct digital control.

G. EPO: Emergency power off. An emergency push-button used to de-energize connected power equipment. EPOs are typically installed at room egresses and have a guard to prevent accidental activation.

H. Gateway: Bidirectional protocol translator that connects control systems that use different communication protocols.

I. I/O: System through which information is received and transmitted. I/O refers to analog input (AI), binary input (BI), analog output (AO) and binary output (BO). Analog signals are continuous and represent control influences such as flow, level, moisture, pressure, and temperature. Binary signals convert electronic signals to digital pulses (values) and generally represent two-position operating and alarm status. "Digital," (DI and (DO), is sometimes used interchangeably with "Binary," (BI) and (BO), respectively.

J. LON Specific Definitions:

1. FTT-10: Echelon Transmitter-Free Topology Transceiver.
2. LonMark: Association comprising suppliers and installers of LonTalk products. Association provides guidelines for implementing LonTalk protocol to ensure interoperability through a standard or consistent implementation.
3. LonTalk: An open standard protocol developed by the Echelon Corporation that uses a "Neuron Chip" for communication. LonTalk is a register trademark of Echelon.
4. LonWorks: Network technology developed by Echelon.
5. Node: Device that communicates using CEA-709.1-C protocol and that is connected to a CEA-709.1-C network.
6. Node Address: The logical address of a node on the network, consisting of a Domain number, Subnet number, and Node number. "Node number" portion of an address is a number assigned to device during installation, is unique within a subnet, and is not a factory-set unique Node ID.
7. Node ID: A unique 48-bit identifier assigned at factory to each CEA-709.1-C device. Sometimes called a "Neuron ID."
8. Program ID: An identifier (number) stored in a device (usually EEPROM) that identifies node manufacturer, functionality of device (application and sequence), transceiver used, and intended device usage.
10. Standard Network Variable Type (SNVT): Pronounced "snivet." A standard format type maintained by LonMark used to define data information transmitted and received by individual nodes. "SNVT" is used in two ways. It is an acronym for "Standard Network Variable Type" and is often used to
indicate a network variable itself (i.e., it can mean "a network variable of a standard network variable type").

11. Subnet: Consists of a logical grouping of up to 127 nodes, where logical grouping is defined by node addressing. Each subnet is assigned a number, which is unique within a Domain. See "Node Address."

12. TP/FT-10: Free Topology Twisted Pair network defined by CEA-709.3 and is most common media type for a CEA-709.1-C control network.

13. TP/XF-1250: High-speed, 1.25-Mbps, twisted-pair, doubly terminated bus network defined by "LonMark Interoperability Guidelines" typically used only to connect multiple TP/FT-10 networks.


15. User-Defined Network Variable Type (UNVT): Network variable format defined by device manufacturer. UNVTs create non-standard communications that other vendors' devices may not correctly interpret and may negatively impact system operation. UNVTs are not allowed.

K. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control, signaling power-limited circuits.

L. Modbus TCP/IP: An open protocol for exchange of process data.

M. MS/TP: Master-slave/token-passing, IEE 8802-3. Datalink protocol LAN option that uses twisted-pair wire for low-speed communication.

N. MTBF: Mean time between failures.

O. Network Controller: Digital controller, which supports a family of programmable application controllers and application-specific controllers, that communicate on peer-to-peer network for transmission of global data.

P. Network Repeater: Device that receives data packet from one network and rebroadcasts it to another network. No routing information is added to protocol.

Q. PC: Personal computer.

R. Peer to Peer: Networking architecture that treats all network stations as equal partners.

S. PID: Proportional plus integral plus derivative.

T. RTD: Resistance temperature detector.

U. UPS: Uninterruptible power supply.

V. USB: Universal Serial Bus.

1.3 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 deg 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 deg F.
   e. Ducted Air Temperature: Plus or minus 1 deg F.
   f. Outside Air Temperature: Plus or minus 2 deg F.
   g. Dew Point Temperature: Plus or minus 3 deg F.
   h. Temperature Differential: Plus or minus 0.25 deg 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 wg.
   n. Air Pressure (Ducts): Plus or minus 0.1-inch wg.
   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.

1.4 ACTION SUBMITTALS

A. Multiple Submissions:
   1. If multiple submissions are required to execute work within schedule, first submit a coordinated schedule clearly defining intent of multiple submissions. Include a proposed date of each submission with a detailed description of submittal content to be included in each submission.
   2. Clearly identify each submittal requirement indicated and in which submission the information will be provided.
   3. Include an updated schedule in each subsequent submission with changes highlighted to easily track the changes made to previous submitted schedule.

B. Product Data: Include manufacturer's technical literature for each control device. Indicate dimensions, capacities, performance characteristics, electrical characteristics, finishes for materials, and installation and startup instructions for each type of product indicated.
1. **DDC System Hardware**: Bill of materials of equipment indicating quantity, manufacturer, and model number. Include technical data for operator workstation equipment, interface equipment, control units, transducers/transmitters, sensors, actuators, valves, relays/switches, control panels, and operator interface equipment.

2. **Control System Software**: Include technical data for operating system software, operator interface, color graphics, and other third-party applications.

3. **Controlled Systems**: Instrumentation list with element name, type of device, manufacturer, model number, and product data. Include written description of sequence of operation including schematic diagram.

C. **Shop Drawings**: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

1. Bill of materials of equipment indicating quantity, manufacturer, and model number.

2. Schematic flow diagrams showing fans, pumps, coils, dampers, valves, and control devices.

3. **Wiring Diagrams**: Power, signal, and control wiring.

4. Details of control panel faces, including controls, instruments, and labeling.

5. Written description of sequence of operation.

6. Schedule of dampers including size, leakage, and flow characteristics.

7. Schedule of valves including flow characteristics.

8. **DDC System Hardware**:

   a. Wiring diagrams for control units with termination numbers.

   b. Schematic diagrams and floor plans for field sensors and control hardware.

   c. Schematic diagrams for control, communication, and power wiring, showing trunk data conductors and wiring between operator workstation and control unit locations.

9. **Control System Software**: List of color graphics indicating monitored systems, data (connected and calculated) point addresses, output schedule, and operator notations.

10. **Controlled Systems**:

    a. Schematic diagrams of each controlled system with control points labeled and control elements graphically shown, with wiring.

    b. Scaled drawings showing mounting, routing, and wiring of elements including bases and special construction.

    c. Written description of sequence of operation including schematic diagram.

    d. Points list.

D. **Software and Firmware Operational Documentation**: Include the following:

1. Software operating and upgrade manuals.

2. Program Software Backup: On a magnetic media or compact disc, complete with data files.

3. Device address list.
4. Printout of software application and graphic screens.
5. Software license required by and installed for DDC workstations and control systems.

E. Software Upgrade Kit: For Owner to use in modifying software to suit future systems revisions or monitoring and control revisions.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer and manufacturer.

B. Field quality-control test reports.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For DDC system to include in emergency, operation and maintenance manuals.

1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

   a. Project Record Drawings of as-built versions of submittal Shop Drawings provided in electronic PDF format.
   b. Testing and commissioning reports and checklists of completed final versions of reports, checklists, and trend logs.
   c. As-built versions of submittal Product Data.
   d. Names, addresses, e-mail addresses and 24-hour telephone numbers of Installer and service representatives for DDC system and products.
   e. Operator's manual with procedures for operating control systems including logging on and off, handling alarms, producing point reports, trending data, overriding computer control and changing set points and variables.
   f. Programming manuals with description of programming language and syntax, of statements for algorithms and calculations used, of point database creation and modification, of program creation and modification, and of editor use.
   g. Engineering, installation, and maintenance manuals that explain how to:

      1) Design and install new points, panels, and other hardware.
      2) Perform preventive maintenance and calibration.
      3) Debug hardware problems.
      4) Repair or replace hardware.

   h. Documentation of all programs created using custom programming language including set points, tuning parameters, and object database.
   i. Backup copy of graphic files, programs, and database on electronic media such as DVDs.
   j. List of recommended spare parts with part numbers and suppliers.
   k. Complete original-issue documentation, installation, and maintenance information for furnished third-party hardware including computer equipment and sensors.
I. Complete original-issue copies of furnished software, including operating systems, custom programming language, operator workstation software, and graphics software.

m. Licenses, guarantees, and warranty documents.

n. Recommended preventive maintenance procedures for system components, including schedule of tasks such as inspection, cleaning, and calibration; time between tasks; and task descriptions.

o. Owner training materials.

1.7 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.

1.8 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.

1.9 COORDINATION

A. Coordinate location of thermostats, humidistats, and other exposed control sensors with plans and room details before installation.

B. Coordinate equipment with Division 28 Section "Access Control" to achieve compatibility with equipment that interfaces with that system.

C. Coordinate equipment with Division 26 Section "Network Lighting Controls" to achieve compatibility with equipment that interfaces with that system.

D. Coordinate equipment with Division 28 Section "Fire Detection and Alarm" to achieve compatibility with equipment that interfaces with that system.

E. Coordinate supply of conditioned electrical branch circuits for control units and operator workstation.

F. Coordinate equipment with Division 26 Section "Electrical Power Monitoring and Control" to achieve compatibility of communication interfaces.

G. Coordinate equipment with Division 26 Section "Panelboards" to achieve compatibility with starter coils and annunciation devices.
H. Coordinate equipment with Division 26 Section "Motor-Control Centers" to achieve compatibility with motor starters and annunciation devices.

I. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03 Section "Cast-in-Place Concrete."

1.10 EXTRA MATERIALS

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

1. Replacement Materials: One replacement diaphragm or relay mechanism for each unique valve motor, controller, and thermostat.
2. Maintenance Materials: One thermostat adjusting key(s) per floor or 50,000 sqft of total conditioned space, whichever is greater.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Invensys Building Systems.
B. Johnson Controls, Inc.; Controls Group.
C. Siemens Building Technologies, Inc.
D. Trane.

2.2 GENERAL REQUIREMENTS

A. Provide labor, materials, equipment, tools and services, and perform operations required for, and reasonably incidental to, the provision, installation and extension of the existing building automation and Control System (FMS) including all related systems and accessories.

B. Control system shall consist of sensors, indicators, actuators, final control elements, interface equipment, other apparatus, accessories, and software connected to distributed controllers operating in multiuser, multitasking environment on token-passing network and programmed to control mechanical systems.

C. System points lists included in the Documents are intended to show the desired alarm, monitoring and control points. Add any control points necessary and as required to accomplish the sequence of operations.
D. Provide a UPS with a minimum of 15 minute backup for all building controllers to prevent disruption during a temporary loss of power, including where the loss of memory, program content, or control function may result.

E. Provide a UPS with a minimum of 15 minute backup for all AHU damper actuators to prevent closure during a temporary loss of power.

F. An operator workstation permits interface with the network via dynamic color graphics with each mechanical system, building floor plan, and control device depicted by point-and-click graphics.

G. The control system shall also include a paging feature with telephone/email alerts to selected personnel for critical alarms as defined by Owner.

H. The control system shall be connected to the facility LAN and shall permit at least 4 simultaneous users to access the system over the LAN, based on password level, monitor parameters, change set points, set up trends, or start/stop controlled equipment. A remote user shall have this capability without having the system data base loaded on his/her remote computer.

I. All terminal box controller parameters shall be mapped to the front end of the FMS.

J. For AHUs, each individual operating state shall have an individual PID control loop for that state.

K. Dynamic animated color graphic displays

1. Color graphic floor plan displays, and system schematics for each piece of mechanical equipment (including air handling units, variable air volume boxes, fan coils, unit ventilators, cabinet heaters, exhaust fans, fin tube radiation, chilled water systems, hot water boiler systems, and so forth) shall be provided, as specified in the point lists of the Documents, in order to optimize system performance analysis, speed alarm recognition, and simplify user interaction. Configure the color graphics and plot all associated control/monitoring points on the screen. Copies of all color graphics screens shall be provided as color printouts to the engineer for approval.

2. System Selection/Penetration: The operator interface shall allow users to access the various system schematics and floor plans via a graphical penetration scheme, menu selection, or test-based commands. Floor plans shall display room numbers and each zone shall be color-coded. The operator shall be able to point and click on a room or zone of rooms (in the case of an air handler that serves more than one zone). The room or zone will display an animated flow diagram of the mechanical equipment that serves that zone, with all control and monitoring points associated with that piece of equipment, including setpoints. Setpoints shall be overridden or modified from this screen.

3. Dynamic Animated Data Displays: Dynamic temperature values, humidity values, flow values, and status indication shall be shown in their actual respective locations, and shall automatically update to represent current conditions without operator intervention. Damper and valve positions, air and water flow shall be animated and shall represent actual, current conditions.

4. System Performance Analysis Screens: System performance analysis screens shall be provided for the major mechanical systems (such as air handlers,
chillers, boilers, and so forth.). For each of these systems, the screen shall be split into quadrants, simultaneously displaying the following data:

a. Quadrant 1. – Dynamic animated flow diagrams.

b. Quadrant 2. – All analog values associated with the mechanical system shall be graphed on an X-Y axis graph. Five-minute samples for the last twenty-four hour period shall be plotted. Scaling shall be automatic.

c. Quadrant 3. – Text sequence of operations from engineering as-built submittals.

d. Quadrant 4. – Space temperature summaries from each zone being served by mechanical system.

5. Windowing: The windowing environment of the PC Operator Workstation shall allow the user to simultaneously view several graphics at the same time to analyze total building operation, or to allow the display of a graphic associated with an alarm to be viewed without interrupting Work in progress.

6. Alarm Annunciation: Any point in a state of alarm shall change the color of its symbol to red until it is no longer in alarm.

7. AHU Summary Graphic Screen: An AHU summary graphic screen shall be provided for economizer and non economizer AHU’s as follows:

a. AHU’s without economizer cycles shall include a summary graphic screen including the following information:

1) Air Handling Unit

   a) AHU number
   b) Supply air temperature
   c) Supply air temperature setpoint
   d) Supply air cfm setpoint
   e) Total terminal box airflow
   f) Chilled water valve position in %
   g) Return air temperature
   h) Return air humidity in %
   i) Outside air temperature
   j) Outside air humidity

2) Chilled Water Secondary System

   a) Chilled water supply temperature
   b) Chilled water return temperature
   c) Chilled water flow in gpm
   d) Building load in tons
   e) Chilled water system differential pressure
   f) Chilled water system differential pressure setpoint
   g) Each chilled water pump speed in %

3) Chillers

   a) Each chillers chilled water supply temperature.

   b. AHU’s with economizer cycles shall include a summary graphic screen including the following information:
1) Air Handling Unit

   a) AHU number
   b) Supply air temperature
   c) Supply air temperature setpoint
   d) Return air temperature
   e) Outside air temperature
   f) Outside air humidity
   g) Mixed air temperature

2) Outside Air

   a) Outside air cfm setpoint
   b) Outside air cfm measured
   c) Return fan speed %
   d) Supply Fan speed %
   e) Supply static pressure setpoint
   f) Supply static pressure actual

3) Dampers

   a) Economizer damper open position %

L. Systems integration/FMS specific requirements

1. FMS Remote Access: The Facility Management System provided shall include the capability for multiple users to access the FMS simultaneously from remote locations via the Internet. Internet access shall be accomplished by use of standard Internet browser software applications such as Netscape Navigator® or Microsoft Internet Explorer® and shall not require the use of proprietary access software. Interface shall be to the entire FMS and provide capability to monitor all I/O and adjust parameters.

2. Open Systems Integration: VFD Integrator Interface

   a. The FMS shall include appropriate hardware equipment and software to allow two-way data communications between the FMS and the VFD manufacturer’s control panel.
   b. Coordinate with the VFD manufacturer to provide a functional data communications connection.
   c. All data supported by the VFD communication protocol shall be mapped into the supervisory DDC controller’s database and shall be displayed on data screens at the Operator Workstation and shall be transparent to the operator.
   d. Furnish a BACnet communications interface as required by the VFD manufacturer.
   e. Provide all communications and power wiring and gateway panel installation for the DDC system. The VFD manufacturer shall provide all hardware for connection of the manufacturer’s processor.
   f. Provide all hardware and software required for the VFD manufacturer’s gateway interface.

3. Open Systems Integration: Chiller Integrator Interface
a. The FMS shall include appropriate hardware equipment and software to allow two-way data communications between the FMS and the chiller manufacturer’s chiller control panel.
b. Coordinate with the chiller manufacturer to provide a functional data communications connection.
c. All data supported by the chiller communication protocol shall be mapped into the supervisory DDC controller’s database and shall be displayed on a chiller data screen at the Operator Workstation and shall be transparent to the operator.
d. Furnish a BACnet communications interface as required by the chiller manufacturer.
e. Provide all communications and power wiring and gateway panel installation for the DDC system. The chiller manufacturer shall provide all hardware for connection of the manufacturer’s processor.
f. Provide all hardware and software required for the chiller manufacturer’s gateway interface.

4. Open Systems Integration: Boiler Integrator Interface

a. The FMS shall include appropriate hardware equipment and software to allow two-way data communications between the FMS and the boiler manufacturer’s Master Boiler Controller Control Panel.
b. Coordinate with the boiler manufacturer to provide a functional data communications connection.
c. All data supported by the boiler communication protocol shall be mapped into the supervisory DDC controller’s database and shall be displayed on a boiler data screen at the Operator Workstation and shall be transparent to the operator.
d. Furnish BACnet communications interface as required by the chiller manufacturer.
e. Provide all communications and power wiring and gateway panel installation for the DDC system. The boiler manufacturer shall provide all hardware for connection of the manufacturer’s processor.
f. Provide all hardware and software required for the boiler manufacturer’s gateway interface.

M. Alarm management

1. Alarm management shall be provided to monitor, buffer, and direct alarm reports to operator devices and memory files. Each DDC panel shall perform distributed, independent alarm analysis and filtering to minimize operator interruptions due to non-critical alarms, to minimize network traffic, and to prevent alarms from being lost. At no time shall the DDC panel’s ability to report alarms be affected by either operator activity at a PC Workstation or local I/O device, or communications with other panels on the network.

2. Point Change Report Description: All alarm or point change reports shall include the point’s English language description, and the time and date of occurrence.

3. Prioritization:

a. Set up all system analog points with high and low alarm limits. All digital system points shall be associated with a status feedback point and all exceptions shall be reported as alarms. The user shall be able to
define the specific system reaction for each point. Alarms shall be prioritized and filtered to minimize nuisance reporting and to speed operator response to critical alarms.
b. The user shall also be able to define under which conditions point changes need to be acknowledged by an operator, and/or sent to follow-up files for retrieval and analysis at a later date.

4. Critical and Non-Critical Alarm Routing:
   a. Critical alarms shall be defined as chiller, boiler, generator, critical space temperature or humidity, and kilowatt demand approaching threshold. Critical alarms shall be displayed at the workstation, printed at the alarm printer, and alpha paged to the on-duty maintenance person over the Owners alphanumeric paging system. Alpha pages shall provide sufficient information to identify the equipment and the point in alarm and the time and date of occurrence.
b. All other alarms shall be considered non-critical and shall be displayed and acknowledged before being sent to the alarm log.

5. Report Routing: Alarm reports, messages, and files will be directed to a user-defined list of operator devices, or PCs used for archiving alarm information. Alarms shall also be automatically directed to a default device in the event a primary device is found to be off-line.

6. Alarm Messages:
   a. In addition to the point’s descriptor and the time and date, the user shall be able to print, display, or store a 65-character alarm message to more fully describe the alarm condition or direct operator response.
b. Each stand-alone DDC panel shall be capable of storing a minimum library of 250 Alarm Messages. Each message may be assignable to any number of points in the panel.

7. Auto-Dial Alarm Management: In Dial-up applications, only critical alarms shall initiate a call to a remote operator device. In all other cases, call activity shall be minimized by time-stamping and saving reports until an operator scheduled time, a manual request is made, or until the buffer space is full. The alarm buffer must store a minimum of 50 alarms.

2.3 DDC EQUIPMENT

A. Diagnostic Terminal Unit: Portable notebook-style, PC-based microcomputer terminal capable of accessing system data by connecting to system network with minimum configuration as follows:

1. System: With three integrated USB 2.0 port, integrated Intel Pro 10/100 (Ethernet), integrated audio, bios, and hardware monitoring.
2. Minimum Processor Speed: 3 GHz, dual core.
3. Random-Access Memory: 4 GB.
4. Graphics: Video adapter, minimum 1024 x 768 pixels, 64-MB video memory.
7. Hard-Disk Drive: 100 GB.
8. Combination CD-ROM Read/Write Drive (48x24x48.) and DVD-ROM Drive
9. Pointing Device: Touch pad or other internal device.
10. Operating System: Microsoft Windows 7 with high-speed Internet access.

B. Control Units: Modular, comprising processor board with programmable, nonvolatile, random-access memory; local operator access and display panel; integral interface equipment; and backup power source.

1. Units monitor or control each I/O point; process information; execute commands from other control units, devices, and operator stations; and download from or upload to operator workstation or diagnostic terminal unit.
2. Stand-alone mode control functions operate regardless of network status. Functions include the following:
   a. Global communications.
   b. Discrete/digital, analog, and pulse I/O.
   c. Monitoring, controlling, or addressing data points.
   d. Software applications, scheduling, and alarm processing.
   e. Testing and developing control algorithms without disrupting field hardware and controlled environment.

3. Standard Application Programs:
   a. Electric Control Programs: Demand limiting, duty cycling, automatic time scheduling, start/stop time optimization, night setback/setup, on-off control with differential sequencing, staggered start, antishort cycling, PID control, DDC with fine tuning, and trend logging.
   b. HVAC Control Programs: Optimal run time, supply-air reset, and enthalpy switchover.
   c. Chiller Control Programs: Control function of condenser-water reset, chilled-water reset, and equipment sequencing.
   d. Programming Application Features: Include trend point; alarm processing and messaging; weekly, monthly, and annual scheduling; energy calculations; run-time totalization; and security access.
   e. Remote communications.
   f. Maintenance management.
   g. Units of Measure: Inch-pound and SI (metric).

4. Local operator interface provides for download from or upload to operator workstation or diagnostic terminal unit.

C. Local Control Units: Modular, comprising processor board with electronically programmable, nonvolatile, read-only memory; and backup power source.

1. Units monitor or control each I/O point, process information, and download from or upload to operator workstation or diagnostic terminal unit.
2. Stand-alone mode control functions operate regardless of network status. Functions include the following:
   a. Global communications.
   b. Discrete/digital, analog, and pulse I/O.
   c. Monitoring, controlling, or addressing data points.
3. Local operator interface provides for download from or upload to operator workstation or diagnostic terminal unit.

D. I/O Interface: Hardwired inputs and outputs may tie into system through controllers. Protect points so that shorting will cause no damage to controllers.

1. Binary Inputs: Allow monitoring of on-off signals without external power.
2. Pulse Accumulation Inputs: Accept up to 10 pulses per second.
3. Analog Inputs: Allow monitoring of low-voltage (0- to 10-V dc), current (4 to 20 mA), or resistance signals.
4. Binary Outputs: Provide on-off or pulsed low-voltage signal, selectable for normally open or normally closed operation with three-position (on-off-auto) override switches and status lights.
5. Analog Outputs: Provide modulating signal, either low voltage (0- to 10-V dc) or current (4 to 20 mA) with status lights, two-position (auto-manual) switch, and manually adjustable potentiometer.
7. Universal I/Os: Provide software selectable binary or analog outputs.

E. Power Supplies: Transformers with Class 2 current-limiting type or overcurrent protection; limit connected loads to 80 percent of rated capacity. DC power supply shall match output current and voltage requirements and be full-wave rectifier type with the following:

1. Output ripple of 5.0 mV maximum peak to peak.
2. Combined 1 percent line and load regulation with 100-mic. second response time for 50 percent load changes.
3. Built-in overvoltage and overcurrent protection and be able to withstand 150 percent overload for at least 3 seconds without failure.

F. Power Line Filtering: Internal or external transient voltage and surge suppression for workstations or controllers with the following:

1. Minimum dielectric strength of 1000 V.
3. Minimum transverse-mode noise attenuation of 65 dB.
4. Minimum common-mode noise attenuation of 150 dB at 40 to 100 Hz.

2.4 UNITARY CONTROLLERS

A. Unitized, capable of stand-alone operation with sufficient memory to support its operating system, database, and programming requirements, and with sufficient I/O capacity for the application.

1. Configuration: Local keypad and display; diagnostic LEDs for power, communication, and processor; wiring termination to terminal strip or card connected with ribbon cable; memory with bios; and 72-hour battery backup.
2. Operating System: Manage I/O communication to allow distributed controllers to share real and virtual object information and allow central monitoring and alarms. Perform scheduling with real-time clock. Perform automatic system diagnostics; monitor system and report failures.
3. Enclosures:
   a. For Conditioned Space: Dustproof rated for operation at 32 to 120 deg F.
   b. For Outdoor and Non-conditioned Space: Waterproof rated for operation at -10 to 150 deg F.

2.5 ALARM PANELS

A. Unitized cabinet with suitable brackets for wall or floor mounting. Fabricate of 0.06-inch-thick, furniture-quality steel or extruded-aluminum alloy, totally enclosed, with hinged doors and keyed lock and with manufacturer's standard shop-painted finish. Provide common keying for all panels.

B. Indicating light for each alarm point, single horn, acknowledge switch, and test switch, mounted on hinged cover.

1. Alarm Condition: Indicating light flashes and horn sounds.
2. Acknowledge Switch: Horn is silent and indicating light is steady.
3. Second Alarm: Horn sounds and indicating light is steady.
4. Alarm Condition Cleared: System is reset and indicating light is extinguished.
5. Contacts in alarm panel allow remote monitoring by independent alarm company.

2.6 ANALOG CONTROLLERS

A. Step Controllers: 6- or 10-stage type, with heavy-duty switching rated to handle loads and operated by electric motor.

B. Electric, Outdoor-Reset Controllers: Remote-bulb or bimetal rod-and-tube type, proportioning action with adjustable throttling range, adjustable set point, scale range minus 10 to plus 70 deg F, and single- or double-pole contacts.

C. Electronic Controllers: Wheatstone-bridge-amplifier type, in steel enclosure with provision for remote-resistance readjustment. Identify adjustments on controllers, including proportional band and authority.

1. Single controllers can be integral with control motor if provided with accessible control readjustment potentiometer.

D. Fan-Speed Controllers: Solid-state model providing field-adjustable proportional control of motor speed from maximum to minimum of 55 percent and on-off action below minimum fan speed. Controller shall briefly apply full voltage, when motor is started, to rapidly bring motor up to minimum speed. Equip with filtered circuit to eliminate radio interference.

E. Receiver Controllers: Single- or multiple-input models with control-point adjustment, direct or reverse acting with mechanical set-point adjustment with locking device, proportional band adjustment, authority adjustment, and proportional control mode.
1. Remote-control-point adjustment shall be plus or minus 20 percent of sensor span, input signal of 3 to 13 psig.
2. Proportional band shall extend from 2 to 20 percent for 5 psig.
3. Authority shall be 20 to 200 percent.
4. Air-supply pressure of 18 psig, input signal of 3 to 15 psig, and output signal of zero to supply pressure.
5. Gauges: 1-1/2 inches in diameter, 2.5 percent wide-scale accuracy, and range to match transmitter input or output pressure.

2.7 INPUT DEVICES

A. General Requirements: Installation, testing, and calibration of all sensors, transmitters, and other input devices shall be provided to meet the system requirements.

B. Temperature Sensors

1. General Requirements:
   a. Sensors and transmitters shall be provided, as outlined in the input/output summary and sequence of operations.
   b. The temperature sensor shall be of the resistance type, and shall be either two-wire 1000 ohm nickel RTD, or two-wire 1000 ohm platinum RTD.
   c. The following point types (and the accuracy of each) are required, and their associated accuracy values include errors associated with the sensor, lead wire, and A to D conversion:
      1) 0.5 deg F:
         a) Chilled Water.
         b) Room Temperature.
         c) Duct Temperature.
      2) 0.75 deg F: All others

2. Room Temperature Sensors
   a. Room sensors shall be constructed for either surface or wallbox mounting.
   b. Room sensors shall have the following options:
      1) Setpoint reset slide switch providing a +5 degree (adjustable) range.
      2) Individual heating/cooling setpoint slide switches.

3. Room Temperature Sensors with Integral Display:
   a. Room sensors shall be constructed for either surface or wallbox mounting.
   b. Room sensors shall have an integral LCD display and four button keypad with the following capabilities:
1) Display room temperature.
2) Display and adjust room comfort setpoint.
3) Display and adjust fan operation status.
4) Timed override request push button with LED status for activation of after-hours operation.
5) Display controller mode.
6) Password selectable adjustment of setpoint and override modes.

4. Thermowells:
   a. When thermowells are required, the sensor and well shall be supplied as a complete assembly, including wellhead and Greenfield fitting.
   b. Thermowells shall be pressure rated and constructed in accordance with the system working pressure.
   c. Thermowells and sensors shall be mounted in a threadolet or 1/2” NPT saddle and allow easy access to the sensor for repair or replacement.
   d. Thermowells shall be constructed of 316 stainless steel.

5. Outside Air Sensors:
   a. Outside air sensors shall be designed to withstand the environmental conditions to which they will be exposed. They shall also be provided with a solar shield.
   b. Sensors shall be shielded by a perforated plate that surrounds the sensor element.
   c. Temperature transmitters shall be of NEMA 3R construction and rated for ambient temperatures.

6. Duct Mount Sensors:
   a. Duct mount sensors shall mount in an electrical box through a hole in the duct, and be positioned so as to be easily accessible for repair or replacement.
   b. Duct sensors shall be insertion type and constructed as a complete assembly, including lock nut and mounting plate.
   c. For outdoor air duct applications, a weatherproof mounting box with weatherproof cover and gasket shall be used.

7. Averaging Sensors:
   a. Similar to JCI TE6300.
   b. For ductwork greater in any dimension than 48 inches, inside air handling units, and/or where air temperature stratification exists, an averaging sensor with multiple sensing points shall be used.
   c. A 20 foot averaging continuous sensor shall be serpentine across the cross section with minimum 1 foot of length for every square foot of cross sectional area. Capillary supports at the sides of the duct shall be provided to support the sensing string.

C. Current Sensing Relays

1. Current sensor shall induce power from the monitored load and shall have an adjustable operating range from 2.5 - 135 A.
2. Visual indicators (LED’s) shall indicate output status and sensor power.
3. Adjustable trip set point to +/- 1%.
4. Current sensor output shall be normally open, solid state, 0.1A @ 30 VAC/DC.

D. Humidity Sensors:

1. Acceptable Manufacturers: Vaisala, General Eastern, and Johnson Controls.
2. The sensor shall be a solid state type, relative humidity sensor of the Bulk Polymer Design. The sensor element shall resist service contamination.
3. The humidity transmitter shall be equipped with non-interactive span and zero adjustments, a 2-wire isolated loop powered, 4-20 mA, 0-100% linear proportional output.
4. The humidity transmitter shall meet the following overall accuracy, including lead loss and Analog to Digital conversion.
   a. Indoor locations and sensors mounted in air handling units or ducts; +/- 3%.
   b. Outdoor locations: Humidity Sensor shall be HyCal +/- 2%.

5. Outside air relative humidity sensors shall include a rain proof, perforated cover. The transmitter shall be include in a NEMA 3R enclosure with saltite fittings and stainless steel bushings.
6. A single point humidity calibrator shall be provided, if required, for field calibration. Transmitters shall be shipped factory pre-calibrated.
7. Duct type sensing probes shall be constructed of 304 stainless steel, and shall be equipped with a neoprene grommet, bushings, and a mounting bracket.

E. Differential Pressure Transmitters:

1. Air and Water Pressure Transmitter Requirements:
   a. Pressure transmitters shall be constructed to withstand 100% pressure over-range without damage, and to hold calibrated accuracy when subject to a momentary 40% over-range input.
   b. Differential pressure transducers shall be piped to permit equalizing pressure prior to disconnecting.
   c. Differential pressure sensors used to control equipment such as fans and pumps, shall be connected directly to the same controller that controls the equipment to insure the continued proper operation of the controlled equipment without dependence on the control network.

F. Flow measuring devices:

1. Air Flow Measuring:
   a. General:
      1) Airflow measuring sensors shall be installed at fan inlet whenever possible and shall be capable of continuously measuring the air handling capacity (air volume) of the respective centrifugal, plug, or vane-axial fan(s).
   b. Manufacturers:
1) Air Monitor Corporation.
2) Paragon Controls Incorporated (PCI), MicroTrans EQ.

**c. Fan Inlet Traverse Probes.**

1) The fan inlet airflow traverse probes shall contain multiple total and static pressure sensors placed at concentric area centers along the exterior surface of the cylindrical probes and internally connected to their respective averaging manifolds.
2) Sensors shall not protrude beyond the surface of the probe. The fan inlet airflow traverse probes shall have symmetrical averaging signal takeoffs, and shall be of aluminum construction with hard anodized finish with galvanized steel mounting hardware.
3) The fan inlet airflow traverse probes shall not significantly impact fan performance or contribute to fan generated noise levels.
4) The probes shall be capable of producing steady, non-pulsating signals of standard total and static pressure, without need for flow corrections or factors, with an accuracy of 3% of actual flow over a fan operating range of 6 to 1 capacity turndown.

d. **Fan Inlet Piezometer Rings**

1) Factory tap fan inlet with sensor ports.
2) **Accuracy:** +/-3% of Full Scale.

e. **Duct mounted:**

1) Manufacturers:
   a) Ebtron.
2) **Description:** Thermal dispersion type. Units shall be provided complete with differential pressure transducers, temperature compensation, square root extraction. Unit shall perform all internal calculations to output to the FMS the CFM readings.
3) **Location:** Provide straight duct before and after device according to the sensor manufacturer’s recommendations. Provide access door in ductwork adjacent to sensors.
4) **Accuracy:** Sensor accuracy shall be +/- 2% of the airflow reading over the entire range of airflow measured.

f. **Transmitter / Transducer**

1) Each sensor shall be provided complete with transmitter.
2) Manufacturers:
   a) Paragon.
3) **Full Scale Accuracy:**
   a) **Accuracy:** +/- 0.25% of Full Scale.
   b) **Terminal Point Non-linearity:** +/- 0.2%.
   c) **Hysteresis:** +/- 0.2%.
d) Non-repeatability: +/- 0.3%.
e) Temperature Effect: +/- 0.15% Full Scale / °F.

4) The transmitter-controller shall be capable of receiving flow signals (total and static pressure) from an airflow station or probe array and produce an output linear and scaled for air volume, velocity, differential pressure, etc. The internal P, I, three-mode controller shall be capable of controlling at a user selectable internal or external setpoint, and output a 0-5VDC, 0-10VDC, or 4-20mA DC control signal.

5) The transmitter-controller shall contain an integral multi-line digital display for use during the configuration and calibration process, and to display one transmitter output plus controller setpoint during normal operating mode. All transmitter configuration, parameter setting, zero and span calibration, plus display formatting and scaling will be performed digitally in the on-board microprocessor via input pushbuttons.

6) The transmitter-controller will be available in multiple natural spans covering the range of 0.05” w.c. to 10.0” w.c. The transmitter-controller shall be furnished with a transducer automatic zeroing circuit, and be capable of maintaining linear output signals on applications requiring 10 to 1 velocity or pressure turndown.

7) The transmitter-controller shall be capable of having its operating span electronically selected without having to perform recalibration involving an external pressure source. The transmitter-controller will provide the means of managing a system for automatic high pressure purge of the airflow station or probe array, with user selectable purge frequency and duration, while maintaining the last transmitter output during the purge cycle. Using a second transmitter as an input, the internal microprocessor can perform a summed flow, flow differential, low signal select, high signal select or percent deviation calculation, with the result being displayed and provided as an analog output signal.

2. Water Flow Measuring:

a. General:

1) Sensors shall operate in line pressures up to 400 psi and liquid temperatures up to 220° F.
2) A certificate of calibration shall be provided with each flow meter.
3) Each flow meter shall be covered by the manufacturer’s two-year warranty.

b. Electromagnetic

1) Manufacturer:
   a) Onicon, F-3500 Series.
2) Accuracy:
a) Less than 2 ft/sec: ± 0.02%.
b) 2 to 30 ft/sec: ± 1%.

3) Provide complete sensor assembly with all installation hardware necessary to enable insertion and removal of the meter without system shutdown.

4) Materials of construction for wetted metal components shall be 316 SS.

5) The flow meter shall average velocity readings from two sets of diametrically opposed electrodes.

6) Each flow meter shall be individually wet-calibrated against a primary volumetric standard that is accurate to within 0.1%.

7) Output signals shall be completely isolated and shall consist of the following:

   a) (1) analog output; 4-20mA, 0-10V, or 0-5V jumper selectable
   b) (1) scalable dry contact output for totalization
   c) (1) high resolution frequency output for use with peripheral devices such as an ONICON display module or Btu meter.

C. Transmitter / Transducer

1) Each sensor shall be provided complete with transmitter.

2) Water meter: The analog transmitter shall be Data Industrial Model 310-00, or equivalent.

3) The analog flow transmitter shall be a loop powered device capable of transmitting a linear 4 - 20 mA signal proportional to frequency. The unit shall be microprocessor controlled with no switches or potentiometers to set.

4) The transmitter shall meet ISA Class L, H and U non-isolated requirements. All circuitry shall be encapsulated in a low profile epoxy body to meet MIL spec M.1-146058C type AR, for humidity, moisture and fungus resistance. Operating range shall be 35°F to 150°F.

5) All programming, including flow sensor selection, pipe size, flow range setting, response time and filtering shall be set digitally via a computer using Windows-based software with programming kit (disk and cable). The transmitter shall be easily programmed in the field using a standard computer.

6) The transmitter shall have a ground lug to maximize EMI protection when necessary. The transmitter shall be mounted directly near the insertion flow sensor on a DIN Rail, as a panel mount or in a weather proof or NEMA 4X enclosure.

3. BTUH Meter

a. BTUH Meter shall be Onicon System 10
b. Insertion type, electromagnetic flow meter as indicted above.

c. Calibration: NIST traceable calibration for meter and solid state temperature sensors.

d. Temperature sensors: Solid state with differential temperature accuracy of +/- 0.15 degree F over calibrated range.
e. Communication: BACnet compatible derail communication over MS/TP.

G. Power Monitoring Devices:

1. Current Measurement (Amps):

   a. Current measurement shall be by a combination current transformer and a current transducer. The current transformer shall be sized to reduce the full amperage of the monitored circuit to a maximum 5 Amp signal, which will be converted to a 4-20 mA DDC compatible signal for use by the Facility Management System.

   b. Current Transformer – A split core current transformer shall be provided to monitor motor amps.

   1) Operating frequency – 50 - 400 Hz.
   2) Insulation – 0.6 Kv class 10Kv BIL.
   3) UL recognized.
   4) Five amp secondary.
   5) Select current ration as appropriate for application.

   c. Current Transducer – A current to voltage or current to mA transducer shall be provided. The current transducer shall include:

   1) 6X input over amp rating for AC inrushes of up to 120 amps.
   2) Manufactured to UL 1244.
   3) Accuracy: +.5%, Ripple +1%.
   4) Minimum load resistance 30kOhm.
   5) Input 0-20 Amps.
   6) Output 4-20 mA.
   7) Transducer shall be powered by a 24VDC regulated power supply (24 VDC +5%).

H. Smoke Detectors:

1. Ionization type air duct detectors shall be furnished as specified elsewhere in Division 26 for installation under Division 23. All wiring for air duct detectors shall be as specified in Division 28 - Fire Alarm System.

I. Status and Safety Switches:

1. General Requirements:

   a. Switches shall be provided to monitor equipment status, safety conditions, and generate alarms at the FMS when a failure or abnormal condition occurs. Safety switches shall be provided with two sets of contacts and shall be interlock wired to shut down respective equipment.

2. Current Sensing Switches:

   a. The current sensing switch shall be self-powered with solid state circuitry and a dry contact output. It shall consist of a current transformer, a solid state current sensing circuit, adjustable trip point,
solid state switch, SPDT relay, and an LED indicating the on or off status. A conductor of the load shall be passed through the window of the device. It shall accept over-current up to twice its trip point range.

b. Current sensing switches shall be used for run status for fans, pumps, and other miscellaneous motor loads.
c. Current sensing switches shall be calibrated to show a positive run status only when the motor is operating under load. A motor running with a broken belt or coupling shall indicate a negative run status.

3. Air Filter Status Switches:
   a. Differential pressure switches used to monitor air filter status shall be of the automatic reset type with SPDT contacts rated for 2 amps at 120VAC.
   b. A complete installation kit shall be provided, including: static pressure tops, tubing, fittings, and air filters.
   c. Provide appropriate scale range and differential adjustment for intended service.

4. Air Flow Switches:
   a. Differential pressure flow switches shall be bellows actuated mercury switches or snap acting micro-switches with appropriate scale range and differential adjustment for intended service.

5. Air Pressure Safety Switches:
   a. Air pressure safety switches shall be of the manual reset type with SPDT contacts rated for 2 amps at 120VAC.
   b. Pressure range shall be adjustable with appropriate scale range and differential adjustment for intended service.


7. Low Temperature Limit Switches: Equal to Johnson Controls A70.
   a. The low temperature limit switch shall be of the manual reset type with Double Pole/Single Throw snap acting contacts rated for 16 amps at 120VAC.
   b. The sensing element shall be one foot long for each square foot of coil area and be a minimum of 15 feet in length and shall react to the coldest 18-inch section. Element shall be mounted horizontally across duct in accordance with manufacturers recommended installation procedures.
   c. For large duct areas where the sensing element does not provide full coverage of the air stream, additional switches shall be provided as required to provide full protection of the air stream.

J. EPO Switches

1. General Description: All products listed shall meet the following requirements:
   a. Operators shall be heavy duty type and comply with UL Type 13/NEMA Type 13 and UL Type 6/NEMA Type 6.
b. Contact blocks shall be rated 10 amperes continuous.

2. EPO Design:
   a. Mushroom type: Flush mounted, two position, maintained push - maintained pull mushroom head type push button operator with 2.25 inch diameter mushroom top, red, with one normally open and one normally closed (1NO - 1NC) contact. Provide with aluminum extended mushroom guard.
   b. Push button type: Flush mounted, two position, momentary push button, red insert, with one normally open and one normally closed (1NO - 1NC) contact. Provide with a hinged, lockable protective cover guard.
   c. Key operated type: Flush mounted, two position, key operated push button, with one normally open and one normally closed (1NO - 1NC) contact. The operator shall be set by rotating the key, with the button in the extended position. The key is removable only in this set position. When pushed, the button will then lock into position. The key must be inserted and rotated to reset to the extended position. Provide with a hinged, lockable protective cover guard.
   d. Break glass type: Flush mounted, two position "break glass" operator. Operator shall be held in a depressed position by a glass disc. When the glass disc is broken by the chain-attached hammer, the button shall return to a normal extended position. Provide a package of five discs with the operator. Provide operator and contact block with one normally open and one normally closed (1NO - 1NC) contact.

2.8 OUTPUT DEVICES

A. Actuators:
   1. General Requirements:
      a. Damper and valve actuators shall be electronic, as specified in the System Description section.

   2. Electronic Damper Actuators:
      a. Electronic damper actuators shall be direct shaft mount, as manufactured by Johnson Controls and Belimo.
      b. Modulating and two-position actuators shall be provided as required by the sequence of operations. Damper sections shall be sized based on actuator manufacturer’s recommendations for face velocity, differential pressure and damper type. The actuator mounting arrangement and spring return feature shall permit normally open or normally closed positions of the dampers, as required. All actuators (except terminal units) shall be furnished with mechanical spring return unless otherwise specified in the sequences of operations. All actuators shall have external adjustable stops to limit the travel in either direction, or a gear release to allow manual positioning.
c. Modulating actuators shall accept 24 VAC or VDC power supply, consume no more than 15 VA, and be UL listed. The control signal shall be 2-10 VDC or 4-20 mA, proportional control.

d. Two-position or open/closed actuators shall accept 24 or 120 VAC power supply and be UL listed. Isolation, smoke, exhaust fan, and other dampers, as specified in the sequence of operations, shall be furnished with adjustable end switches to indicate open/closed position or be hard wired to start/stop associated fan. Two-position actuators, as specified in sequences of operations as “quick acting,” shall move full stroke within 20 seconds. All smoke damper actuators shall be quick acting.

3. Electronic Valve Actuators:

a. Electronic valve actuators shall be manufactured by the valve manufacturer or Belimo Air Controls. Each actuator shall have current limiting circuitry incorporated in its design to prevent damage to the actuator.

b. Modulating and two-position actuators shall be provided as required by the sequence of operations. Actuators shall provide the minimum torque required for proper valve close off against the system pressure for the required application. The valve actuator shall be sized based on valve manufacturer's recommendations for flow and pressure differential. All actuators shall fail in the last position unless specified with mechanical spring return in the sequence of operations. The spring return feature shall permit normally open or normally closed positions of the valves, as required. All direct shaft mount rotational actuators shall have external adjustable stops to limit the travel in either direction.

c. Modulating Actuators shall accept 24 VAC or VDC and 120 VAC power supply and be UL listed. The control signal shall be 2-10 VDC or 4-20 mA, proportional control.

d. Two-position or open/closed actuators shall accept 24 or 120 VAC power supply and be UL listed. Butterfly isolation and other valves, as specified in the sequence of operations, shall be furnished with adjustable end switches to indicate open/closed position or be hard wired to start/stop the associated pump or chiller.

B. Control Dampers:

1. Furnish all automatic dampers that are not furnished with air handling units. Coordinate exact damper requirements with the air handling unit manufacturer. All automatic dampers shall be sized for the application or as specifically indicated on the Drawings.

2. All dampers used for throttling airflow shall be of the opposed blade type arranged for normally open or normally closed operation, as required. The damper is to be sized so that, when wide open, the pressure drop is a sufficient amount of its close-off pressure drop to shift the characteristic curve to near linear.

3. All dampers used for two-position, open/close control shall be parallel blade type arranged for normally open or closed operation, as required.

4. All dampers used for smoke control applications shall be UL 555 listed.

5. Damper frames and blades shall be constructed of either galvanized steel or aluminum. Maximum blade length in any section shall be 48”. Damper blades shall be 16-gauge minimum and shall not exceed six (6) inches in width.
Damper frames shall be 16-gauge minimum hat channel type with corner bracing. Additional stiffening or bracing shall be provided for any section exceeding 48” in height. All damper bearings shall be made of stainless steel or oil-impregnated bronze. Dampers shall be tight closing, low leakage type, with synthetic elastomeric seals on the blade edges and flexible stainless steel side seals. Dampers of 48”x48” size shall not leak in excess of 8.5 cfm per square foot when closed against 4” w.g. static pressure when tested in accordance with AMCA Std. 500.

6. Airfoil blade dampers of double skin construction with linkage out of the air stream shall be used whenever the damper face velocity exceeds 1500 FPM or system pressure exceeds 2.5” w.g., but no more than 4000 FPM or 6” w.g. Acceptable manufacturers: Johnson Controls D-1300, Ruskin CD50, and Vent Products 5650.

7. One piece rolled blade dampers with exposed or concealed linkage may be used with face velocities of 1500 FPM or below.

8. Acceptable manufacturers: Johnson Controls D-1100, Ruskin CD36, and Vent Products 5800.

9. Multiple section dampers may be jack-shafted to allow mounting of piston pneumatic actuators and direct connect electronic actuators. Each end of the jackshaft shall receive at least one actuator to reduce jackshaft twist.

C. Control Relays:

1. Control Pilot Relays:

   a. Control pilot relays shall be of a modular plug-in design with retaining springs or clips.
   b. Mounting bases shall be snap-mount.
   c. DPDT, 3PDT, or 4PDT relays shall be provided, as appropriate for application.
   d. Contacts shall be rated for 10 amps at 120VAC.
   e. Relays shall have an integral indicator light and check button.

D. Control Valves:

1. All automatic control valves shall be fully proportioning and provide near linear heat transfer control. The valves shall be quiet in operation and fail-safe open, closed, or in their last position. All valves shall operate in sequence with another valve when required by the sequence of operations. All control valves shall be sized by the control manufacturer, and shall be guaranteed to meet the heating and cooling loads, as specified. All control valves shall be suitable for the system flow conditions and close against the differential pressures involved. Body pressure rating and connection type (sweat, screwed, or flanged) shall conform to the pipe schedule elsewhere in this Section.

2. Chilled water control valves shall be modulating plug, ball, and/or butterfly, as required by the specific application. Modulating water valves shall be sized per manufacturer’s recommendations for the given application. In general, valves (2 or 3-way) serving variable flow air handling unit coils shall be sized for a pressure drop equal to the actual coil pressure drop, but no more than 5 PSI. Valves (3-way) serving constant flow air handling unit coils with secondary circuit pumps shall be sized for a pressure drop equal to 25% the actual coil pressure drop, but no more than 2 PSI. Mixing valves (3-way)
serving secondary water circuits shall be sized for a pressure drop of no more than 5 PSI. Valves for terminal reheat coils shall be sized for a 2 PSIG pressure drop, but no more than a 5 PSI drop.

3. Modulating plug water valves of the single-seat type with equal percentage flow characteristics shall be used for all hot and chilled water applications, except those described hereinafter. The valve discs shall be composition type. Valve stems shall be stainless steel.

4. Ball valves shall be acceptable for water terminal reheat coils, radiant panels, unit heaters, package air conditioning units, and fan coil units.

5. Butterfly valves shall be acceptable for modulating large flow applications greater than modulating plug valves, and for all two-position, open/close applications. In-line and/or three-way butterfly valves shall be heavy-duty pattern with a body rating comparable to the pipe rating, replaceable lining suitable for temperature of system, and a stainless steel vane. Valves for modulating service shall be sized and travel limited to 50 degrees of full open. Valves for isolation service shall be the same as the pipe. Valves in the closed position shall be bubble-tight.

6. Control valves for ball valves shall not use pulse of tri-mode controllers or actuators. Controllers installed shall be capable of being spanned for the two stem travel ranges of 0-20% open and 85-100% open.

E. Electronic Signal Isolation Transducers:

1. A signal isolation transducer shall be provided whenever an analog output signal from the Facility Management System is to be connected to an external control system as an input (such as a chiller control panel), or is to receive as an input signal from a remote system.

2. The signal isolation transducer shall provide ground plane isolation between systems.

3. Signals shall provide optical isolation between systems.

F. Motor starters: an integral HAND/OFF/AUTO switch shall override the controlled device pilot relay.

1. A status input to the Facility Management System shall indicate whenever the switch is not in the automatic position.

2. A Status LED shall illuminate whenever the output is ON.

3. An Override LED shall illuminate whenever the HAND/OFF/AUTO switch is in either the HAND or OFF position.

4. Contacts shall be rated for a minimum of 1 amp at 24 VAC.

G. Variable frequency motor controllers: an integral HAND/AUTO pushbutton shall override the controlled device pilot relay.

1. A status input to the Facility Management System shall indicate whenever the controller is in the hand or bypass position.

2. A Status LED shall illuminate whenever the output is ON.

3. An Override LED shall illuminate whenever the HAND/AUTO pushbutton is in either the HAND or OFF position.

4. Contacts shall be rated for a minimum of 1 amp at 24 VAC.
2.9 CONTROL CABLE

A. Electronic and fiber-optic cables for control wiring are specified in Division 27 Section "Communications Horizontal Cabling."

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify that conditioned power supply is available to control units and operator workstation.

3.2 INSTALLATION

A. Install software in control units and operator workstation(s). Implement all features of programs to specified requirements and as appropriate to sequence of operation.

1. Connect and configure equipment and software to achieve sequence of operation

B. Verify location of thermostats, humidistats, and other exposed control sensors with Drawings and architectural room details before installation. Install devices 48 inches above the floor.

C. Install manual reset switches, such as high and low static resets, no higher than 6’-0” above nearest adjacent finished floor.

D. Install averaging elements in ducts, plenums, and coil faces in crossing or zigzag pattern. Provide one linear foot of sensor per square foot of coil in a pattern that will create an even distribution of sensor over the entire cross sectional area of duct or air handling unit.

E. Install freezestats to provide one linear foot of sensor per square foot of coil.

F. Install temperature sensor on the leaving side of all cooling and heating coils in AHUs.

G. Install outdoor air temperature sensors on a north facing wall and away from direct sunlight as well as 20 feet (minimum) from exhaust or relief air fans.

H. Install outdoor air humidity sensors on a north facing wall and away from direct sunlight as well as 20 feet (minimum) from exhaust or relief air fans. Do not install within 20 feet of cooling tower discharge, steam vents, or downstream of similar services in the direction of typical wind patterns.

I. Install guards on thermostats in the following locations:

1. Entrances.
2. Public areas.
3. Where indicated.

J. Install BTU meters for the following systems:
   1. Chilled Water.

K. Flow Station Locations:
   1. Air side
      a. Provide piezometer ring type at fan inlet for all fans located in AHUs and as indicated on drawings.
      b. Fans external to AHU may be piezometer or inlet probe type.
      c. Duct mounted flow stations shall be thermal dispersion type.
   2. Water side
      a. Water flow stations shall be electromagnetic type.
      b. Flow meters shall be installed in the following locations as a minimum:
         1) boiler feed water
         2) central plant steam supply
         3) chilled water loops
         4) closed condenser water loops
         5) heating water loops
         6) pumped condensate
      c. Adequate straight pipe shall be installed before (10 pipe diameters) and after (5 pipe diameters) device according to the manufacturer's recommendations.

L. Install pressure monitors across walls dividing spaces with monitored pressure requirements, including the following applications:
   1. Pharmacy

M. Coordinate EPO switch location and type with Division 26.

N. Install automatic dampers according to Division 23 Section "Air Duct Accessories."

O. Install damper motors on outside of duct in warm areas, not in locations exposed to outdoor temperatures.

P. Install labels and nameplates to identify control components according to Division 23 Section "Identification for HVAC Piping and Equipment."

Q. Install hydronic instrument wells, valves, and other accessories according to Division 23 Section "Hydronic Piping."

R. Install steam and condensate instrument wells, valves, and other accessories according to Division 23 Section "Steam and Condensate Heating Piping."
S. Install refrigerant instrument wells, valves, and other accessories according to Division 23 Section "Refrigerant Piping."

T. Install duct volume-control dampers according to Division 23 Sections specifying air ducts.

U. Install electronic and fiber-optic cables according to Division 27 Section "Communications Horizontal Cabling."

V. Unit Heaters: Unit heaters shall each be provided with a low voltage electric wall-mounted room thermostat, which shall cause the heater to be cycled "on" or "off" as required to satisfy the thermostat setting. Control circuit voltage shall not exceed 120 volts to ground. In the off position, water shall be circulated through the unit.

W. Cooling Tower Basin Heating: When the outside air temperature reaches 35 degrees F. (adj.), the cooling tower basin heating system shall be activated to maintain a 40 degree F. basin water temperature.

3.3 EQUIPMENT STATUS MONITORS

A. Current sensing relays are to be installed across motors and must be sensitive enough to detect and alarm when driven equipment, such as a fan motor is operating without a belt or a pump motor is operating without flow.

B. Where a current sensing relay is not sensitive as described above, provide differential pressure transducers switches to monitor equipment status.

3.4 ELECTRICAL WIRING AND CONNECTION INSTALLATION

A. Install raceways, boxes, and cabinets according to Division 26 Section "Raceway and Boxes for Electrical Systems."

B. Install building wire and cable according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

C. Install signal and communication cable according to Division 27 Section "Communications Horizontal Cabling."

1. Conceal cable, except in mechanical rooms and areas where other conduit and piping are exposed.
2. Install exposed cable in raceway.
3. Install concealed cable in raceway.
4. Bundle and harness multiconductor instrument cable in place of single cables where several cables follow a common path.
5. Fasten flexible conductors, bridging cabinets and doors, along hinge side; protect against abrasion. Tie and support conductors.
6. Number-code or color-code conductors for future identification and service of control system, except local individual room control cables.
7. Install wire and cable with sufficient slack and flexible connections to allow for vibration of piping and equipment.
D. Connect manual-reset limit controls independent of manual-control switch positions. Automatic duct heater resets may be connected in interlock circuit of power controllers.

E. Connect hand-off-auto selector switches or hand/auto push buttons to override automatic interlock controls when switch or pushbutton is in hand position.

3.5 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections, and to assist in field testing. Report results in writing.

B. Perform the following field tests and inspections and prepare 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 instrument tubing for proper fittings, slope, material, and support.
5. Check installation of air supply for each instrument.
6. Check flow instruments. Inspect tag number and line and bore size, and verify that inlet side is identified and that meters are installed correctly.
7. Check pressure instruments, piping slope, installation of valve manifold, and self-contained pressure regulators.
8. Check temperature instruments and material and length of sensing elements.
9. Check control valves. Verify that they are in correct direction.
10. 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.
D. Replace damaged or malfunctioning controls and equipment and repeat testing procedures.

3.6 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, including:

      1) Status indicators for fans shall be tested to indicate an alarm upon belt loss or dead-head pump condition. Adjust current sensing relays appropriately.
      2) Status indicators for preheat circulating pumps shall be tested to indicate an alarm upon dead-head condition. Adjust current sensing relay appropriately.

   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 for visits to Project during other than normal occupancy hours for this purpose.

3.7 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain HVAC instrumentation and controls. Refer to Division 01 Section "Demonstration and Training."

END OF SECTION
SECTION 232113
HYDRONIC PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes pipe and fitting materials, and joining methods for the following:

1. Hot-water heating piping.
2. Chilled-water piping.
3. Condensate-drain piping.

B. Related Sections include the following:

1. Division 23 Section "Expansion Fittings and Loops for HVAC Piping" for expansion fittings.
2. Division 23 Section “General-Duty Valves for HVAC Piping” for valves and accessories for piping.
3. Division 23 Section "HVAC Insulation – Duct, Equipment, and Piping" for pipe saddles at pipe hangers.
4. Division 23 Section “Vibration and Seismic Controls for HVAC Piping and Equipment” for seismic and wind restraint requirements.

1.2 PERFORMANCE REQUIREMENTS

A. Hydronic piping components and installation shall be capable of withstanding 150 psig at the corresponding temperature as the minimum working pressure and temperature, unless otherwise indicated:

1. Hot-Water Heating Piping: 200 deg F.
2. Chilled-Water Piping: 200 deg F.
3. Condensate-Drain Piping: 200 deg F.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of the following:

1. Pressure-seal fittings.
2. Valves. Include flow and pressure drop curves based on manufacturer's testing for calibrated-orifice balancing valves and automatic flow-control valves.
3. Air control devices.
4. Hydronic specialties.
B. Shop Drawings: Detail, at 1/4 scale, the piping layout, fabrication of pipe anchors, hangers, supports for multiple pipes, alignment guides, expansion joints and loops, and attachments of the same to the building structure. Detail location of anchors, alignment guides, and expansion joints and loops.

1.4 INFORMATIONAL SUBMITTALS

A. Welding certificates.
B. Qualification Data: For Installer.
C. Field quality-control test reports.
D. Operation and Maintenance Data: For air control devices, hydronic specialties, and special-duty valves to include in emergency, operation, and maintenance manuals.

1.5 QUALITY ASSURANCE

A. All piping shall be American manufactured, unless otherwise indicated.
B. Installer Qualifications:
   1. Installers of Pressure-Sealed Joints: Installers shall be certified by the pressure-seal joint manufacturer as having been trained and qualified to join piping with pressure-seal pipe couplings and fittings. Provide proof of training with Installer’s Credential Card.
C. Steel Support Welding: Qualify processes and operators according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."
D. Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX.
   1. Comply with provisions in ASME B31 Series, "Code for Pressure Piping."
   2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.
E. 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 EXTRA MATERIALS

A. Differential Pressure Meter: For each type of balancing valve and automatic flow control valve, include flowmeter, probes, hoses, flow charts, and carrying case.
PART 2 - PRODUCTS

2.1 COPPER TUBE AND FITTINGS

A. Drawn-Temper Copper Tubing: ASTM B 88, Type L.
B. Annealed-Temper Copper Tubing: ASTM B 88, Type K.
C. DWV Copper Tubing: ASTM B 306, Type DWV.
D. Wrought-Copper Fittings: ASME B16.22.
   1. Grooved-End Copper Fittings: ASTM B 75, copper tube or ASTM B 584, bronze casting.
   2. Grooved-End-Tube Couplings: Rigid pattern, unless otherwise indicated; gasketed fitting. Ductile-iron housing with keys matching pipe and fitting grooves, prelubricated EPDM gasket rated for minimum 230 deg F for use with housing, and steel bolts and nut.
E. Copper or Bronze Pressure-Seal Fittings:
   1. Manufacturers:
      a. Elkhart Products (Apolloxpress).
      b. NIBCO Inc. (Press System).
      c. Viega (ProPress).
   2. Housing: Copper.
   3. O-Rings and Pipe Stops: EPDM.
   4. Tools: Manufacturer's special tools.
   5. Minimum 200-psig working-pressure rating at 250 deg F.
   6. Smart Connect feature to guarantee identification of unpressed connections during the testing process.
F. Wrought-Copper Unions: ASME B16.22.

2.2 STEEL PIPE AND FITTINGS

A. Steel Pipe: ASTM A 53/A 53M, black steel with plain ends; type, grade, and wall thickness as indicated in Part 3 "Piping Applications" Article.
   1. Cast-Iron Threaded Fittings: ASME B16.4; Classes 125 and 250 as indicated in Part 3 "Piping Applications" Article.
   4. 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 Part 3 "Piping Applications" Article.
5. Wrought-Steel Fittings: ASTM A 234/A 234M, wall thickness to match adjoining pipe.
6. 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:
   b. End Connections: Butt welding.
   c. Facings: Raised face.

B. Grooved Mechanical-Joint Fittings and Couplings:
   1. Manufacturers:
      a. Anvil International, Inc.
      b. Grinnell, Inc.
      c. Victaulic Company of America.
   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, 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 synthetic rubber gasket of central cavity pressure-responsive design; with nuts, bolts, locking pin, locking toggle, or lugs to secure grooved pipe and fittings.

C. Steel Pipe Nipples: ASTM A 733, made of same materials and wall thicknesses as pipe in which they are installed.

2.3 JOINING MATERIALS

A. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.
   1. ASME B16.21, nonmetallic, flat, asbestos free, 1/8-inch maximum thickness unless thickness or specific material is indicated.
      a. Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.
      b. Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.

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

C. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.

D. Brazing Filler Metals: AWS A5.8, BCuP Series, copper-phosphorus alloys for joining copper with copper; or BAg-1, silver alloy for joining copper with bronze or steel.

E. Welding Filler Metals: Comply with AWS D10.12/D10.12M for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.
F. Gasket Material: Thickness, material, and type suitable for fluid to be handled and working temperatures and pressures.

2.4 DIELECTRIC FITTINGS

A. Description: Combination fitting of copper-alloy and ferrous materials with threaded, solder-joint, plain, or weld-neck end connections that match piping system materials.

B. Insulating Material: Suitable for system fluid, pressure, and temperature.

C. Dielectric Unions:
   1. Manufacturers:
      b. Central Plastics Company.
      d. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
      e. Zurn Plumbing Products Group; AquaSpec Commercial Products Division.
   2. Factory-fabricated union assembly, for 250-psig minimum working pressure at 180 deg F.

D. Dielectric Flanges:
   1. Manufacturers:
      b. Central Plastics Company.
      c. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
   2. Factory-fabricated companion-flange assembly, for 150- or 300-psig minimum working pressure as required to suit system pressures.

E. Dielectric-Flange Kits:
   1. Manufacturers:
      a. Advance Products & Systems, Inc.
      b. Calpico, Inc.
      c. Central Plastics Company.
      d. Pipeline Seal and Insulator, Inc.
   2. Companion-flange assembly for field assembly. Include flanges, full-face- or ring-type neoprene or phenolic gasket, phenolic or polyethylene bolt sleeves, phenolic washers, and steel backing washers.
   3. Separate companion flanges and steel bolts and nuts shall have 150- or 300-psig minimum working pressure where required to suit system pressures.

F. Dielectric Couplings:
1. Manufacturers:
   a. Calpico, Inc.
   b. Lochinvar Corporation.

2. Galvanized-steel coupling with inert and noncorrosive thermoplastic lining; threaded ends; and 300-psig minimum working pressure at 225 deg F.

G. Dielectric Nipples:

1. Manufacturers:
   a. Grinnell Mechanical Products.
   b. Perfection Corporation; a subsidiary of American Meter Company.
   c. Precision Plumbing Products, Inc.
   d. Sioux Chief Manufacturing Company, Inc.
   e. Victaulic Company of America.

2. Electroplated steel nipple with inert and noncorrosive, thermoplastic lining; plain, threaded, or grooved ends; and 300-psig minimum working pressure at 225 deg F.

**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 or brazed or pressure-seal joints.
2. Standard weight, Type S, Grade B steel pipe, fully welded, with Class 150 wrought cast or forged steel flanges at equipment and valve connections only.
3. Standard weight steel pipe; Class 125, cast-iron 150, malleable-iron 250, cast-iron 300, malleable-iron fittings; cast-iron flanges and flange fittings; and threaded joints.

B. Hot-water heating piping, aboveground, NPS 2-1/2 and larger, shall be any of the following:

1. Type L, drawn-temper copper tubing, wrought-copper fittings, and soldered or brazed joints.
2. Standard weight, Type S, Grade B steel pipe, fully welded, with Class 150 wrought cast or forged steel flanges at equipment and valve connections only.
3. Standard weight steel pipe, wrought-steel fittings and wrought-cast or forged-steel flanges and flange fittings, and welded and flanged joints.
4. Standard weight steel pipe; grooved, mechanical joint coupling and fittings; and grooved, mechanical joints.
C. Chilled-water piping, aboveground, NPS 2 and smaller, shall be any of the following:
   1. Type L, drawn-temper copper tubing, wrought-copper fittings, and soldered brazed or pressure-seal joints.
   2. Standard weight, Type S, Grade B steel pipe, fully welded, with Class 150 wrought cast or forged steel flanges at equipment and valve connections only.
   3. Standard weight steel pipe; Class 125, cast-iron 150, malleable-iron 250, cast-iron 300, malleable-iron fittings; cast-iron flanges and flange fittings; and threaded joints.

D. Chilled-water piping, aboveground, NPS 2-1/2 and larger, shall be any of the following:
   1. Type L, drawn-temper copper tubing, wrought-copper fittings, and soldered or brazed joints.
   2. Standard weight, Type S, Grade B steel pipe, fully welded, with Class 150 wrought cast or forged steel flanges at equipment and valve connections only.
   3. Standard weight steel pipe, wrought-steel fittings and wrought-cast or forged-steel flanges and flange fittings, and welded and flanged joints.
   4. Standard weight steel pipe; grooved, mechanical joint coupling and fittings; and grooved, mechanical joints.

E. Condensate-Drain Piping: Type DWV, drawn-temper copper tubing, wrought-copper fittings, and soldered joints.

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. Cut pipe to measurements established at site and work into place with forcing or springing.

C. Piping shall be installed by skilled mechanics using designated basic materials plus any required supplementary materials.

D. Install piping in concealed locations, unless otherwise indicated and except in equipment rooms and service areas.

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

F. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
G. Install piping to permit valve servicing.
H. Install piping at indicated slopes.
I. Install piping straight and true, free of sags and bends.
J. Install fittings for changes in direction and branch connections.
K. Install piping to allow application of insulation.
L. Select system components with pressure rating equal to or greater than system operating pressure.
M. Install groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves.
N. 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.
O. Reduce pipe sizes using eccentric reducer fitting installed with level side up.
P. Install branch connections to mains using mechanically formed tee fittings in main pipe, with the branch connected to the bottom of the main pipe. For up-feed risers, connect the branch to the top of the main pipe.
Q. Install unions in piping, NPS 2 and smaller, adjacent to valves, at final connections of equipment, and elsewhere as indicated.
R. Install flanges in piping, NPS 2-1/2 and larger, at final connections of equipment and elsewhere as indicated.
S. Identify piping as specified in Division 23 Section "Identification for HVAC Piping and Equipment."

3.3 PIPE GRADING

A. General: Grade each system in accordance with good established practice to avoid air pockets, to relieve liquids and vent gases. Grade uniformly between indicated elevations or at indicated slope. Slopes shown on plans shall take precedence over any listed herein.
B. Heating and Chilled Water Circulating Lines: Lay on an even slope; grade to drain at a valve at the circulating pump whenever possible; where other low points are unavoidable, provide service drains. Where horizontal mains change size, keep the tops of the coupled pipes on the same level using eccentric couplings.
C. Equipment Drains: Each line from a relief valve, air vent valve, separator or a boiler, drip pan elbow, exhaust head, heat exchanger, compression tank, receiver, pump base, air conditioning unit pan, air washer overflow and drain, evaporator pan, and similar drain shall grade down to a point of open sight discharge and/or as indicated on the drawings.
3.4 HANGERS AND SUPPORTS

A. Piping support must account for expansion and contraction, vibration, dead load of piping and its contents, and seismic-bracing requirements.

B. Hanger, support, and anchor devices are specified in Division 23 Section "Hangers and Supports for HVAC Piping and Equipment."

C. Seismic restraints are specified in Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment."

3.5 PIPE JOINT CONSTRUCTION

A. Join pipe and fittings according to the following requirements and Division 23 Sections specifying piping systems.

B. Use manufacturer’s recommended methods and follow all applicable codes for joining each piping system.

C. Make square cuts on all pipes using proper tools and alignment devices. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.

D. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

E. 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.

   1. Use solder joint fittings in copper tubing lines.
   2. Do not anneal copper tubing and fittings.
   3. Tubing shall be cut square, and burrs shall be removed. Insides of fittings and outsides of tubing shall be well cleaned with steel wool, steel brushes, and/or emery cloth before assembly.
   4. Installation shall be made by skilled mechanics in accordance with the material manufacturer’s recommendations.
   5. Mitering of joints for elbows and notching of straight runs for tees will not be permitted.
   6. All joints shall be made with solid string or wire solder. Fluxes shall be non-corrosive pastes of the proper type. Solder shall be lead free. No cored solder will be permitted.


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.


1. All joints shall be fusion welded by a metallic arc or gas welding process. Pipe ends shall be beveled 37½°. All welding operations shall conform to the latest recommendations of the American Welding Society or to the applicable provisions of the Code for Pressure Piping, ANSI B31.1, latest edition, amended to date.
2. Weld rods shall be of the proper type for each application to match the line materials.
3. If the Engineer so requests, the Contractor shall have each of his welders prepare test coupons which shall be tested in an approved independent testing laboratory and any defects found shall be cause for dismissal of the welder from the project. All cost of such tests shall be borne by the Contractor.
4. Branch takeoffs not larger than 2/3 of the main may be made using shaped nipples, weldedots, or threadolets to match branch line fabrication methods.

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

J. Copper Fittings

1. Use wrought copper solder joint type in all patterns and sizes available. Use long radius copper elbows wherever available and space will permit.

K. Welding Fittings

1. All fittings in welded lines shall be factory-fabricated welding fittings of the same material and the same weight or Schedule as the piping attached.
2. All elbow tees, caps and special fittings including connections into headers shall be standard butt welding fittings, conforming to ANSI B16.9, with the following exception: Branch take-offs from lines 2½" and larger and where the size of the takeoff does not exceed 2/3 of the normal diameter of the mains to which connected, may be made with shaped nipples or with Bonney Weldolets or Threadolets as required by the class of fabrication.
3. Mitering of pipe to form elbows, notching of straight runs to form tees, or any similar construction will not be permitted.

L. Flanges

1. At connections to flanged valves and equipment outlets in steel piping systems using welding neck, slip on welding flanges, screwed steel, or cast iron companion flanges.
   a. It will be permissible to use cast iron flanged fittings at connections to equipment items.
2. In grooved end piping systems use matching flanged adapter nipples.
3. In copper lines use brass flanges.
4. Connecting flanges shall have matching flat or raised faces. Faces shall be free of imperfections that would prevent proper seating.
5. Tighten bolts uniformly all around to prevent any stress.

M. Gaskets

1. Manufactured from proper materials as with performance and materials described in Division 23 “Common Work Results for HVAC”, unless otherwise indicated. Full-faced type for flat-faced flanges and ring type for raised-faced flanges.
   b. Steam and Condensate Return Lines: Non-asbestos sheeting.
   c. Dielectric Flanges: As provided with the flanges.
   d. Other Lines: As recommended for the duty.

N. 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.

O. Mechanically Formed, Copper-Tube-Outlet Joints: Use manufacturer-recommended tool and procedure, and brazed joints.

P. Pressure-Sealed Joints:

1. Use manufacturer-recommended tool and procedure. Leave insertion marks on pipe after assembly.
2. Sealing element shall be verified for the intended use.
3. Tube ends shall be cut on a right angle (square) to the tube.
4. Tube ends shall be reamed and chamfered, all grease, oil or dirt shall be removed from the tube end with a clean rag.
5. Visually examine the fitting sealing element to ensure there is no damage, and it is properly seated into the fitting.
6. Utilizing an Insertion Depth Inspection Gauge mark the tube wall, with a felt tip pen, at the appropriate location, or insert the tube fully into the fitting and mark the tube wall at the face of the fitting.
7. Always examine the tube to ensure it is fully inserted into the fitting prior to pressing the joint.
8. Pressure-seal fittings ½-inch thru 4-inch shall be joined using appropriate sized tools.
9. Pressure-seal fittings shall be installed according to the most current edition of the Manufacturer's installation guidelines.

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 bypass piping with globe valve around control valve. If parallel control valves are installed, only one bypass is required.

D. Install ports for pressure gages and thermometers at coil inlet and outlet connections according to Division 23 Section "Meters and Gages for HVAC Piping."

3.7 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. Procedures in subparagraphs below are paraphrased from ASME B31.9.
2. Test piping prior to backfilling, concealing, insulating or painting; isolate pressure sensitive equipment from tests.
   a. Test portions as required by construction schedule. When previously tested sections are expanded, retest at connections.
   b. Test new portions as required by construction schedule; test new connections into existing lines.
3. Use ambient temperature water as a testing medium unless there is risk of damage due to freezing. Air may be substituted as a testing medium instead of water. Refrigerant lines shall be leak tested with air unless otherwise indicated.
4. 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.
5. Isolate expansion tanks and determine that hydronic system is full of water.
6. 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 "SE" value in Appendix A in ASME B31.9, "Building Services Piping."
7. After hydrostatic test pressure has been applied for at least 4 hours, examine piping, joints, and connections for leakage. Eliminate leaks by tightening, repairing, or replacing components and repeat hydrostatic test until there are no leaks.
8. Prepare written report of testing. All test results shall be submitted to the Owner and Architect. Provide all tests required by acceptable codes.

9. Furnish all compressed air, vacuum and water pumps; tanks of compressed air, nitrogen, carbon dioxide, refrigerant, gauges, plugs, seals, etc., as required to obtain, maintain and measure pressures during tests.

10. Pressure test all systems per governing codes, to a minimum of 1.5 times the working pressure, or the following table, whichever is greater:

<table>
<thead>
<tr>
<th>Piping System</th>
<th>Test Pressure (psig)</th>
</tr>
</thead>
<tbody>
<tr>
<td>High Pressure Steam (above 15 psig)</td>
<td>200</td>
</tr>
<tr>
<td>Low Pressure Steam (15 psig and less)</td>
<td>100</td>
</tr>
<tr>
<td>Gravity Steam Condensate Returns</td>
<td>100</td>
</tr>
<tr>
<td>Pumped Steam Condensate Return</td>
<td>200</td>
</tr>
<tr>
<td>Heating, Chilled, and Condenser Water</td>
<td>150</td>
</tr>
<tr>
<td>Refrigerant</td>
<td>450</td>
</tr>
</tbody>
</table>

11. Prepare written report of testing.

C. Perform the following tests on pressure-seal piping:

1. After fittings have been installed a “two step test” shall be followed.
   a. Pressurize the system with application appropriate test medium, water between 15 and 85 psi, or air/dry nitrogen between .5 and 45 psi.
   b. Check the pressure gauge for pressure loss.
   c. If the system does not hold pressure, walk the system and check for un-pressed fittings.
   d. Should an un-pressed fitting/s be identified, ensure the tube is fully inserted into the fitting, and properly marked, prior to pressing the joint.
   e. After appropriate repairs have been made, retest the system per local code, or specification requirements, not to exceed 600 psi with water.

D. Perform the following before operating the system:

1. Open manual valves fully.
2. Inspect pumps for proper rotation.
3. Set makeup pressure-reducing valves for required system pressure.
4. Inspect air vents at high points of system and determine if all are installed and operating freely (automatic type), or bleed air completely (manual type).
5. Set temperature controls so all coils are calling for full flow.
6. Inspect and set operating temperatures of hydronic equipment, such as boilers, chillers, cooling towers, to specified values.
7. Verify lubrication of motors and bearings.

3.8 REPAIRS

A. Effect repairs as recommended by the manufacturer of the pipe and fittings materials; replace any defective materials. When procedures involve additional work on a joint and they fail, remake the joint. Repair operations shall include:

1. Screwed Joints: Additionally tighten.
2. Caulked Joints: Additionally caulk.
3. Welded Joints: Chip out old weld metal and re-weld.
4. Compression Joints: Re-clean; replace seal, compression rings, couplings, etc.
5. Mechanical Joints: Re-clean; additionally tighten.
6. Soldered or Brazed Joints: Remake joint, no additional soldering or brazing allowed.

3.9 CLEANING

A. Clean all new piping systems and components prior to putting into service.

B. Heating Water Systems: Fill the entire system with a solution consisting of one pound of caustic soda or 3 pounds of trisodium phosphate per 100 gallons of water; heat to 150°F and circulate for 48 hours over at least a 3 day period; drain, flush with fresh water and refill with fresh water to which adequate amounts of suitable chemicals have been added.

C. Chilled Water Systems: Fill the entire system with a solution consisting of one pound caustic soda or 3 pound of trisodium phosphate per 100 gallons of water; circulate for 60 hours over at least a 5 day period; drain, flush with fresh water and refill with fresh water to which adequate amounts of suitable chemicals have been added.

D. Blow off all strainers.

E. Waste and Drain Lines: Swab out lines; flush with fresh water.

F. Repetition: Repeat the above procedures until all parts of each piping system are thoroughly cleaned of all foreign materials.

END OF SECTION
1.1 SUMMARY

A. Section includes special-duty valves and specialties for the following:
   1. Hot-water heating piping.
   2. Chilled-water piping.
   3. Condenser-water piping.

B. Related Sections include the following:
   1. Division 23 Section "Expansion Fittings and Loops for HVAC Piping" for expansion fittings.
   2. Division 23 Section “General-Duty Valves for HVAC Piping” for valves and accessories for piping.
   3. Division 23 Section "HVAC Insulation – Duct, Equipment, and Piping" for pipe saddles at pipe hangers.
   4. Division 23 Section “Vibration and Seismic Controls for HVAC Piping and Equipment” for seismic and wind restraint requirements.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of the following:
   1. Pressure-seal fittings.
   2. Valves: Include flow and pressure drop curves based on manufacturer's testing for calibrated-orifice balancing valves and automatic flow-control valves.
   3. Air-control devices.
   4. Hydronic specialties.

B. Shop Drawings: Detail, at 1/4 scale, the piping layout, fabrication of pipe anchors, hangers, supports for multiple pipes, alignment guides, expansion joints and loops, and attachments of the same to the building structure. Detail location of anchors, alignment guides, and expansion joints and loops.

1.3 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For air-control devices, hydronic specialties, and special-duty valves to include in emergency, operation, and maintenance manuals.
1.4 MAINTENANCE MATERIAL SUBMITTALS

A. Differential Pressure Meter: For each type of balancing valve and automatic flow control valve, include flowmeter, probes, hoses, flow charts, and carrying case.

1.5 QUALITY ASSURANCE

A. Installer Qualifications:

1. Installers of Pressure-Sealed Joints: Installers shall be certified by the pressure-seal joint manufacturer as having been trained and qualified to join piping with pressure-seal pipe couplings and fittings.
2. Pipe Welding: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code: Section IX.
   a. 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 1.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Hydronic piping components and installation shall be capable of withstanding 150 psig minimum working pressure at the temperature listed below, unless otherwise indicated:

1. Hot-Water Heating Piping: 200 deg F.
2. Chilled-Water Piping: 200 deg F.
3. Condenser-Water Piping: 200 deg F.

2.2 VALVES

A. Gate, Globe, Check, Ball, and Butterfly Valves: Comply with requirements specified in Division 23 Section "General-Duty Valves for HVAC Piping."

B. Automatic Temperature-Control Valves, Actuators, and Sensors: Comply with requirements specified in Division 23 Section "Instrumentation and Control for HVAC."

C. Bronze, Calibrated-Orifice, Balancing Valves:

1. Manufacturers:
   a. Armstrong Pumps, Inc.
   b. Bell & Gossett Domestic Pump; a division of ITT Industries.
   c. Flow Design Inc.
   d. Griswold Controls.
   e. Taco.
2. Body: Bronze, ball or plug type with calibrated orifice or venturi.
3. Ball: Brass or stainless steel.
4. Plug: Resin.
5. Seat: PTFE.
6. End Connections: Threaded or socket.
8. Handle Style: Lever, with memory stop to retain set position.
10. Maximum Operating Temperature: 250 deg F.

D. Cast-Iron or Steel, Calibrated-Orifice, Balancing Valves:

1. Manufacturers:
   a. Armstrong Pumps, Inc.
   b. Bell & Gossett Domestic Pump; a division of ITT Industries.
   c. Flow Design Inc.
   d. Grinnell Mechanical Products.
   e. Griswold Controls.
   f. Taco.
   g. Tour & Andersson; available through Victaulic Company of America.

2. Body: Cast-iron or steel body, ball, plug, or globe pattern with calibrated orifice or venturi.
3. Ball: Brass or stainless steel.
5. Seat: PTFE.
6. End Connections: Flanged or grooved.
7. Handle Style: Lever, with memory stop to retain set position.
8. CWP Rating: Minimum 125 psig.
9. Maximum Operating Temperature: 250 deg F.

E. Diaphragm-Operated, Pressure-Reducing Valves:

1. Manufacturers:
   a. Amtrol, Inc.
   b. Armstrong Pumps, Inc.
   c. Bell & Gossett Domestic Pump; a division of ITT Industries.
   d. Conbraco Industries, Inc.
   e. Spence Engineering Company, Inc.
   f. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. Body: Bronze or brass.
5. Diaphragm: EPT.
6. Low inlet-pressure check valve.
7. Inlet Strainer: Stainless steel, removable without system shutdown.
9. Valve Size, Capacity, and Operating Pressure: Selected to suit system in which installed, with operating pressure and capacity factory set and field adjustable.

F. Diaphragm-Operated Safety Valves: ASME labeled.

1. Manufacturers:
   a. Amtrol, Inc.
   b. Armstrong Pumps, Inc.
   c. Bell & Gossett Domestic Pump; a division of ITT Industries.
   d. Conbraco Industries, Inc.
   e. Spence Engineering Company, Inc.
   f. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. Body: Bronze or brass.
5. Diaphragm: EPT.
7. Inlet Strainer: Stainless steel, removable without system shutdown.
9. Valve Size, Capacity, and Operating Pressure: Comply with ASME Boiler and Pressure Vessel Code: Section IV, and selected to suit system in which installed, with operating pressure and capacity factory set and field adjustable.

G. Automatic Flow-Control Valves:

1. Manufacturers:
   a. Flow Design Inc.
   b. Griswold Controls.
   c. Nexus.
   d. NuTech.

2. Body: Brass or ferrous metal.
3. Piston and Spring Assembly: Stainless steel, tamper proof, self cleaning, and removable.
4. Combination Assemblies: Include bronze or brass-alloy ball valve.
5. Identification Tag: Marked with zone identification, valve number, and flow rate.
6. Size: Same as pipe in which installed.
7. Performance: Maintain constant flow, plus or minus 5 percent over system pressure fluctuations.
9. Minimum Operating Temperature: 200 deg F.

2.3 AIR-CONTROL DEVICES

A. Manufacturers:
1. Amtrol, Inc.
2. Armstrong Pumps, Inc.
3. Bell & Gossett Domestic Pump; a division of ITT Industries.
4. Taco.
5. Spirotherm.

B. Manual Air Vents:
1. Body: Bronze.
2. Internal Parts: Nonferrous.
3. Operator: Screwdriver or thumbscrew.
4. Inlet Connection: NPS 1/2 (DN 15).
6. Minimum Simultaneous Operating Point: 150 psig at 225 deg F.

C. Automatic Air Vents:
1. Body: Bronze or cast iron.
2. Internal Parts: Nonferrous.
4. Inlet Connection: NPS 1/2 (DN 15).
5. Discharge Connection: NPS 1/4 (DN 8).
6. Minimum Simultaneous Operating Point: 150 psig at 240 deg F.

2.4 HYDRONIC PIPING SPECIALTIES

A. Strainer Perforations: All strainers shall be stainless steel and sized based on the service and installed pipe size as indicated by the table below, unless indicated otherwise.

<table>
<thead>
<tr>
<th>SERVICE DUTY</th>
<th>PIPE SIZE (NPS)</th>
<th>STRAINER BASKET PERFORATION SIZE (in)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chilled and Hot Water</td>
<td>1/4” to 2”</td>
<td>0.033</td>
</tr>
<tr>
<td></td>
<td>2-1/2” to 4”</td>
<td>0.057</td>
</tr>
<tr>
<td></td>
<td>6” and Larger</td>
<td>0.125”</td>
</tr>
<tr>
<td>Condenser Water</td>
<td>1/4” to 2”</td>
<td>0.020</td>
</tr>
<tr>
<td></td>
<td>2-1/2” to 4”</td>
<td>0.045</td>
</tr>
<tr>
<td></td>
<td>6” and Larger</td>
<td>0.100</td>
</tr>
</tbody>
</table>

B. Y-Pattern Strainers:
1. Body: ASTM A 126, Class B, cast iron with bolted cover and bottom drain connection.
2. End Connections: Threaded ends for NPS 2 and smaller; flanged ends for NPS 2-1/2 and larger. Grooved and Pressure-seal connections are also acceptable.


C. Basket Strainers:

1. Body: ASTM A 126, Class B, high-tensile cast iron with bolted cover and bottom drain connection.

2. End Connections: Threaded ends for NPS 2 and smaller; flanged ends for NPS 2-1/2 and larger. Grooved and Pressure-seal connections are also acceptable.


D. T-Pattern Strainers:

1. Body: Ductile or malleable iron with removable access coupling and end cap for strainer maintenance.

2. End Connections: Grooved ends. Pressure-seal connections are also acceptable.

3. CWP Rating: 750 psig.

E. Stainless-Steel Bellow, Flexible Connectors:


2. End Connections: Threaded or flanged to match equipment connected.

3. Performance: Capable of 3/4-inch (20-mm) misalignment.

4. CWP Rating: 150 psig (1035 kPa).

5. Maximum Operating Temperature: 250 deg F (121 deg C).

F. Spherical, Rubber, Flexible Connectors:


2. End Connections: Steel flanges drilled to align with Classes 150 and 300 steel flanges.


4. CWP Rating: 150 psig (1035 kPa).

5. Maximum Operating Temperature: 250 deg F (121 deg C).

PART 3 - EXECUTION

3.1 VALVE APPLICATIONS

A. Install valves according to Division 23 Section "General-Duty Valves for HVAC Piping."

B. Install shutoff-duty valves at each branch connection to supply mains and at supply connection to each piece of equipment.
C. Install calibrated-orifice, balancing valves in the return pipe of each heating or cooling terminal.

D. Install check valves at each pump discharge and elsewhere as required to control flow direction.

E. Install safety valves at hot-water generators and elsewhere as required by ASME Boiler and Pressure Vessel Code. Install drip-pan elbow on safety-valve outlet and pipe without valves to the outdoors; pipe drain to nearest floor drain or as indicated on Drawings. Comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1, for installation requirements.

F. Install pressure-reducing valves at makeup-water connection to regulate system fill pressure.

G. All valves shall be installed with stems in vertical position, unless otherwise indicated. If not possible, stems may be installed 45° off vertical position where allowed by manufacturer.

H. Install unions in piping, NPS 2 and smaller, adjacent to valves, at final connections of equipment, and elsewhere as indicated.

I. Install flanges in piping, NPS 2-1/2 and larger, at final connections of equipment and elsewhere as indicated.

J. Install strainers on inlet side of each control valve, pressure-reducing valve, solenoid valve, in-line pump, and elsewhere as indicated. Install NPS 3/4 nipple and ball valve in blowdown connection of strainers NPS 2 and larger. Match size of strainer blowoff connection for strainers smaller than NPS 2.

3.2 HYDRONIC SPECIALTIES INSTALLATION

A. Select system components with pressure rating equal to or greater than system operating pressure.

B. Install manual air vents at high points in piping, at heat-transfer coils, and elsewhere as required for system air venting.

C. Install automatic air vents at high points of system piping in mechanical equipment rooms only. Install manual vents at heat-transfer coils and elsewhere as required for air venting.

D. Install expansion tanks on the floor or suspended as indicated. Vent and purge air from hydronic system, and ensure that tank is properly charged with air to suit system Project requirements.

END OF SECTION
SECTION 232300
REFRIGERANT PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Refrigerant pipes and fittings.
   2. Refrigerant piping valves and specialties.
   3. Refrigerants.

B. Related Sections:
   1. Division 23 Section "Common Work Results" for description of concrete bases used as vibration isolation.
   2. Division 23 Section "Hangers and Supports for HVAC Piping and Equipment" for installation locations of pipe saddles at pipe hangers.
   3. Division 23 Section "HVAC Insulation – Duct, Equipment, and Piping" for pipe saddles at pipe hangers.
   4. Division 23 Section “Vibration and Seismic Controls for HVAC Piping and Equipment” for seismic and wind restraint requirements.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of valve, refrigerant piping, and piping specialty.
   1. Include pressure drop, based on manufacturer's test data, for the following:
      a. Thermostatic expansion valves.
      b. Solenoid valves.
      c. Hot-gas bypass valves.
      d. Filter dryers.
      e. Strainers.
      f. Pressure-regulating valves.

B. Shop Drawings:
   1. Delegated-Design Submittal: As a 1/8 inch equals 1 foot scale drawing, show:
      a. Layout of refrigerant piping and specialties, including pipe, tube, and fitting sizes, as well as slopes of horizontal runs.
      b. Valve arrangements and locations.
      c. Oil traps.
      d. Double risers.
      e. Wall and floor penetrations.
f. Equipment connection details. Indicate elevation difference between compressor and evaporator, refrigerant flows, and other information to ensure proper operation and compliance with warranties of connected equipment.
   2. Show interface and spatial relationships between piping and equipment.

1.3 INFORMATIONAL SUBMITTALS

A. Welding certificates.
B. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For refrigerant valves and piping specialties to include in maintenance manuals.

1.5 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel according to 2010 ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."
C. Comply with ASME B31.5, "Refrigeration Piping and Heat Transfer Components."

1.6 PRODUCT STORAGE AND HANDLING

A. Store piping with end caps in place to ensure that piping interior and exterior are clean when installed.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS
Line Test Pressure for Refrigerant R-134a:


B. Line Test Pressure for Refrigerant R-407C:


C. Line Test Pressure for Refrigerant R-410A:

2.2 COPPER TUBE AND FITTINGS

A. Copper Tube:
   1. ASTM B 88, Type K or L
   2. ASTM B 280, Type ACR.

B. Wrought-Copper Fittings: ASME B16.22.

C. Wrought-Copper Unions: ASME B16.22.

D. Solder Filler Metals: ASTM B 32. Use 95-5 tin antimony or alloy HB solder to join copper socket fittings on copper pipe.

E. Brazing Filler Metals: AWS A5.8/A5.8M.

F. Flexible Connectors:
   2. End Connections: Socket ends.
   3. Offset Performance: Capable of minimum 3/4-inch misalignment in minimum 7-inch-long assembly.
   5. Maximum Operating Temperature: 250 deg F.

2.3 STEEL PIPE AND FITTINGS

A. Steel Pipe: ASTM A 53/A 53M, black steel with plain ends; type, grade, and wall thickness as selected in piping application articles.

B. Wrought-Steel Fittings: ASTM A 234/A 234M, for welded joints.

C. Steel Flanges and Flanged Fittings: ASME B16.5, steel, including bolts, nuts, and gaskets, bevel-welded end connection, and raised face.

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

E. Flanged Unions:
   1. Body: Forged-steel flanges for NPS 1 to NPS 1-1/2 and ductile iron for NPS 2 to NPS 3. Apply rust-resistant finish at factory.
   2. Gasket: Fiber asbestos free.
   3. Fasteners: Four plated-steel bolts, with silicon bronze nuts. Apply rust-resistant finish at factory.
4. End Connections: Brass tailpiece adapters for solder-end connections to copper tubing.
5. Offset Performance: Capable of minimum 3/4-inch misalignment in minimum 7-inch-long assembly.
7. Maximum Operating Temperature: 330 deg F.

F. Flexible Connectors:
2. End Connections:
   a. NPS 2 and Smaller: With threaded-end connections.
   b. NPS 2-1/2 and Larger: With flanged-end connections.
3. Offset Performance: Capable of minimum 3/4-inch misalignment in minimum 7-inch-long assembly.
5. Maximum Operating Temperature: 250 deg F.

2.4 VALVES AND SPECIALTIES

A. Diaphragm Packless Valves:
1. Body and Bonnet: Forged brass or cast bronze; globe design with straight-through or angle pattern.
3. Operator: Rising stem and hand wheel.
5. End Connections: Socket, union, or flanged.
7. Maximum Operating Temperature: 275 deg F.

B. Packed-Angle Valves:
1. Body and Bonnet: Forged brass or cast bronze.
2. Packing: Molded stem, back seating, and replaceable under pressure.
3. Operator: Rising stem.
5. Seal Cap: Forged-brass or valox hex cap.
6. End Connections: Socket, union, threaded, or flanged.
8. Maximum Operating Temperature: 275 deg F.

C. Check Valves:
1. Body: Ductile iron, forged brass, or cast bronze; globe pattern.
2. Bonnet: Bolted ductile iron, forged brass, or cast bronze; or brass hex plug.
5. End Connections: Socket, union, threaded, or flanged.
6. Maximum Opening Pressure: 0.50 psig.
8. Maximum Operating Temperature: 275 deg F.

D. Service Valves:
   1. Body: Forged brass with brass cap including key end to remove core.
   2. Core: Removable ball-type check valve with stainless-steel spring.
   4. End Connections: Copper spring.

E. Solenoid Valves: Comply with AHRI 760 and UL 429; listed and labeled by a National Recognized Testing Laboratory (NRTL).
   1. Manufacturers:
      a. Danfoss Inc.
      b. Emerson Climate Technologies.
      d. Body and Bonnet: Plated steel.
      e. Solenoid Tube, Plunger, Closing Spring, and Seat Orifice: Stainless steel.
      f. Seat: Polytetrafluoroethylene.
      g. End Connections: Threaded.
      h. Electrical: Molded, watertight coil in NEMA 250 enclosure of type required by location with 1/2-inch conduit adapter, and 24 or 115-V ac coil.
      i. Working Pressure Rating: 400 psig.
      j. Maximum Operating Temperature: 240 deg F.

F. Safety Relief Valves: Comply with 2010 ASME Boiler and Pressure Vessel Code; listed and labeled by an NRTL.
   1. Body and Bonnet: Ductile iron and steel, with neoprene O-ring seal.
   4. End Connections: Threaded.
   6. Maximum Operating Temperature: 240 deg F.

G. Thermostatic Expansion Valves: Comply with AHRI 750.
   1. Body, Bonnet, and Seal Cap: Forged brass or steel.
   4. Capillary and Bulb: Copper tubing filled with refrigerant charge.
   5. Suction Temperature: 40 deg F.
   7. End Connections: Socket, flare, or threaded union.

H. Hot-Gas Bypass Valves: Comply with UL 429; listed and labeled by an NRTL.
1. Body, Bonnet, and Seal Cap: Ductile iron or steel.
5. Seat: Polytetrafluoroethylene.
6. Equalizer: Internal or External.
7. Electrical: Molded, watertight coil in NEMA 250 enclosure of type required by location with 1/2-inch conduit adapter and 24 or 115-V ac coil.
11. Maximum Operating Temperature: 240 deg F.

I. Straight-Type Strainers:
2. Screen: 100-mesh stainless steel.
3. End Connections: Socket or flare.
5. Maximum Operating Temperature: 275 deg F.

J. Angle-Type Strainers:
1. Body: Forged brass or cast bronze.
2. Drain Plug: Brass hex plug.
3. Screen: 100-mesh monel.
4. End Connections: Socket or flare.
6. Maximum Operating Temperature: 275 deg F.

K. Moisture/Liquid Indicators:
2. Window: Replaceable, clear, fused glass window with indicating element protected by filter screen.
3. Indicator: Color coded to show moisture content in parts per million (ppm).
5. End Connections: Socket or flare.
7. Maximum Operating Temperature: 240 deg F.

L. Replaceable-Core Filter Dryers: Comply with AHRI 730.
1. Body and Cover: Painted-steel shell with ductile-iron cover, stainless-steel screws, and neoprene gaskets.
2. Filter Media: 10 micron, pleated with integral end rings; stainless-steel support.
3. Desiccant Media: Activated alumina or charcoal.
4. Designed for reverse flow (for heat-pump applications).
5. End Connections: Socket.
9. Maximum Operating Temperature: 240 deg F.

M. Permanent Filter Dryers: Comply with AHRI 730.
   2. Filter Media: 10 micron, pleated with integral end rings; stainless-steel support.
   3. Desiccant Media: Activated alumina or charcoal.
   4. Designed for reverse flow (for heat-pump applications).
   5. End Connections: Socket.
   9. Maximum Operating Temperature: 240 deg F.

N. Mufflers:
   2. End Connections: Socket or flare.
   4. Maximum Operating Temperature: 275 deg F.

O. Receivers: Comply with AHRI 495.
   1. Comply with 2010 ASME Boiler and Pressure Vessel Code; listed and labeled by an NRTL.
   2. Comply with UL 207; listed and labeled by an NRTL.
   4. Tappings: Inlet, outlet, liquid level indicator, and safety relief valve.
   5. End Connections: Socket or threaded.
   7. Maximum Operating Temperature: 275 deg F.

P. Liquid Accumulators: Comply with AHRI 495.
   2. End Connections: Socket or threaded.
   4. Maximum Operating Temperature: 275 deg F.

2.5 REFRIGERANTS

A. ASHRAE 34, R-134a: Tetrafluoroethane.

B. ASHRAE 34, R-407C: Difluoromethane / Pentafluoroethane / 1,1,1,2-Tetrafluoroethane.

C. ASHRAE 34, R-410A: Pentafluoroethane/Difluoromethane.
PART 3 - EXECUTION

3.1 PIPING APPLICATIONS FOR REFRIGERANT

A. Unless otherwise required by the manufacturer or applicable codes, provide the following for all applications including suction, hot gas, and safety piping:

1. Aboveground Locations:
   a. Sizes up to NPS 3/4: ACR, soldered with wrought copper fittings.
   b. Sizes greater than NPS 3/4 to NPS 4: Type K, brazed with wrought copper fittings.
   c. Sizes above NPS 4: Schedule 40, black-steel and wrought-steel fittings with welded joints.

2. Safety-Relief-Valve Discharge Piping: Schedule 40, black-steel and wrought-steel fittings with welded joints.

3.2 VALVE AND SPECIALTY APPLICATIONS

A. Install diaphragm packless or packed-angle valves in suction and discharge lines of compressor.

B. Install service valves for gage taps at inlet and outlet of hot-gas bypass valves and strainers if they are not an integral part of valves and strainers.

C. Except as otherwise indicated, install diaphragm packless or packed-angle valves on inlet and outlet side of filter dryers.

D. Install a full-size, three-valve bypass around filter dryers.

E. Install solenoid valves upstream from each expansion valve and hot-gas bypass valve. Install solenoid valves in horizontal lines with coil at top.

F. Install thermostatic expansion valves as close as possible to distributors on evaporators.

   1. Install valve so diaphragm case is warmer than bulb.
   2. Secure bulb to clean, straight, horizontal section of suction line using two bulb straps. Do not mount bulb in a trap or at bottom of the line.
   3. If external equalizer lines are required, make connection where it will reflect suction-line pressure at bulb location.

G. Install safety relief valves where required by 2010 ASME Boiler and Pressure Vessel Code. Pipe safety-relief-valve discharge line to outside according to ASHRAE 15.

H. Install moisture/liquid indicators in liquid line at the inlet of the thermostatic expansion valve or at the inlet of the evaporator coil capillary tube.

I. Install strainers upstream from and adjacent to the following unless they are furnished as an integral assembly for the device being protected:
1. Solenoid valves.
2. Thermostatic expansion valves.
3. Hot-gas bypass valves.
4. Compressor.

J. Install filter dryers in liquid line between compressor and thermostatic expansion valve, and in the suction line at the compressor.

K. Install receivers sized to accommodate pump-down charge.

L. Install flexible connectors at compressors.

3.3 PIPING INSTALLATION

A. Install refrigerant piping according to ASHRAE 15.

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 adjacent to machines to allow service and maintenance.

F. Install piping free of sags and bends.

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

H. Select system components with pressure rating equal to or greater than system operating pressure.

I. Install piping as short and direct as possible, with a minimum number of joints, elbows, and fittings.

J. Arrange piping to allow inspection and service of refrigeration equipment. Install valves and specialties in accessible locations to allow for service and inspection. Install access doors or panels where valves or equipment requiring maintenance is concealed behind finished surfaces.

K. Install refrigerant piping in protective conduit where installed belowground.

L. Install refrigerant piping in rigid or flexible conduit in locations where exposed to mechanical injury.

M. Slope refrigerant piping as follows:

   1. Install horizontal hot-gas discharge piping with a uniform slope downward away from compressor.
2. Install horizontal suction lines with a uniform slope downward to compressor.
3. Install traps and double risers to entrain oil in vertical runs.
4. Liquid lines may be installed level.

N. When brazing or soldering, remove solenoid-valve coils and sight glasses; also remove valve stems, seats, and packing, and accessible internal parts of refrigerant specialties. Do not apply heat near expansion-valve bulb.

O. Before installation of steel refrigerant piping, clean pipe and fittings using the following procedures:
   1. Shot blast the interior of piping.
   2. Remove coarse particles of dirt and dust by drawing a clean, lintless cloth through tubing by means of a wire or electrician's tape.
   3. Draw a clean, lintless cloth saturated with trichloroethylene through the tube or pipe. Continue this procedure until cloth is not discolored by dirt.
   4. Draw a clean, lintless cloth, saturated with compressor oil, squeezed dry, through the tube or pipe to remove remaining lint. Inspect tube or pipe visually for remaining dirt and lint.
   5. Finally, draw a clean, dry, lintless cloth through the tube or pipe.
   6. Safety-relief-valve discharge piping is not required to be cleaned but is required to be open to allow unrestricted flow.

P. Install piping with adequate clearance between pipe and adjacent walls and hangers or between pipes for insulation installation.

Q. Identify refrigerant piping and valves according to Division 23Section, "Identification for HVAC Piping and Equipment."

R. Install sleeve seals for piping penetrations of concrete exterior walls and slabs, interior walls, ceilings, and floors. Comply with requirements for sleeve seals specified in Division 23Section "Common Work Results."

S. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Division 23 Section "Common Work Results."

3.4 PIPE JOINT CONSTRUCTION

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

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

C. Fill pipe and fittings with an inert gas (nitrogen or carbon dioxide), during brazing or welding, to prevent scale formation.

D. Soldered Joints: Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook."

E. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," Chapter "Pipe and Tube."
1. Use Type BCuP (copper-phosphorus) alloy for joining copper socket fittings with copper pipe.
2. Use Type BAg (cadmium-free silver) alloy for joining copper with bronze or steel.

F. Threaded Joints: Thread steel pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and to restore full ID. Join pipe fittings and valves as follows:
   1. Apply appropriate tape or thread compound to external pipe threads unless dry-seal threading is specified.
   2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

G. Steel pipe can be threaded, but threaded joints must be seal brazed or seal welded.


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 HANGERS AND SUPPORTS

A. Comply with requirements for pipe hangers and supports specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

B. Install the following pipe attachments:
   1. Adjustable steel clevis hangers for individual horizontal runs less than 20 feet long.
   2. Roller hangers and spring hangers for individual horizontal runs 20 feet or longer.
   3. Pipe Roller: MSS SP-58, Type 44 for multiple horizontal piping 20 feet or longer, supported on a trapeze.
   4. Spring hangers to support vertical runs.
   5. Copper-clad hangers and supports for hangers and supports in direct contact with copper pipe.

C. Support multifloor vertical runs at least at each floor.

3.6 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:
   1. Comply with ASME B31.5, Chapter VI.
   2. Test refrigerant piping, specialties, and receivers. Isolate compressor, condenser, evaporator, and safety devices from test pressure if they are not rated above the test pressure.
3. Test high- and low-pressure side piping of each system separately at not less than the pressures indicated in "Performance Requirements" Article.
   a. Fill system with nitrogen to the required test pressure.
   b. System shall maintain test pressure at the manifold gage throughout duration of test.
   c. Test joints and fittings with electronic leak detector or by brushing a small amount of soap and glycerin solution over joints.
   d. Remake leaking joints using new materials, and retest until satisfactory results are achieved.

B. Prepare test and inspection reports.

3.7 SYSTEM CHARGING

A. Charge system using the following procedures:
   1. Install core in filter dryers after leak test but before evacuation.
   2. Evacuate entire refrigerant system with a vacuum pump to 500 micrometers. If vacuum holds for 12 hours, system is ready for charging.
   3. Break vacuum with refrigerant gas, allowing pressure to build up to 2 psig.
   4. Charge system with a new filter-dryer core in charging line.

3.8 ADJUSTING

A. Adjust thermostatic expansion valve to obtain proper evaporator superheat.

B. Adjust high- and low-pressure switch settings to avoid short cycling in response to fluctuating suction pressure.

C. Adjust set-point temperature of air-conditioning or chilled-water controllers to the system design temperature.

D. Perform the following adjustments before operating the refrigeration system, according to manufacturer’s written instructions:
   1. Open shutoff valves in condenser water circuit.
   2. Verify that compressor oil level is correct.
   3. Open compressor suction and discharge valves.
   4. Open refrigerant valves except bypass valves that are used for other purposes.
   5. Check open compressor-motor alignment and verify lubrication for motors and bearings.

E. Replace core of replaceable filter dryer after system has been adjusted and after design flow rates and pressures are established.

END OF SECTION
SECTION 233113
METAL DUCTS

PART 1 - GENERAL

1.1 SUMMARY
A. This Section includes metal ducts for supply, return, outside, and exhaust air-distribution systems in pressure classes from minus 2- to plus 10-inch wg. Metal ducts include the following:

1. Rectangular ducts and fittings.
2. Single-wall, round, and flat-oval spiral-seam ducts and formed fittings.

B. Related Sections include the following:
1. Division 23 Section "Air Duct Accessories" for dampers, sound-control devices, duct-mounting access doors and panels, turning vanes, and flexible ducts.
2. Division 23 Section “Hangers and Supports for HVAC Piping and Equipment”.
3. Division 23 Section "Air Duct Accessories" for fire and smoke.
4. Division 07 Section "Penetration Firestopping" for firestopping materials and installation methods.

1.2 DEFINITIONS
A. FRP: Fiberglass-reinforced plastic.

1.3 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 will provide original design results without increasing system total pressure.

1.4 ACTION SUBMITTALS
A. Product Data: For each type of the following products:

1. Liners and adhesives.
2. Sealants and gaskets.
B. Shop Drawings: CAD-generated and drawn to same scale as contract drawings, minimum 1/8 inch equals 1 foot scale. Show fabrication and installation details for metal ducts.

1. Shop drawings required for all areas of the building
2. Fabrication, assembly, and installation, including plans, elevations, sections, components, and attachments to other work.
3. Duct sizes shown on the drawings are net free area and indicate design intent. When obstructions occur within the duct from motorized actuators, damper frames, duct liner, etc., the duct size shall be increased to preserve free area design intent. Duct layout indicating the following:
   a. Sizes and pressure classes.
   b. Elevations of top and bottom of ducts.
   c. Dimensions of main duct runs from building grid lines.
   d. Fittings.
   e. Duct accessories, including access doors and panels.
   f. Notes indicating deviations from design intent for detailed review by Engineer.

4. Equipment installation based on equipment being used on Project.
5. Submit the following with the initial shop drawing package:
   a. Reinforcement and spacing.
   b. Seam and joint construction.
   c. Penetrations through fire-rated and other partitions.
   d. Hangers and supports, including methods for duct and building attachment, vibration isolation, and seismic restraints.
   e. Dampers
      1) Locations of fire-smoke dampers.
      2) Locations of motorized control dampers.
      3) Indication of location, size, and quantity of damper actuators in the air stream.
      4) Location of damper actuator access for maintenance and inspection.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings are required for all areas and shall remain on site. Coordinate with all trades.

B. Welding certificates.

C. Field quality-control test reports.

1.6 QUALITY ASSURANCE

A. Welding: Qualify procedures and personnel according to AWS D1.1, "Structural Welding Code--Steel," for hangers and supports, AWS D1.2, "Structural Welding
BROWARD HEALTH PHARMACY


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."

1.7 DELIVERY, STORAGE, AND HANDLING

A. After fabrication and before the ductwork is installed it shall be "wiped clean" and "heat-shrink wrapped" or some other method of wrap for maintaining a clean ductwork system during delivery to and storage at the jobsite.

B. Deliver ducts with all openings protected and sealed. Maintain covered openings through shipping, storage, and handling to prevent entrance of dirt, debris, and moisture.

C. The area provided for duct storage at the jobsite shall be clean, dry and exposure to dust minimized.

PART 2 - PRODUCTS

2.1 SHEET METAL MATERIALS

A. Comply with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods, unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

B. Galvanized Sheet Steel: Lock-forming quality; complying with ASTM A 653/A 653M and having G90 coating designation; ducts shall have mill-phosphatized finish for surfaces exposed to view and minimum 26 gage thickness.

C. Carbon-Steel Sheets: ASTM A 366/A 366M, cold-rolled sheets; commercial quality; with oiled, matte finish for exposed ducts.

D. Stainless Steel: ASTM A 480/A 480M, Type 316 and having a No. 2D finish for concealed ducts and 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 for exposed ducts.

F. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts.
G. Tie Rods: Galvanized steel, 1/4-inch minimum diameter for lengths 36 inches or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

2.2 DUCT FIRE WRAP
   A. Fire wrap: An assembly providing at least a 2-hour fire rating for sheet metal ducts.
   B. Manufacturers:
      1. Pabco.
      2. Unifrax: FyreWrap.
   D. Where permitted by local codes, the products above may be a substitute for a 2-hour fire rated gypsum board covering.

2.3 SEALANT MATERIALS
   A. Joint and Seam Sealants, General: The term "sealant" is not limited to materials of adhesive or mastic nature but includes tapes and combinations of open-weave fabric strips and mastics.
   C. Tape Sealing System: Woven-fiber tape impregnated with gypsum mineral compound and modified acrylic/silicone activator to react exothermically with tape to form hard, durable, airtight seal.
   D. 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.
   E. Solvent-Based Joint and Seam Sealant: One-part, nonsag, solvent-release-curing, polymerized butyl sealant formulated with a minimum of 75 percent solids.
   F. Flanged Joint Mastic: One-part, acid-curing, silicone, elastomeric joint sealant complying with ASTM C 920, Type S, Grade NS, Class 25, Use O.
   G. Flange Gaskets: Butyl rubber or EPDM polymer with polyisobutylene plasticizer.

2.4 HANGERS AND SUPPORTS
   A. Building Attachments: Concrete inserts, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.
   B. Hanger Materials: Galvanized sheet steel or threaded steel rod.
1. Hangers Installed in Corrosive Atmospheres: Electrogalvanized, all-thread rods or galvanized rods with threads painted with zinc-chromate primer after installation.
2. Strap and Rod Sizes: Comply with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for steel sheet width and thickness and for steel rod diameters.
3. Galvanized-steel straps attached to aluminum ducts shall have contact surfaces painted with zinc-chromate primer.

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/A 36M.
3. Supports for Aluminum Ducts: Aluminum support materials unless materials are electrolytically separated from ducts.

2.5 RECTANGULAR DUCT FABRICATION

A. Fabricate ducts, elbows, transitions, offsets, branch connections, and other construction according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" and complying with requirements for metal thickness, reinforcing types and intervals, tie-rod applications, and joint types and intervals.
1. Lengths: Fabricate rectangular ducts in lengths appropriate to reinforcement and rigidity class required for pressure class.
2. Deflection: Duct systems shall not exceed deflection limits according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible."

B. Transverse Joints: Prefabricated slide-on joints and components constructed using manufacturer's guidelines for material thickness, reinforcement size and spacing, and joint reinforcement.
1. Manufacturers:
   a. Ductmate Industries, Inc.
   b. Nexus Inc.
   c. Ward Industries, Inc.

C. Formed-On Flanges: Construct according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible," Figure 1-4, using corner, bolt, metal cleat, and gasket details.
1. Manufacturers:
   a. Ductmate Industries, Inc.
   b. Lockformer.
2. Duct Size: Maximum 30 inches wide and up to 2-inch wg pressure class.
3. Longitudinal Seams: Pittsburgh lock sealed with noncuring polymer sealant.
D. Cross Breaking or Cross Beading: Cross break or cross bead duct sides 19 inches and larger and 0.0359 inch thick or less, with more than 10 sq. ft. of nonbraced panel area unless ducts are lined.

2.6 ROUND AND FLAT-OVAL DUCT AND FITTING FABRICATION

A. Diameter as applied to flat-oval ducts in this Article is the diameter of a round duct with a circumference equal to the perimeter of a given size of flat-oval duct.

B. Round, Spiral Lock-Seam Ducts: Fabricate supply ducts of galvanized steel according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible."

1. Manufacturers:
   b. SEMCO Incorporated.

C. Duct Joints:

   1. Ducts up to 20 Inches in Diameter: Interior, center-beaded slip coupling, sealed before and after fastening, attached with sheet metal screws.
   2. Ducts 21 to 72 Inches in Diameter: Three-piece, gasketed, flanged joint consisting of two internal flanges with sealant and one external closure band with gasket.
   3. Ducts Larger Than 72 Inches in Diameter: Companion angle flanged joints per SMACNA "HVAC Duct Construction Standards--Metal and Flexible," Figure 3-2.
   4. Flat-Oval Ducts: Prefabricated connection system consisting of two flanges and one synthetic rubber gasket.

   a. Manufacturers:
      1) Ductmate Industries, Inc.
      3) SEMCO Incorporated.

D. 90-Degree Tees and Laterals and Conical Tees: Fabricate to comply with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible," with metal thicknesses specified for longitudinal-seam straight ducts.

E. Diverging-Flow Fittings: Fabricate to comply with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible," with reduced entrance to branch taps and with no excess material projecting from fitting onto branch tap entrance.

F. Fabricate elbows using die-formed, pleated, or mitered construction. Bend radius of die-formed, gored, and pleated elbows shall be 1-1/2 times duct diameter. Unless elbow construction type is indicated, fabricate elbows as follows:

   1. Mitered-Elbow Radius and Number of Pieces: Welded construction complying with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible," unless otherwise indicated.
2. Round Mitered Elbows: Welded construction with the following metal thickness for pressure classes from minus 2- to plus 2-inch wg:
   a. Ducts 3 to 36 Inches in Diameter: 0.034 inch.
   b. Ducts 37 to 50 Inches in Diameter: 0.040 inch.
   c. Ducts 52 to 60 Inches in Diameter: 0.052 inch.
   d. Ducts 62 to 84 Inches in Diameter: 0.064 inch.

3. Round Mitered Elbows: Welded construction with the following metal thickness for pressure classes from 2- to 10-inch wg:
   a. Ducts 3 to 26 Inches in Diameter: 0.034 inch.
   b. Ducts 27 to 50 Inches in Diameter: 0.040 inch.
   c. Ducts 52 to 60 Inches in Diameter: 0.052 inch.
   d. Ducts 62 to 84 Inches in Diameter: 0.064 inch.

4. Round Elbows 8 Inches and Less in Diameter: Fabricate die-formed elbows for 45- and 90-degree elbows and pleated elbows for 30, 45, 60, and 90 degrees only.
5. Round Elbows Larger Than 9 Inches in Diameter: Fabricate pleated elbows for 30, 45, 60, and 90 degrees unless space restrictions require mitered elbows.
6. Die-Formed Elbows for Sizes through 8 Inches in Diameter and All Pressures 0.040 inch thick with 2-piece welded construction.
7. Pleated Elbows for Sizes through 14 Inches in Diameter and Pressures through 10-Inch wg: 0.022 inch.

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PART 3 - EXECUTION

3.1 DUCT APPLICATIONS

A. Static-Pressure Classes: Unless otherwise indicated, construct ducts according to the following:
   1. Primary Supply Ducts (before Air Terminal Units): 4-inch wg.
   4. Exhaust Ducts (Negative Pressure): 2-inch wg or 3-inch wg.

B. All ducts shall be galvanized steel except as follows, unless otherwise indicated:
   1. Acid-Resistant (Fume-Handling) Ducts: Type 316, stainless-steel sheet with No. 4 or No. 3 finish.

3.2 DUCT INSTALLATION

A. Construct and install ducts according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible," unless otherwise indicated.

B. Install ducts with fewest possible joints.
C. Install fabricated fittings for changes in directions, size, and shape and for connections.

D. Install couplings tight to duct wall surface with a minimum of projections into duct. Secure couplings with sheet metal screws.

E. Install ducts, unless otherwise indicated, vertically and horizontally and parallel and perpendicular to building lines; avoid diagonal runs.

F. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.

G. Install ducts with a clearance of 1 inch, plus allowance for insulation thickness.

H. Provide break away flange for all stainless steel ductwork at fire/smoke damper interfaces. Install stainless steel drain pans extending beyond in all directions with automatic condensate pumps and piping to nearest code approved drain at break away.

I. Conceal ducts from view in finished spaces. Do not encase horizontal runs in solid partitions unless specifically indicated.

J. Coordinate layout with suspended ceiling, fire- and smoke-control dampers, lighting layouts, and similar finished work.

K. Seal all joints and seams. Apply sealant to male end connectors before insertion, and afterward to cover entire joint and sheet metal screws.

L. Electrical Equipment Spaces: Route ducts to avoid passing through transformer vaults and electrical equipment spaces and enclosures.

M. Non-Fire-Rated Partition Penetrations: Where ducts pass through interior partitions and exterior walls and are exposed to view, conceal spaces between construction openings and ducts or duct insulation with sheet metal flanges of same metal thickness as ducts. Overlap openings on 4 sides by at least 1-1/2 inches.

N. Fire-Rated Partition Penetrations: Where ducts pass through interior partitions and exterior walls, install appropriately rated fire dampers, sleeves, and firestopping sealant.

O. Install ducts with hangers and braces designed to withstand, without damage to equipment, seismic force required by applicable building codes. Refer to SMACNA's "Seismic Restraint Manual: Guidelines for Mechanical Systems.", unless otherwise indicated.

P. Protect duct interiors from the elements and foreign materials until building is enclosed. Follow SMACNA's "Duct Cleanliness for New Construction."

Q. Paint interiors of metal ducts that do not have duct liner, for 24 inches upstream of registers and grilles. Apply one coat of flat, black, latex finish coat over a compatible galvanized-steel primer. Paint materials and application requirements are specified in Division 09 painting Sections. Painting not required for ducts serving mechanical, electrical and data rooms.
R. Provide concrete pipe curb in floors of mechanical equipment areas or other wet areas 4 inches above finished floor level.

S. Provide temperature range for duct mounted thermometer dials: Minus 40 to plus 110 deg F, with 2-degree scale divisions.

3.3 SEAM AND JOINT SEALING

A. Seal duct seams and joints according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for ducts, per Seal Class ‘A’.

B. Seal ducts before external insulation is applied.

3.4 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. Support Ducts per SMACNA’s "HVAC Duct Construction Standards--Metal and Flexible" for ducts.

F. Do not use powder-actuated concrete fasteners.

3.5 CONNECTIONS

A. Make connections to equipment with flexible connectors according to Division 23 Section "Air Duct Accessories."

B. Comply with SMACNA’s "HVAC Duct Construction Standards--Metal and Flexible" for branch, outlet and inlet, and terminal unit connections.

3.6 FIELD QUALITY CONTROL

A. The leak testing shall be observed by the General Contractor’s representative and the Owner’s representative. Provide 48 hours notification of such tests.

B. All ducts shall be tested. Submit a written report. The contractor is required to maintain on-site a set of ductwork prints that are shaded in different colors to show the duct section isolated for each test. Also the Contractor shall indicate on the print the date each section of duct was tested and the final percent leakage rate measured for each test section.
C. If any duct section fails the leakage test, the contractor shall repair the leakage and re-perform the leakage test.

D. The duct systems shall be pressure tested for leaks at their specified pressure ratings and shall be within the maximum allowed by the following:

1. Primary Air (medium pressure ducts) Systems – 3% leakage.
2. Other Systems – 2% leakage.

E. The leakage test shall be performed using a kit as furnished by United McGill Corp. or approved equal and shall include the following components:

1. Blower
2. Two manometers or U-tubes
3. Calibrated orifice tube

F. The leakage test procedure is as follows:

1. Carefully seal off all openings (except one for connecting the test equipment) to the duct run-out section to be tested.
2. Connect the downstream end of the orifice tube to the duct system using a piece of flexible tubing.
3. Connect one manometer to the static taps on the tube to read orifice differential pressure. Connect the other manometer to a 5/16” tap in the duct at least one foot from the blower connection to read test static pressure.
4. Attach the blower to the orifice tube and block off the inlet to prevent overpressurizing a tight system.
5. Start the blower and slowly open the inlet until the desired test static pressure is reached. Let the blower run for at least one minute to insure a steady state.
6. At this point, the air flowing through the orifice tube is going into the duct system and is equal to the amount leaking out. This leakage rate can be read from the calibration chart on the orifice tube. This measured cfm is used to determine the leakage percent.
7. If the duct system is too large and the allowable leakage is greater than the capacity of the blower, the system shall be tested in several sections and the results added together.

3.7 DUCT CLEANLINESS AND DUCT CLEANING

1. DUCT CLEANLINESS

   a. It is the intent to provide an installation of a ductwork system that appears to be visibly clean.
   b. A visual inspection of porous and non-porous ductwork components must be monitored by the Contractor to ensure that the system is visibly clean. The system has excessive dust or debris when an accumulation of particles can be observed in the ductwork. An interior surface is considered visibly clean when it is free from non-adhered substances and debris.
c. Cleanliness verification shall be performed after the ductwork system has been “wiped clean” and prior to the application of any piece of equipment or component being used in operation.
d. If air handling units are operated without the pre-filters and the final filters in place, the ductwork shall be replaced or vacuumed per Article B “Cleaning New Systems” below.

2. Condition of new ductwork shall include the following measures:
   
a. Any internal exposed mastic sealant to be removed.
b. The light coating of oil on machine formed sheet metal ductwork is to be removed.
c. The discoloration marks from the plasma cutting process must be removed.
d. Before installation of the individual duct sections they are to be visually inspected for dust and/or debris, and wiped clean, if necessary.
e. After the ductwork has been installed, the cleanliness procedure shall be to temporarily cover the open ends of the ductwork to prevent dust and debris of finding its way to the system.
f. If vacuuming is required to adequately clean the ductwork, the vacuum cleaner must be HEPA filtered and capable of achieving a minimum of 40 inches of water gage. The vacuum should be fitted with a 2.5” round nylon brush attached to a 1.5” diameter vacuum hose.

3. Conditions of existing ductwork and equipment within the systems that serve the renovated areas shall be visually inspected for dust and debris.
   
a. If dust and/or debris is observed within the existing system, it shall be cleaned to remove all visual dust and debris. This process may include the addition of access doors to facilitate the “wiping” and/or “vacuuming” of the ductwork systems.
b. The system cleanliness procedures shall be adhered to during the construction process of the renovations.
c. New ductwork required for additions within the existing renovated area shall follow the procedures addressed above for the new ductwork.
d. If vacuuming is required to adequately clean the ductwork, the vacuum cleaner must be HEPA filtered and capable of achieving a minimum of 40 inches of water gage. The vacuum should be fitted with a 2.5” round nylon brush attached to a 1.5” diameter vacuum hose.

B. CLEANING NEW SYSTEMS

1. Mark position of dampers and air-directional mechanical devices before cleaning, and perform cleaning before air balancing.
2. Use service openings, as required, for physical and mechanical entry and for inspection.
   
a. Create other openings to comply with duct standards.
b. Disconnect flexible ducts as needed for cleaning and inspection.
c. Remove and reinstall ceiling sections to gain access during the cleaning process.
3. Vent vacuuming system to the outside. Include HEPA 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.

4. Clean the following metal duct systems by removing surface contaminants and deposits:
   a. Air outlets and inlets (registers, grilles, and diffusers).
   b. 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.
   c. 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.
   d. Coils and related components.
   e. Return-air ducts, dampers, and actuators except in ceiling plenums and mechanical equipment rooms.
   f. Supply-air ducts, dampers, actuators, and turning vanes.

5. Mechanical Cleaning Methodology:
   a. Clean metal duct systems using mechanical cleaning methods that extract contaminants from within duct systems and remove contaminants from building.
   b. 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.
   c. Use mechanical agitation to dislodge debris adhered to interior duct surfaces without damaging integrity of metal ducts, duct liner, or duct accessories.
   d. Do not permit fibrous-glass duct liner to get wet. Remove and replace wet duct liner.
   e. 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. Cleanliness Verification:
   a. Visually inspect metal ducts for contaminants.
   b. Where contaminants are discovered, re-clean and reinspect ducts.

C. CLEANING EXISTING SYSTEMS

1. Use service openings, as required, for physical and mechanical entry and for inspection.
   a. Use existing service openings where possible.
   b. Create other openings to comply with duct standards.
   c. Disconnect flexible ducts as needed for cleaning and inspection.
   d. Reseal rigid fiberglass duct systems according to NAIMA recommended practices.
   e. Remove and reinstall ceiling sections to gain access during the cleaning process.
2. Mark position of dampers and air-directional mechanical devices before cleaning, and restore to their marked position on completion.

3. Particulate Collection and Odor Control:
   a. When venting vacuuming system inside the building, use HEPA filtration with 99.97 percent collection efficiency for 0.3-micron size (or larger) particles.
   b. 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.

4. Clean the following metal duct systems by removing surface contaminants and deposits:
   a. Air outlets and inlets (registers, grilles, and diffusers).
   b. 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.
   c. 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.
   d. Coils and related components.
   e. Return-air ducts, dampers, and actuators except in ceiling plenums and mechanical equipment rooms.
   f. Supply-air ducts, dampers, actuators, and turning vanes.
   g. Dedicated exhaust and ventilation components and makeup air systems.

5. Mechanical Cleaning Methodology:
   a. Clean metal duct systems using mechanical cleaning methods that extract contaminants from within duct systems and remove contaminants from building.
   b. 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.
   c. Use mechanical agitation to dislodge debris adhered to interior duct surfaces without damaging integrity of metal ducts, duct liner, or duct accessories.
   d. 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.
   e. 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. Provide operative drainage system for washdown procedures.
   g. 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.

6. Cleanliness Verification:
a. Verify cleanliness after mechanical cleaning and before application of treatment, including biocidal agents and protective coatings.
b. Visually inspect metal ducts for contaminants.
c. Where contaminants are discovered, re-clean and reinspect ducts.

7. Gravimetric Analysis: At discretion and expense of Owner, sections of metal duct system, chosen randomly by Owner, may be tested for cleanliness according to NADCA vacuum test gravimetric analysis.

   a. If analysis determines that levels of debris are equal to or lower than suitable levels, system shall have passed cleanliness verification.
   b. If analysis determines that levels of debris exceed suitable levels, system cleanliness verification will have failed and metal duct system shall be re-cleaned and re-verified.

8. 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 SUMMARY

A. This Section includes the following:
   1. Backdraft dampers.
   2. Volume dampers.
   3. Motorized control dampers.
   4. Fire dampers.
   5. Ceiling fire dampers.
   7. Combination fire and smoke dampers.
   8. Duct silencers.
   10. Turning vanes.
   11. Duct-mounting access doors.
   12. Flexible connectors.
   13. Flexible ducts.
   14. Duct accessory hardware.

B. Related Sections include the following:
   1. Division 23 Section "Instrumentation and Control for HVAC" for electric and pneumatic damper actuators.
   2. Division 23 Section “Metal Ducts” for duct construction and fittings.
   3. Division 28 Section "Fire Detection and Alarm" for duct-mounting fire and smoke detectors.

1.2 DEFINITIONS

A. Low Leakage: Class 1A as defined by AMCA Standard 511, equating to less than 3cfm/ft² of damper area, at differential pressure of 1-inch wg, less than 8cfm/ft² of damper area, at differential pressure of 4-inch wg when damper is being held by torque of 50 in. x lbf; when tested according to AMCA 500D.

1.3 ACTION SUBMITTALS

A. Product Data: For the following:
   1. Backdraft dampers.
   2. Volume dampers.
   3. Motorized control dampers.
   4. Fire dampers.
5. Ceiling fire dampers.
7. Combination fire and smoke dampers.
8. Duct silencers.
10. Duct-mounting access doors.
11. Flexible connectors.
12. Flexible ducts.

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

1. Special fittings.
3. Motorized-control damper installations.
4. Fire-damper, smoke-damper, and combination fire- and smoke-damper installations, including sleeves and duct-mounting access doors.
5. Identify duct velocity and pressure class of duct system dampers are installed in.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plans, drawn to scale and coordinating penetrations and ceiling-mounting items. Show ceiling-mounting access panels and access doors required for access to duct accessories.

1.5 QUALITY ASSURANCE


1.6 EXTRA MATERIALS

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

1. Fusible Links: Furnish quantity equal to 10 percent, rounding up, for each type of amount installed with a minimum of one.
PART 2 - PRODUCTS

2.1 SHEET METAL MATERIALS

A. Comply with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods, unless otherwise indicated.

B. Galvanized Sheet Steel: Lock-forming quality; complying with ASTM A 653/A 653M and having G90 coating designation; ducts shall have mill-phosphatized finish for surfaces exposed to view.

C. Stainless Steel: ASTM A 480/A 480M.

D. Aluminum Sheets: ASTM B 209, alloy 3003, temper H14; with mill finish for concealed ducts and standard, 1-side bright finish for exposed ducts.


F. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts; compatible materials for aluminum and stainless-steel ducts.

G. Tie Rods: Galvanized steel, 1/4-inch minimum diameter for lengths 36 inches or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

2.2 BACKDRAFT DAMPERS

A. Manufacturers:
   1. Air Balance, Inc.
   2. American Warming and Ventilating.
   3. Duro Dyne Corp.
   5. Loren Cook.
   7. Potteroff.
   8. Prefco Products, Inc.

B. Description: Multiple or single-blade, parallel action gravity balanced, with center-pivoted blades of maximum 6-inch width, with sealed edges, assembled in rattle-free manner with 90-degree stop, steel ball bearings, and axles; adjustment device to permit setting for varying differential static pressure.

C. Frame: Extruded aluminum, with welded corners and mounting flange.

D. Blades: 0.050-inch-thick aluminum sheet.

E. Blade Seals: Neoprene.
F. Blade Axles: Nonferrous.

G. Tie Bars and Brackets: Aluminum.

H. Return Spring: Adjustable tension.

2.3 VOLUME DAMPERS

A. Manufacturers:

1. Air Balance, Inc.
2. American Warming and Ventilating.
3. Flexmaster U.S.A., Inc.
5. METALAIRE, Inc.
7. National Controlled Air.
10. Ruskin Company.
12. Young Regulator Company.

B. General Description: Factory fabricated, with required hardware and accessories. Stiffen damper blades for stability. Include locking device to hold single-blade dampers in a fixed position without vibration. Close duct penetrations for damper components to seal duct consistent with pressure class.

1. Pressure Classes of 3-Inch wg or Higher: End bearings or other seals for ducts with axles full length of damper blades and bearings at both ends of operating shaft.
2. Dampers integral to building envelope shall be AMCA 511 Class 1 rated, minimum.

C. Duct Dampers.

1. Standard Volume:
   a. Multiple- or single-blade, parallel- or opposed-blade design, AMCA 511 Class 2 rated, with linkage outside airstream, and suitable for horizontal or vertical applications. Blade and frame materials shall match.
   b. Steel:
      1) Frames: Hat-shaped, stainless sheet steel channels, with mitered and welded corners; frames with flanges where indicated for attaching to walls and flangeless frames where indicated for installing in ducts.
      2) Roll-Formed Blades: Stainless sheet steel.
   c. Aluminum
1) Frames: Hat-shaped, aluminum sheet channels; frames with flanges where indicated for attaching to walls; and flangeless frames where indicated for installing in ducts.
2) Roll-Formed Blades: 0.10-inch-thick aluminum sheet.
3) Extruded-Aluminum Blades: 0.050-inch-thick extruded aluminum.

e. Bearings: Oil-impregnated bronze, molded synthetic, or stainless-steel sleeve.
f. Tie Bars and Brackets: Aluminum.

2. Low-Leakage Volume:

a. Multiple-blade, parallel- or opposed-blade design as indicated, AMCA 511 Class 1A rated, with linkage outside airstream, and suitable for horizontal or vertical applications. Blade and frame materials shall match.

b. Steel:

1) Frames: Hat, U-, or angle-shaped, stainless sheet steel channels, with mitered and welded corners; frames with flanges where indicated for attaching to walls and flangeless frames where indicated for installing in ducts.
2) Roll-Formed Blades: 0.064-inch-thick, stainless sheet steel.

c. Aluminum:

1) Frames: Hat, U-, or angle-shaped, aluminum sheet channels; frames with flanges where indicated for attaching to walls and flangeless frames where indicated for installing in ducts.
2) Roll-Formed Blades: 0.10-inch-thick aluminum sheet.
3) Extruded Blades: 0.050-inch-thick extruded aluminum.

e. Bearings: Oil-impregnated bronze or stainless-steel sleeve thrust or ball.
f. Blade Seals: Vinyl or Neoprene.
g. Jamb Seals: Cambered stainless steel.
h. Tie Bars and Brackets: Aluminum.

3. Remote Mounted:

a. Rack-and-pinion controller fabricated from minimum 14 gage galvanized steel with graduations for positive locking control.
b. Control cable shall be .054” stainless steel in 1/16” flexible galvanized casing.

D. Duct Tap-Offs

1. Duct tap offs from rectangular or round duct are round, conical connector, with spin-in or twist-in collar, and integral damper. Include bead from using mechanical strap.
2. Side taps, consisting of an eccentric wedge pointing into the flow narrowing to a round duct are also acceptable.

3. Construction materials and pressure class shall identical to the attached duct system.

E. Jackshaft: Pipe matching linkage material rotating within pipe-bearing assembly mounted on supports at each mullion and at each end of multiple-damper assemblies.

1. Length and Number of Mountings: Appropriate to connect linkage of each damper in multiple-damper assembly.

F. Damper Hardware: Zinc-plated, die-cast core with dial and handle made of 3/32-inch-thick zinc-plated steel, and a 3/4-inch hexagon locking nut. Include center hole to suit damper operating-rod size. Include elevated platform for insulated duct mounting.

2.4 MOTORIZED CONTROL DAMPERS

A. Manufacturers:

1. Air Balance, Inc.
2. American Warming and Ventilating.
3. Duro Dyne Corp.
6. METALAIRE, Inc.
7. Nailor Industries Inc.
8. National Controlled Air.

B. General Description: Class 1A, AMCA 511, parallel or opposed-blade airfoil design; galvanized-steel frames with holes for duct mounting; galvanized-steel damper blades with maximum blade width of 8 inches.

1. Secure blades to 1/2-inch-diameter, zinc-plated axles using zinc-plated hardware, with nylon blade bearings, blade-linkage hardware of zinc-plated steel and brass, ends sealed against spring-stainless-steel blade bearings, and thrust bearings at each end of every blade.
2. Operating Temperature Range: From minus 40 to plus 200 deg F.
3. Provide parallel- or opposed-blade design with inflatable seal blade edging, or replaceable rubber seals, rated for low leakage.

2.5 FIRE DAMPERS

A. Manufacturers:

1. Air Balance, Inc.
2. Greenheck.
4. METALAIRE, Inc.
5. Nailor Industries Inc.
6. National Controlled Air.
7. Penn Ventilation Company, Inc.
8. Potteroff.
9. Prefco Products, Inc.
10. Ruskin Company.

B. Fire dampers shall be labeled according to UL 555, Class 1.

C. Fire Rating: 1-1/2 and 3 hours.
   1. Type 304, stainless-steel dampers are also available for corrosive atmospheres.

D. Frame: fabricated with roll-formed galvanized steel; with mitered and interlocking corners.
   1. Provide multiple-blade type for dynamic applications.

E. Mounting Sleeve: Factory- or field-installed, galvanized sheet steel.
   1. Exceptions: Omit sleeve where damper frame width permits direct attachment of perimeter mounting angles on each side of wall or floor, and thickness of damper frame complies with sleeve requirements.


G. Horizontal Dampers: Include blade lock and stainless-steel closure spring.

H. Resets:
   1. Fusible Links: Replaceable, 212 deg F (100 deg C) rated.

2.6 CEILING FIRE DAMPERS

A. Manufacturers:
   1. Air Balance, Inc.
   2. Greenheck.
   4. METALAIRE, Inc.
   5. Nailor Industries Inc.
   6. National Controlled Air.
   7. Penn Ventilation Company, Inc.
   8. Potteroff.
   9. Prefco Products, Inc.
   10. Ruskin Company.

B. General Description: Labeled according to UL 555C, Class 1; comply with construction details for tested floor- and roof-ceiling assemblies as indicated in UL's "Fire Resistance Directory."

C. Frame: Galvanized sheet steel, round or rectangular, style to suit ceiling construction.

D. Blades: Galvanized sheet steel with refractory insulation.

E. Resets:
   1. Fusible Links: Replaceable, 212 deg F (100 deg C) rated.

2.7 SMOKE AND COMBINATION FIRE / SMOKE DAMPERS

A. Manufacturers:
   1. Air Balance, Inc.
   2. Greenheck.
   3. Nailor Industries Inc.
   4. National Controlled Air.
   5. Penn Ventilation Company, Inc.
   6. Potteroff.
   7. Ruskin Company.

B. General Description: Labeled according to UL 555S, Class 1. Combination fire and smoke dampers shall be labeled according to UL 555 for 1-1/2-hour rating.

C. Resets:
   1. Automatic.

D. Frame and Blades: 0.064-inch-thick, galvanized sheet steel.

E. Mounting Sleeve: Factory-installed galvanized sheet steel; length to suit wall or floor application.

F. Damper Motors: Modulating and two-position action.
   1. Comply with requirements in Division 23 Section "Common Motor Requirements for HVAC Equipment."
   2. Permanent-Split-Capacitor or Shaded-Pole Motors: With oil-immersed and sealed gear trains.
   3. 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.
   4. Outdoor Motors and Motors in Outside-Air Intakes: Equip with O-ring gaskets designed to make motors weatherproof. Equip motors with internal heaters.
to permit normal operation at 10 degrees lower than ASHRAE 99.6% Heating DB.

5. Nonspring-Return Motors: For dampers larger than 25 sq. ft., size motor for running torque rating of 150 in. x lbf and breakaway torque rating of 300 in. x lbf.

6. Electrical Connection: 115 V, single phase, 60 Hz.

2.8 DUCT SILENCERS

A. Manufacturers:

1. Dynasonics.
2. I.A.C.
3. Industrial Noise Control, Inc.
5. Ruskin Company.
6. SEMCO.

B. General Description: Factory-fabricated and -tested, round or rectangular silencers with performance characteristics and physical requirements as indicated. Gage and material of casing shall be no less than the requirements of the system served.

C. Fire Performance: Adhesives, sealants, packing materials, and accessory materials shall have fire ratings not exceeding 25 for flame-spread index and 50 for smoke-developed index when tested according to ASTM E 84.

D. Rectangular Units: Fabricate casings with solid galvanized sheet metal for outer casing and ASTM A 653/A 653M, G90, perforated galvanized sheet metal for inner casing.

E. Round Units:

1. Outer Casings:

2. Interior Casing, Partitions, and Baffles:
   b. At least 0.034 inch thick and designed for minimum aerodynamic losses.

F. Sheet Metal Perforations: 1/8-inch diameter for inner casing and baffle sheet metal.

G. Fill Material: Inert, moisture proof, and vermin-proof material, packed under not less than 5 percent compression.

1. Erosion Barrier:
   a. Polymer or Tedlar bag enclosing fill and heat-sealed before assembly.
   b. Mylar layer attached with adhesive between fill and airstream.
H. Fabricate silencers to form rigid units that will not pulsate, vibrate, rattle, or otherwise react to system pressure variations.
   1. Do not use nuts, bolts, or sheet metal screws for unit assemblies.
   2. Lock form and seal or continuously weld joints.
   3. Suspended Units: Factory-installed suspension hooks or lugs attached to frame in quantities and spaced to prevent deflection or distortion.
   4. Reinforcement: Cross or trapeze angles for rigid suspension.

I. Source Quality Control:
   1. Acoustic Performance: Test according to ASTM E 477.
   2. Record acoustic ratings, including dynamic insertion loss and self-noise power levels with an airflow of at least 2000-fpm face velocity.
   3. Leak Test: Test units for airtightness at 200 percent of associated fan static pressure or 6-inch wg static pressure, whichever is greater.

2.9 ELECTRIC DUCT HEATERS

A. Manufacturers
   1. Bel Thermal Units
   2. Chromalox
   3. Indeeco
   4. Nailor
   5. Warren Products

B. Description: Slip-in-type, open-coil design with integral control box factory wired and installed. Include the following features:
   1. Primary and secondary over-temperature protection.
   2. Nickel chrome 80/20 heating elements.
   3. Airflow switch.
   5. Fuses (for coils more than 48 A).
   7. Pneumatic-electric switches and relays.
   8. Magnetic contactor for each step of control (for three-phase coils).

2.10 TURNING VANES

A. Fabricate to comply with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for vanes and vane runners. Vane runners shall automatically align vanes.

B. Manufactured Turning Vanes: Fabricate 1-1/2-inch-wide, double-vane, curved blades of galvanized sheet steel set 3/4 inch o.c.; support with bars perpendicular to blades set 2 inches o.c.; and set into vane runners suitable for duct mounting.
   1. Manufacturers:
      a. Ductmate Industries, Inc.
b. Duro Dyne Corp.
c. Dynasonics.
d. I.A.C.
e. METALAIRE, Inc.
f. SEMCO.
g. Ward Industries, Inc.

c. Acoustic Turning Vanes: Fabricate airfoil-shaped aluminum extrusions with perforated faces and fibrous-glass fill, with Mylar or Tedlar wrap around fill.

d. Acoustic Elbows: Fabricate airfoil-shaped aluminum extrusions with perforated faces and fibrous-glass fill, with Mylar or Tedlar wrap around fill.

2.11 DUCT-MOUNTING ACCESS DOORS

A. General Description: Fabricate doors airtight and suitable for duct pressure class.

B. Door: Double wall, duct mounting, and rectangular; fabricated of galvanized sheet metal with insulation fill and thickness as indicated for duct pressure class. Include vision panel where indicated. Include 1-by-1-inch butt or piano hinge and cam latches.

1. Manufacturers:
   a. American Warming and Ventilating.
   b. Ductmate Industries, Inc.
   c. Flexmaster U.S.A., Inc.
   d. Greenheck.
   f. Nailor Industries Inc.

2. Frame: Galvanized sheet steel, with bend-over tabs and foam gaskets.
3. Provide number of hinges and locks as follows:

   a. Less Than 12 Inches Square: Secure with two sash locks.
   b. Up to 18 Inches Square: Two hinges and two sash locks.
   c. Up to 24 by 48 Inches: Three hinges and two compression latches with outside and inside handles.
   d. Sizes 24 by 48 Inches and Larger: One additional hinge.

C. Door: Double wall, duct mounting, and round; fabricated of galvanized sheet metal with insulation fill and 1-inch thickness. Include cam latches.

1. Manufacturers:
   a. Ductmate Industries, Inc.
   b. Flexmaster U.S.A., Inc.

2. Frame: Galvanized sheet steel, with spin-in notched frame.
D. Pressure Relief Access Door: Single or double wall and duct mounting; fabricated of galvanized sheet metal with insulation fill and thickness as indicated for duct pressure class. Include vision panel where indicated, latches, and retaining chain.

1. Manufacturers:
   a. American Warming and Ventilating.
   b. Ductmate Industries, Inc.
   c. Greenheck.
   d. KEES, Inc.
   f. Nexus PDQ.

2. Frame: Galvanized sheet steel, with bend-over tabs and foam gaskets.

E. Seal around frame attachment to duct and door to frame with neoprene or foam rubber.

F. Insulation: 1-inch-thick, fibrous-glass or polystyrene-foam board.

2.12 FLEXIBLE CONNECTORS

A. Manufacturers:
   1. Ductmate Industries, Inc.
   2. Duro Dyne Corp.
   3. Ventfabrics, Inc.

B. General Description: Flame-retardant or noncombustible fabrics, coatings, and adhesives complying with NFPA 90A & 90B.

C. 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. Select metal compatible with ducts.

   1. Minimum Weight: 26 oz./sq. yd..
   2. Tensile Strength: 480 lbf/inch in the warp and 360 lbf/inch in the filling.
   3. Service Temperature: Minus 40 to plus 200 deg F.

E. Outdoor System, Flexible Connector Fabric: Glass fabric double coated with weatherproof, synthetic rubber resistant to UV rays and ozone.
   1. Minimum Weight: 24 oz./sq. yd..
   2. Tensile Strength: 530 lbf/inch in the warp and 440 lbf/inch in the filling.
   3. Service Temperature: Minus 50 to plus 250 deg F.

1. Minimum Weight: 16 oz./sq. yd..
2. Tensile Strength: 285 lbf/inch in the warp and 185 lbf/inch in the filling.
3. Service Temperature: Minus 67 to plus 500 deg F.


1. Minimum Weight: 14 oz./sq. yd..
2. Tensile Strength: 450 lbf/inch in the warp and 340 lbf/inch in the filling.
3. Service Temperature: Minus 67 to plus 500 deg F.

2.13 FLEXIBLE DUCTS

A. Manufacturers:

1. Flexmaster U.S.A., Inc.
3. Thermaflex.
4. Wiremold.

B. Noninsulated Flexible Ducts: UL 181, Class 1, black polymer film supported by helically wound, spring-steel wire.

1. Pressure Rating: 4-inch wg positive and 0.5-inch wg negative.
3. Temperature Range: Minus 20 to plus 175 deg F.

C. Insulated Flexible Ducts: UL 181, Class 1, black polymer film supported by helically wound, spring-steel wire; fibrous-glass insulation with a minimum value of R-6; polyethylene or aluminized vapor barrier film.

1. Pressure Rating: 4-inch wg positive and 0.5-inch wg negative.
3. Temperature Range: Minus 20 to plus 175 deg F.

D. Metal Lined Insulated Flexible Ducts: UL 181, Class 1, Triple locked aluminum inner core; fibrous glass insulation with a minimum value of R-6.

1. Pressure Rating: 6-inch wg (1500 Pa) positive and 2-inch wg (500 Pa) negative.
3. Temperature Range: Minus 20 to plus 250 deg F

Insulated Fabric Ducts: UL 181, Class 1, with Chlorinated Polyethylene (CPE) inner core supported by helical wound galvanized steel; fibrous-glass insulation with a minimum R-6 value.

4. Pressure Rating: 6-inch wg (1500 Pa) positive and 2-inch wg (500 Pa) negative.
6. Temperature Range: Minus 20 to plus 250 deg F

Flexible Duct Clamps: Stainless-steel band with cadmium-plated hex screw to tighten band with a worm-gear action or Nylon strap, in sizes 3 through 18 inches to suit duct size.
2.14 DUCT ACCESSORY HARDWARE

A. Instrument Test Holes: Cast iron or cast aluminum to suit duct material, including screw cap and gasket. Size to allow insertion of pitot tube and other testing instruments and of length to suit duct insulation thickness.

B. Adhesives: High strength, quick setting, neoprene based, waterproof, and resistant to gasoline and grease.

PART 3 - EXECUTION

3.1 APPLICATION AND INSTALLATION

A. Install duct accessories according to applicable details in SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for metal ducts.

B. Where damper actuators are located in the air stream, increase duct free area to maintain design intent.

C. Provide duct accessories of materials suited to duct materials; use galvanized-steel accessories in galvanized-steel ducts, stainless-steel accessories in stainless-steel ducts, and aluminum accessories in aluminum ducts.

D. Install backdraft dampers on exhaust fans or exhaust ducts nearest to outside and where indicated.

E. Provide balancing dampers at points on supply, return, and exhaust systems where branches lead from larger ducts as required for air balancing. Install at a minimum of two duct widths from branch takeoff.

F. Install duct test holes where indicated and required for testing and balancing purposes.

G. Install remote dampers a minimum of 5 feet, or two duct diameters, whichever is greater, before air device.

H. Remote dampers shall include controller box as approved by architect.

I. Provide test holes at fan inlets and outlets and elsewhere as indicated.

J. Install fire and smoke dampers, with reset operators or fusible links, according to manufacturer's UL-approved written instructions.

K. Install duct silencers rigidly to ducts.

L. Install duct heaters square to duct and perpendicular to air travel. Provide disconnecting means at heater.

M. Connect duct discharge temperature sensor downstream of duct heater.

N. Connect controlling thermostat or control cable to duct heater.
O. Install turning vanes in all square elbows, except for combustion air, dryer vent, and grease duct services, unless otherwise indicated.

P. Install flexible connectors immediately adjacent to equipment in ducts associated with fans and motorized equipment supported by vibration isolators.

Q. For fans developing static pressures of 5-inch wg and higher, cover flexible connectors with loaded vinyl sheet held in place with metal straps.

R. Connect terminal units to supply ducts.

S. Connect diffusers or light troffer boots to low pressure ducts with maximum 60-inch lengths of flexible duct clamped or strapped in place.

T. Install metal-lined or CPE fabric insulated ducts for flexible ducts as required by the Florida Building Code.

U. Do not use flexible ducts to change directions.

V. Connect flexible ducts to metal ducts with draw bands.

W. Flexible duct may only be installed above hard ceilings with direct access to all both ends of the flexible duct runs. Flexible duct shall not be installed more than 24” inside a hard ceiling edge or transition.

3.2 END SWITCH APPLICATIONS

A. Install an end switches for each damper:
   1. Motorized control damper.
   2. Fire damper.
   3. Fire/smoke damper.

B. Connect each motorized control damper to the FMS.

C. Connect each fire and fire/smoke damper to the FMS or fire alarm system.

3.3 FIRE AND FIRE/SMOKE DAMPER APPLICATIONS

1. Unless otherwise indicated, provide dampers according to the following criteria:
   a. Type-B dampers
      1) Pressure: up to 8 inches wg.
      2) Velocity: up to 3500 ft/min

2. Where dampers are required at sidewall grilles, damper shall be Frame Style G for flush installation of air device.

3. Provide an end switch for each damper and tie to FMS and fire alarm system.
# 3.4 DUCT ACCESS DOOR APPLICATIONS

A. Install duct access doors to allow for inspecting, adjusting, and maintaining accessories and terminal units as follows:

1. On both sides of duct coils.
2. Downstream from volume dampers, motorized dampers, and equipment.
3. Adjacent to fire or smoke dampers, providing access to reset or reinstall fusible links.
4. To interior of ducts for cleaning; before and after each change in direction, at maximum 50-foot spacing.
5. On sides of ducts where adequate clearance is available.

B. Install the following sizes for duct-mounting, rectangular access doors:

1. One-Hand or Inspection Access: 8 by 8 inches.
3. Head and Hand Access: 18 by 18 inches.

C. Install the following sizes for duct-mounting, round access doors:

1. One-Hand or Inspection Access: 8 inches in diameter.
3. Head and Hand Access: 12 inches in diameter.

D. Label access doors according to Division 23 Section "Identification for HVAC Piping and Equipment."

# 3.5 ADJUSTING

A. Adjust duct accessories for proper settings.

B. Adjust fire and smoke dampers for proper action.

C. Final positioning of manual-volume dampers is specified in Division 23 Section "Testing, Adjusting, and Balancing for HVAC."

**END OF SECTION**
SECTION 233400
HVAC FANS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following:
1. High velocity plume exhaust fans.

B. Related Sections include the following:
1. Division 03 Sections "Cast-in-Place Concrete" and "Miscellaneous Cast-in-Place Concrete".
2. Division 07 Section "Roof Accessories” for roof curbs, equipment supports, and roof penetrations.
3. Division 23 Section "Air Duct Accessories" for flexible connectors, dampers, etc. are specified in.
4. Division 23 Section "Common Motor Requirements for HVAC" for fan motors.
5. Division 23 Section "Hangers and Supports for HVAC Piping and Equipment".
6. Division 23 Section "Identification for HVAC Piping and Equipment" for fan label requirements.
7. Division 23 Section "Instrumentation and Controls for HVAC".
8. Division 23 Section "Variable Frequency Drives".
9. Division 23 Section “Vibration and Seismic Controls for HVAC Piping and Equipment” for seismic and wind restraint requirements.

1.2 PERFORMANCE REQUIREMENTS

A. Project Altitude: Base fan performance ratings on actual Project site elevations above sea level.

B. Operating Limits: Classify according to AMCA 99.

1.3 ACTION SUBMITTALS

A. Product Data: Include rated capacities, furnished specialties, and accessories for each type of product indicated and include the following:
1. Fan schedule, by equipment mark, with capacity selections indicating required accessories.
2. Certified fan performance curves with system operating conditions indicated.
3. Certified fan sound-power ratings.
4. Motor ratings and electrical characteristics, plus motor and electrical accessories.
5. Material thickness and finishes, including color charts.
6. Dampers, including housings, linkages, and operators.
7. Fan speed controllers, including, but not limited to, variable speed drives.

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   2. Short-circuit current rating of equipment assembly. Rating must match the rating of the overcurrent protective device serving the assembly.
   3. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
   4. Vibration Isolation Base Details: Detail fabrication, including anchorages and attachments to structure and to supported equipment. Include auxiliary motor slides and rails, and base weights.

1.4 SIMULTANEOUS ACTION SUBMITTALS

A. HVAC Fan Product Data submittal shall be made in conjunction with action submittals required under Division 26 Section “Overcurrent Protective Device Coordination Study.”

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Show fan room layout and relationships between components and adjacent structural and mechanical elements. Show support locations, type of support, and weight on each support. Indicate and certify field measurements.

B. Field quality-control test reports.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: Data to include in emergency, operation, and maintenance manuals.

1.7 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. AMCA Compliance: Products shall comply with performance requirements and shall be licensed to use the AMCA-Certified Ratings Seal.

C. NEMA Compliance: Motors and electrical accessories shall comply with NEMA standards.

D. UL Standard: Power ventilators shall comply with UL 705.
E. Fans shall not exceed 85% of class rating at the selection point.

F. Sound-Power Level Ratings:
   1. Comply with AMCA 301, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data."
   2. Factory test fans according to AMCA 300, "Reverberant Room Method for Sound Testing of Fans."
   3. Label fans with the AMCA-Certified Ratings Seal.

G. Fan Performance Ratings: Establish flow rate, pressure, power, air density, speed of rotation, and efficiency by factory tests and ratings according to AMCA 210, "Laboratory Methods of Testing Fans for Rating."

1.8 DELIVERY, STORAGE, AND HANDLING

A. Deliver fans as factory-assembled units, to the extent allowable by shipping limitations, with protective crating and covering.

B. Disassemble and reassemble units, as required for moving to final locations, according to manufacturer's written instructions.

C. Lift and support units with manufacturer's designated lifting or supporting points.

1.9 COORDINATION

A. Coordinate size and location of structural-steel support members.

B. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases.

C. Coordinate installation of roof curbs, equipment supports, and roof penetrations.

1.10 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Belts: One set(s) for each belt-driven unit.

1.11 LABELS

A. All fans shall have a firmly affixed metal nameplate recording the design air capacity, static pressure, and brake horsepower.
PART 2 - PRODUCTS

2.1 HIGH VELOCITY PLUME EXHAUST FANS

A. Manufacturers:

1. Greenheck.
2. Loren Cook Company.
3. MK Plastics.
4. Strobic Air.
5. Twin City Fan & Blower.

B. Description: Factory-fabricated, -assembled, -tested, and -finished, belt-driven centrifugal fan consisting of housing, wheel, outlet guide vanes, fan shaft, bearings, motor and disconnect switch, drive assembly, mounting brackets, and accessories.

C. Housing: Split, spun aluminum with aluminum straightening vanes, inlet and outlet flanges, and support bracket adaptable to floor, side wall, or ceiling mounting.

D. Belt-Driven Units: Motor mounted on adjustable base, with adjustable sheaves, enclosure around belts within fan housing, and lubricating tubes from fan bearings extended to outside of fan housing.

E. Fan Wheels: Aluminum, airfoil blades welded to aluminum hub.

F. Accessories:

1. Variable-Speed Controller: Solid-state control to reduce speed from 100 to less than 50 percent.
2. Volume-Control Damper: Manually operated with quadrant lock, located in fan outlet.
3. Companion Flanges: For inlet and outlet duct connections.
4. Motor and Drive Cover (Belt Guard): Epoxy-coated steel.
5. Exit Nozzle: Nozzle shall be designed by manufacturer to discharge air at a minimum velocity of 3000 fpm per ANSI Z9.5 and create a plume 10 feet minimum above top of unit.
6. Bypass Air Intake: Air intake at mixing box above roof curb to dilute exhaust stream with additional outside air. Bypass air damper may be motorized or manual.
7. Dilution Nozzle: In addition to providing a minimum exit velocity of 3000 fpm per ANSI and plume height of 10 feet above top of unit, the nozzle shall entrain additional air to dilute the exhaust stream. Nozzle shall be made from coated steel.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install fans level and plumb.
B. Equipment shall be supported as described in Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment ".

C. Secure roof mounted fans to roof curbs with cadmium-plated hardware.

D. Install units with clearances for service and maintenance.

3.2 CONNECTIONS

A. Coordinate duct installations and specialty arrangements with schematics on Drawings and with requirements specified in duct systems.

B. Duct installation and connection requirements are specified in other Division 23Sections. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connectors.

C. Install ducts adjacent to fans to allow service and maintenance.

D. For fans with scroll drains, install line-sized piping from drain connection, with trap with seal equal to 1.5 times specified static pressure, to nearest floor drain.

E. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

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

3.3 FIELD QUALITY CONTROL

A. Perform the following field tests and inspections and prepare test reports:

1. Verify that shipping, blocking, and bracing are removed.
2. Verify that unit is secure on mountings and supporting devices and that connections to ducts and electrical components are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.
3. Verify that cleaning and adjusting are complete.
4. Disconnect fan drive from motor, verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearing operation. Reconnect fan drive system, align and adjust belts, and install belt guards.
5. Adjust belt tension.
6. Adjust damper linkages for proper damper operation.
7. Verify lubrication for bearings and other moving parts.
8. Verify that manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in fully open position.
9. Disable automatic temperature-control operators, energize motor and confirm proper motor rotation and unit operation, adjust fan to indicated rpm, and measure and record motor voltage and amperage.
10. Replace fan and motor pulleys as required to achieve design airflow.
11. Shut unit down and reconnect automatic temperature-control operators.
12. Remove and replace malfunctioning units and retest as specified above.
B. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

3.4 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain fans. Refer to Division 01 Section "Demonstration and Training."

END OF SECTION
ARTICLE 233600
AIR TERMINAL UNITS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following:
   1. Shutoff single-duct air terminal units.

B. Related Sections include the following:
   1. Division 23 Section "Hydronic Piping".
   2. Division 23 Section "General-Duty Valves for HVAC Piping" for valves and accessories for piping.
   3. Division 23 Section "Instrumentation and Control for HVAC".

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product indicated, include rated capacities, furnished specialties, sound-power ratings, and accessories.

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, required clearances, method of field assembly, components, and location and size of each field connection.

   1. Include a schedule showing unique model designation, room location, model number, size, and accessories furnished.
   2. Wiring Diagrams: Power, signal, and control wiring.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

   1. Ceiling suspension assembly members.
   2. Size and location of initial access modules for acoustic tile.
   3. Ceiling-mounted items including lighting fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings.

B. Field quality-control reports.
1.4 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 Division 01 Section "Operation and Maintenance Data" include the following:

1. Instructions for resetting minimum and maximum air volumes.
2. Instructions for adjusting software set points.

1.5 QUALITY ASSURANCE

A. Product Options: Drawings indicate size, profiles, and dimensional requirements of air terminal units and are based on the specific system indicated. Refer to Division 01 Section "Product Requirements."

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

C. NFPA Compliance: Install air terminal units according to NFPA 90A, "Standard for the Installation of Air Conditioning and Ventilating Systems."

D. Identification: Label each air terminal unit with plan number, nominal airflow, maximum and minimum factory-set airflows, coil type, and ARI certification seal.

E. Verification of Performance: Rate air terminal units according to ARI 880.

1.6 COORDINATION

A. Coordinate layout and installation of air terminal units and suspension system with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, fire-suppression system, and partition assemblies.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers:
1. Enviro-tec.
2. Johnson Controls, Inc.
4. METALAIRE, Inc.; Metal Industries Inc.
5. Nailor Industries.
7. Price Industries.
1. Siemens Industry Inc.
2. Titus.
2.2 GENERAL

A. Terminal units shall be pre-assembled with factory-installed piping and pre-commissioned, factory-installed controls.

B. Terminal units shall not exceed NC 26 at 3” w.g. per AHRI 880.

C. All terminal boxes shall be insulated and not expose insulation media to the air stream.

D. Terminals with hydronic reheat shall implement two PID loops, one with the zone temperature as the input and the second one with the box DAT as input.

2.3 UNIT CONTROLS

A. Factory-Mounted and -Wired Controls: Electrical components including, differential pressure sensor and air flow sensing tubes, shall be mounted in NEMA 250, Type 1 control box with removable cover, mounted on side of unit and sealed from airflow. Incorporate single-point electrical connection to power source.

1. Control Transformer: Factory mounted for 24 VAC control voltage on electric and electronic control units with terminal strip in control box for field wiring of thermostat and power source. Units with fans shall also require fan start/stop relay.

2. Wiring Terminations: Fan and controls to terminal strip, and terminal lugs shall 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 for Fan on Fan Powered Units: Factory-mounted, fused type.

4. Terminal unit manufacturer’s primary air damper actuator and a pressure independent primary air controller.

5. Airflow sensing tubes:
   a. Sensing tubes of the multipoint, automatic averaging type shall be included in each unit inlet.
   b. Dual-duct units shall have airflow sensing tubes at the unit outlet.
   c. Airflow sensing tubes are to include ‘tees’ utilized as balancing taps for field adjustment of the maximum (and minimum) primary CFM, without having to remove tubes from controller.
   d. The balancing taps shall be used in conjunction with a flow chart on each terminal unit to permit readjustment of the primary air. Field readjustment shall be by means of adjustment screws.

6. A schematic drawing shall be affixed to each box indicating proper hookups for electronic thermostats.

B. DDC Controls: Bidirectional damper operators and microprocessor-based controller and room sensor shall be compatible with temperature controls specified in Division 23 Section "Instrumentation and Control for HVAC" and shall have the following features:

1. Damper Actuators: 24 V, powered open.
2. Velocity Sensors: Multipoint array with velocity sensors in all air inlets and air outlet and integral to unit.

3. Terminal Unit Controller: Pressure independent, variable-air or constant-volume controller with electronic airflow transducers factory calibrated to minimum and maximum air volumes, and having the following features:
   a. Proportional, plus integral control of room temperature.
   b. Time-proportional reheat-coil control.
   c. Occupied and unoccupied operating mode.
   d. Remote reset of airflow or temperature set points.
   e. Adjusting and monitoring with portable terminal.
   f. Communication with temperature-control system specified in Division 23Section "Instrumentation and Control for HVAC."

2.4 HEATING COILS

A. Hot-Water: Copper tube, mechanically expanded into aluminum-plate fins; leak tested underwater to 200 psig; and factory installed.
   1. Minimum two-row coils with tube thickness not less than 0.016”.
   2. Coil performance shall be based on ARI 410.

B. Electric: Slip-in-type, open-coil design with integral control box factory wired and installed. Include the following features:
   1. Primary and secondary over-temperature protection.
   2. Nickel chrome 80/20 heating elements.
   3. Airflow switch.
   4. Fan interlock contact for fan powered terminal units.
   5. Noninterlocking disconnect switch.
   6. Fuses (for coils more than 48 A).
   7. Mercury contactors.
   8. Pneumatic-electric switches and relays.
   9. Magnetic contactor for each step of control (for three-phase coils).
   10. First stage of heating shall be fan only. Additional stages of heat shall energize electrical coils.

C. Where indicated, boxes shall be provided with a hot water heating coil and modulating control valve.

D. Heating coils shall be removable without removing the terminal unit.

2.5 SHUTOFF SINGLE-DUCT AIR TERMINAL UNITS

A. Configuration: Variable-volume damper assembly inside unit casing with control components located inside a protective metal shroud.

B. Casing: 0.034-inch steel.
   a. Casing Lining:
b. Thermal insulation equivalent in performance to 1-inch-thick, coated, fibrous-glass duct liner complying with ASTM C 1071; secured with adhesive. Cover liner with one of the following nonporous sheets:

1) Foil.
2) Metal.
3) Mylar.
4) Tedlar.

c. Adhesive attached, 3/4-inch-thick, polyurethane foam insulation.
d. All linings and adhesives shall comply with the following standards:

1) ASTM E 84 for Flame and Smoke, 25/50.
2) ASTM C 665 for Fungi Resistance.
3) UL 181 for Air Erosion and Mold Growth and Humidity.
4) UL 723 for Flame and Smoke, 25/50.

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 dampers and other parts requiring service, adjustment, or maintenance; with airtight gasket.

C. Regulator Assembly: Extruded-aluminum or galvanized-steel components; key damper blades onto shaft with nylon-fitted pivot points located inside unit casing.

1. Automatic Flow-Control Assembly: Combined spring rates shall be matched for each volume-regulator size with machined dashpot for stable operation.
2. Factory-calibrated and field-adjustable assembly with shaft extension for connection to externally mounted control actuator.

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 6-inch wg inlet static pressure.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install air terminal units level and plumb.

B. Maintain sufficient clearance for normal service and maintenance to all portions, including coil connections.

1. Provide at least 24” clear in front of terminal unit control panel access.
2. Provide at least NEC clearances in front of terminal unit disconnects.
3.2 CONNECTIONS

A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to air terminal units to allow service and maintenance.

C. Hot-Water Piping: In addition to requirements in Division 23 Section "Hydronic Piping," connect heating coils to supply with shutoff valve, strainer, control valve, and union or flange; and to return with balancing valve and union or flange.

D. Connect ducts to air terminal units according to Division 23 Section "Metal Ducts" or "Nonmetal Ducts," as required by duct material.

E. Ground units with electric heating coils according to Division 26 Section "Grounding and Bonding for Electrical Systems."

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

G. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

H. Install 24VAC transformer for all terminal unit controls.

I. Install discharge air temperature sensor at each terminal unit.

3.3 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect field-assembled components and equipment installation, including connections. Report results in writing.

B. Perform the following field tests and inspections and prepare test reports:

1. After installing air terminal units and after electrical circuitry has been energized, test for compliance with requirements.
2. Leak Test: After installation, fill water coils and test for leaks. Repair leaks and retest until no leaks exist.
3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. Remove and replace malfunctioning units and retest as specified above.
3.4 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain air terminal units. Refer to Division 01 Section "Demonstration and Training."

END OF SECTION
SECTION 233713
DIFFUSERS, REGISTERS, AND GRILLES

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes ceiling- and wall-mounted diffusers, registers, and grilles.

B. Related Sections include the following:

1. Division 08 Section "Louvers and Vents" for fixed and adjustable louvers and wall vents, whether or not they are connected to ducts.
2. Division 23 Section "Air Duct Accessories" for fire and smoke dampers and volume-control dampers not integral to diffusers, registers, and grilles.
3. Division 23 Section "Particulate Air Filtration" for HEPA media applied in HEPA filter grilles.

1.2 ACTION SUBMITTALS

A. Product Data: For each product indicated, include the following:

1. Data Sheet: Indicate drawing designation, model number, size, materials of construction, finish, and mounting details; and performance data including throw and drop, accessories, static-pressure drop, and noise ratings.
2. Diffuser, Register, and Grille Schedule: Indicate Drawing designation, model number, size, and accessories furnished.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Kreuger.

B. MetalAire, Inc.; Metal Industries Inc.

C. Nailor.

D. Price Industries.

E. Titus.
2.2 CAPACITIES AND CHARACTERISTICS

A. Provide Grilles, Registers, and Diffusers with capacities and characteristics as indicated in the drawings.

B. Maximum NC shall be 25 at CFM indicated, including neck damper.

C. Coordinate frame style with drawings.

D. Finish: Baked enamel, color selected by Architect.

E. Ceiling mounted critical environment grilles, registers, and diffusers shall have an independent hanger or chain to structure.

F. Insulate the top of the following supply air diffusers:
   1. Critical Environment Diffusers
   2. Systems with a supply air temperature of less than 45°F (7.2°C)

2.3 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. Deliver and store clean and shrink wrapped. Touch up any paint damage.

3.2 INSTALLATION

A. Install diffusers, registers, and grilles level and plumb.

B. Ceiling-Mounted Outlets and Inlets: Drawings indicate general arrangement of ducts, fittings, and accessories. Air outlet and inlet locations have been indicated to achieve design requirements for air volume, noise criteria, airflow pattern, throw, and pressure drop. Make final locations where indicated, as much as practicable. For units installed in lay-in ceiling panels, locate units in the center of panel. Where architectural features or other items conflict with installation, notify Architect for a determination of final location.
C. Install diffusers, registers, and grilles with airtight connections to ducts and to allow service and maintenance of dampers, air extractors, and fire dampers.

D. Install insulation blankets on the back-pan of all air devices directly under an exposed roof. Refer to Division 23 “HVAC Insulation – Duct, Equipment, and Piping”.

E. At each ceiling and sidewall take-off from a duct, install an adjustable volume extractor with appropriate operator. Refer to Division 23 “Air Duct Accessories”.

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 234000

HVAC AIR CLEANING DEVICES

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes factory-fabricated air-filter devices and media used to remove particulate matter from air for HVAC applications.

B. Related Sections include the following:

1. Division 23 Section “Metal Ductwork” for duct materials and pressure classes.

C. References and Standards

2. ANST/UL-900 - Test Performance of Air Filter Units.
3. ANSI/UL 586 - Test Performance of High Efficiency Particulate, Air Filter Units.
7. DOE-STD-3020-97, SPECIFICATION FOR HEPA FILTERS USED BY DOE CONTRACTORS, January 1997
8. IEST-RP-CC001.3 - HEPA and ULPA Filters -, The Institute of Environmental Science and Technology, Rolling Meadows, IL.
9. IEST-RP-CC034.1 - HEPA and ULPA Filter Leak Tests - The Institute of Environmental Science and Technology, Rolling Meadows, IL.
12. SMACNA - HVAC Duct Construction Standards - Metal and Flexible.

1.2 DEFINITIONS

A. DOP: Dioctyl phthalate or bis-(2-ethylhexyl) phthalate.

B. HEPA: High-efficiency particulate air.

C. ULPA: Ultra low penetration air.
1.3 ACTION SUBMITTALS

A. Product Data: Include dimensions; operating characteristics; required clearances and access; rated flow capacity, including initial and final pressure drop at rated airflow; efficiency and test method; fire classification; furnished specialties; frame construction and materials; and accessories for each model indicated.

B. Shop Drawings: Include plans, elevations, sections, and details to illustrate component assemblies and attachments.
   1. Show filter rack assembly, dimensions, materials, and methods of assembly of components.
   2. Include setting drawings, templates, and requirements for installing anchor bolts and anchorages.

1.4 INFORMATIONAL SUBMITTALS

A. Operation and Maintenance Data: For each type of filter and rack to include in emergency, operation, and maintenance manuals.

B. Manufacturer’s Letter:
   1. Manufacturer shall provide a letter of compliance along with cost proposal stating that the manufacturer complies with all requirements of specifications and drawings.
   2. For HEPA filter housing seals, manufacturer shall also provide written assurance that sealant is compatible with all decontamination materials including VHP.

C. When specified performance characteristics are not published in the manufacturer's literature, the submittal data shall include certified documentation of performance by an approved independent test laboratory.

D. For HEPA filter housings, all welding procedures, welders and welder operators shall be qualified in accordance with ASME Boiler and Pressure Vessel Code, Section IX. All production welds shall be visually inspected per standard procedure per ANSI/AWS D9.1-1990, “Specifications for Welding Sheet Metal” and shall be recorded with a certified weld inspection and report.

1.5 QUALITY ASSURANCE

A. Product Options: Drawings indicate size, profiles, and dimensional requirements of air filters and are based on the specific system indicated. Refer to Division 01 Section "Product Requirements."

B. Comply with ARI 850.

C. Comply with ASHRAE 52.1 and ASHRAE 52.2 for method of testing and rating air-filter units.
D. Comply with NFPA 90A and NFPA 90B.

E. Manufacturer: All manufacturers shall specialize in the production of components specified herein for not less than three years documented experience and shall also issue a complete catalog with all data for the total product as described in "Submittals" above.

1.6 EXTRA MATERIALS

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

1. Provide one complete set of filters for each filter bank. If system includes prefilters, provide only prefilters.
2. Provide one complete set of filters for each section of each unit to be installed when the project is turned over to the Owner.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS

A. Configuration: Fabricate with fan(s), coils, etc. plus accessories, including:

1. Filters.
2. Filter Housings and Frames.
3. Filter Gauges.

B. Fabrication: Conform to AMCA 99 and ARI 430.

C. All air filters shall be listed as Class 1 in accordance with Underwriters' Laboratories, Inc., Building Materials Director requirements, except ultrahigh efficiency filters (HEPA) shall be manufactured of materials that are so listed by UL.

2.2 FILTERS

A. Type "C": Replaceable, Dry.

1. Manufacturers:
   a. Camfill 30/30.
   b. American Air Filter.
   c. Air Guard.
   d. Flanders.

2. Description: Pleated, disposable, nonwoven, lofted cotton media. The media shall be cemented to the inside of the frame to prevent air bypass.
3. Frame: Galvanized steel frame with 96% free support grid and contour stabilizers. The support grid and frame shall be continuously bonded to the leaving air face of the media.

4. Performance: MERV 8 (30%).

5. Thickness: 2”.

6. Initial Resistance: Initial clean resistance to air flow shall not exceed 0.30” w.g.

7. Maximum Face Velocity: The net velocity shall not exceed 500 FPM.

8. Installation: Filters shall be installed in side access or front access frames, as shown on the drawings. Filters in front access frames shall be furnished with lift handles.

9. Capacity: a 24” x 24” size shall be certified for a dust holding capacity of not less than 200 grams of ASHRAE Test Dust at 500 FPM and a final resistance of 1.0” w.g.

B. Type "D": Replaceable, Dry.

1. Manufacturers:
   a. AmAir 1100.
   b. Flanders 62RM11.
   c. Camfill AP Eleven.

2. Description: High density, microfine glass fiber media laminated to a nonwoven synthetic backing. The media shall be cemented to the inside of the frame to prevent air bypass.

3. Frame: Galvanized beverage board frame with 96% free support grid and contour stabilizers. The support grid and frame shall be continuously bonded to the leaving air face of the media.

4. Performance: MERV 11 (65%).

5. Thickness: 4” – 12”.

6. Initial Resistance: Initial clean resistance to air flow shall not exceed 0.35” w.g.

7. Maximum Face Velocity: The net velocity shall not exceed 500 FPM.

8. Installation: Filters shall be installed in side access or front access frames, as shown on the drawings. Filters in front access frames shall be furnished with lift handles.

9. Capacity: a 24” x 24” x 12” size shall be certified for the dust holding capacity above to a final resistance of 1.0” w.g.

C. Type "E": Replaceable, Dry.

1. Manufacturers:
   a. Camfill Aeropac or N/S Model III.
   b. American Air Filter.
   c. Flanders.

2. Description: High density, microfine glass fiber media laminated to a nonwoven synthetic backing. The media shall be cemented to the inside of the frame to prevent air bypass.
3. **Frame:** Galvanized beverage board frame with 96% free support grid and contour stabilizers. The support grid and frame shall be continuously bonded to the leaving air face of the media.

4. **Performance:** MERV 14 (90%).

5. **Thickness:** 12”.

6. **Initial Resistance:** Initial clean resistance to air flow shall not exceed 1.0” w.g.

7. **Maximum Face Velocity:** The net velocity shall not exceed 500 FPM.

8. **Installation:** Filters shall be installed in side access or front access frames, as shown on the drawings. Filters in front access frames shall be furnished with lift handles.

9. **Capacity:** A 24” x 24” x 12” size shall be certified for the dust holding capacity above to a final resistance of 1.75” w.g.

D. **Type "F":** HEPA.

1. **Manufacturers:**
   a. Camfil Camfill.
   b. Flanders.

2. **Description:** A continuous pleated 28mm thick sheet of molded, waterproof, all glass media without separators. The media shall be permanently bonded to the inside of the frame to prevent air bypass with a rubber based sealant.

3. **Frame:** Stainless steel frame with a rubber based, gas-tight membrane between the filter frame and the frame housing.

4. **Performance:**
   a. MERV 17 (99.97% on 0.30um particles, IEST Type A).
   b. MERV 18 (99.99% on 0.30um particles, IEST Type C).
   c. MERV 19 (99.999% on 0.30um particles, IEST Type D).
   d. MERV 20 (0.10 - 0.20um particles, IEST Type F).
   e. Efficiency shall conform to:
      1) MIL-STD-282.
      2) IEST-RP-C001.3 Type E.
      3) MIL-F-51079.
      4) ASME AG-1 Code, Section FC, Section 5140: withstand a pressure differential of 10” w.g. without visible deformation.

5. **Thickness:** 12” (minimum).
6. **Initial Resistance:** Initial clean resistance to air flow shall not exceed 1.0” w.g.

7. **Maximum Face Velocity:** The net velocity shall not exceed 500 FPM.

8. **Installation:** Filters shall be installed in front access frames and be provided with a mechanical lock.

9. **Nameplate:** All performance data, including penetration and air friction shall be stated on the nameplate affixed to the exterior of each filter frame.

### 2.3 FILTER HOUSINGS AND FRAMES

A. **Side Access Housings**
1. All housings shall:
   a. Be fabricated of not less than an all welded 16 gauge galvanized steel and be equipped with standing flanges and hinged access doors at both ends.
   b. Receive filters of any manufacturer without alteration to filter, including 2” deep panel type prefilters, or housing.
   c. Incorporate a permanent provision for sealing the filters against leakage around the entire perimeter of each filter, eliminating the need to purchase replacement filters with factory applied gasket strips. Replaceable woven pile seals shall be an integral component of the downstream flange of each extrusion so that the seals are compressed by the pressure drop across the filters, preventing bypass of unfiltered air.
   d. Not exceed 36 inches in direction of air flow.
   e. Be constructed and rated for use at listed air handling unit static pressures.

2. Doors are to be fitted with positive sealing, heavy duty multiple latches and with sponge neoprene gaskets.

3. Provide housings with static pressure taps.

B. Face Access Housings

1. All housings shall:
   a. Be fabricated of not less than 16 gauge galvanized steel with holes prepunched for convenient assembly into banks.
   b. Be a minimum of 2-5/8" deep for maximum structural strength and resistance to racking.
   c. Be fitted with polyurethane foam gaskets, held in place by long lasting adhesive, and with a minimum of four heavy duty spring type fasteners.

2. Fasteners shall attach to the frames without requiring tools and shall be capable of withstanding 25 pounds of pressure without deflection.

3. All joints in the field assembled banks of frames shall be thoroughly caulked to prevent bypass of unfiltered air between frames and surrounding ductwork or plenum chambers.

C. HEPA Filter Housings

1. Frame Construction
   a. All hardware on the housing and all mechanical components of the filter sealing mechanism shall be 300 series stainless steel, except for the cast aluminum access door knobs.
   b. All pressure retaining weld joints and seams shall be continuously welded with no prones allowed and tested for zero (0) leakage at 10” w.g. differential pressure.
   c. Joints and seams shall be wire brushed and/or buffed to remove heat discoloration, burrs and sharp edges.
   d. All weld joints and seam that are a portion of any sealing surface (e.g., duct connecting flanges) shall be ground smooth and flush with the adjacent base metal.
e. Flanges

1) The upstream and downstream flanges shall have a 1-½” minimum flange width.
2) Flanges shall be turned to the outside of the airstream to prevent contamination build-up and allow the customer to connect mating ductwork from outside the housing.

2. The HEPA Filter Housing Fluid Seal

a. Fluid seals, silicone or approved equal, shall be non-evaporative, highly viscous, self-healing, non-newtonian substance.
b. The housing seal design shall incorporate a knife edge that mates into the fluid filled perimeter channel of the face on the filter.
c. The filter sealing mechanism shall exert equal force at the top and bottom edge of the filter when engaging or disengaging the filter from the knife edge.
d. There shall be safety feature where the filter locking arm and access doors shall interface in such a manner that eliminates the possibility of the door being closed until the filters are correctly seating in the housing.
e. Prior to delivery housing will be inspected with an alignment gauge to ensure proper alignment with the filter and the knife edge and report filed per commissioning requirements.

3. Multi-wide housings

a. All multi-wide housings shall be equipped with filter removal rods to draw the filters to the change-out position.
b. The removal rods shall be operated from inside the housing, and the filter(s) shall be removed by pulling against the bottom of the filter frame.
c. There shall be no penetration through the housing for operation of the removal rod.

4. Provide manual gas tight dampers at the inlet and the outlet of each HEPA caisson. A manually actuated bubble tight damper will be installed at the bio-containment barrier.

5. Decontamination Ports:

a. Each filter housing shall have locking decontamination ports installed to allow for gaseous decontamination of the entire caisson section.
b. Ports shall be provided with 3” stainless steel ball valve fitted with 3” cam-lock coupling fittings compatible with housing construction.
c. Pressure gauges shall be provided across each filter section.

6. Provide upstream and downstream testing and scanning sections for each bank of HEPA filters.

7. Provide a minimum of 4 feet clearance in front of the filter access door for filter change-out.

8. HEPA Filter Housing Testing
a. The housing shall be tested for filter fit, operation of the filter clamping mechanism, knife edge alignment and leak tightness before leaving the factory.

b. Both the filter sealing surface and the complete assembly pressure boundary shall be leak tested by the “Pressure Decay Method”, accordance with ASME N510-1995 “Reaffirmed”, “Testing of Air Cleaning Systems”, paragraphs 6 and 7. Pressure readings are recorded once a minute for 5 minutes.

c. There shall be a maximum leak rate of 0.2% of housing volume per hour at 10 inches water gauge.

9. ABSL3 and BSL3 Laboratory Exhaust. In addition to the above items, provide the following:

a. The filter housings shall be side access design and shall be manufactured from unpainted 14 and 11 gauge type 304L stainless steel.

b. The housing shall be adequately reinforced to withstand a negative or positive pressure 15 inches water gauge.

c. The design and filter arrangement shall allow air to enter and exit the housing through required number of filter banks.

2.4 FILTER GAUGES

A. Manufacturers:

1. Airguard Industries, Inc.

2. Dwyer Instruments, Inc.

B. Description: Diaphragm type with dial and pointer in metal case, vent valves, black figures on white background, and front recalibration adjustment.

1. Diameter: 4-1/2 inches.

2. Range: The range of the scale shall start at 0 and end no greater than 1" w.g. (250 Pa) above the filter manufacturer's recommended final resistance for the type of filter to which the gauge is being applied.

C. Accessories: Each gauge shall be provided with an adjustable signal flag, two static pressure tips with compression fittings, two three-way vent valves with compression fittings, two lengths of aluminum tubing, and a mounting plate with screws.

D. For HEPA filter banks, the following shall also apply:

1. Factory mounted photohelic gauge by Dwyer, 3003 SGT or engineer approved equal.

2. Gauge shall have zero adjustment capability.

3. In lieu of aluminum, provide stainless steel tubing, fittings, mounting brackets, identification labels.

4. Identification labels shall be stitch welded to mounting bracket.
5. Each gauge assembly shall be complete with stainless steel inline HEPA filters, tee fitting, gauge decontamination port, and 2-way stainless steel plug valves.

**PART 3 - EXECUTION**

3.1 INSTALLATION

A. Install filter frames according to manufacturer's written instructions.

B. Position each filter unit with clearance for normal service and maintenance. Anchor filter holding frames to substrate.

C. Install filters in position to prevent passage of unfiltered air.

D. Install filter gauge for each filter bank.

E. An integral transmitter shall read differential pressure across each filter bank and report to the FMS.

F. Install filter gauge static-pressure tips upstream and downstream from filters to measure pressure drop through filter. Mount filter gauges on outside of filter housing or filter plenum in an accessible position. Adjust and level inclined gauges.

G. Coordinate filter installations with duct and air-handling unit installations.

H. Electrical wiring and connections are specified in Division 26 Sections.

I. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

J. Do not operate units for any purpose, temporary or permanent, until ductwork is clean, filters are in place, bearings lubricated, and fan has been test run under observation.

3.2 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components, filter and filter-frame installation, and electrical wiring, and to assist in field testing. Report results in writing.

B. HEPA Filters:

1. All HEPA filter housing requires that the filters can be quantitatively leak tested.
2. The injection port and sampling ports shall be of sufficient size for insertion of the output line from the aerosol generator or photometer probe used by the owner or its authorized testing agency.
3. Total leak test or efficiency test and scan leak tests shall be performed.
4. The scan test apparatus must be qualified to be capable of traversing the entire filter sealing gasket and the perimeter of the filter support/duct housing structure in addition to the filter. Each test system is qualified only once prior to conducting periodic leak tests. The total leak test is prescribed in ASME N510-1989, Section 10, and the scan leak test is prescribed in IEST-RP-CC034.1.

5. Access to Inject Challenge Aerosol: Access is required to permit the injection of challenge aerosol upstream of the filter. The aerosol can be injected at a device served by the filter system or via a port installed in the ductwork upstream of the features that accomplish the tasks listed in the following Sections.

6. Mixing Devices Upstream of the Filter: The challenge aerosol should be mixed thoroughly using installed devices that are designed to induce turbulence, or by adding a device to create mixing by inducing turbulence, such as a Stairmand disk.

7. Qualification to Ensure Uniform Downstream Concentration for Total Leak Test: Thorough mixing is required for any leaking aerosol downstream from the filter. Turbulence shall be induced using engineered system in the downstream airflow that produces mixing. An engineered turbulence induction and sampling manifold system which collects samples at multiple points downstream of all portions of the filter after mixing for concurrent measurement of the average concentration is allowed.

8. Scan Test to Measure All Leaks:
   a. Scanning one inch from the downstream ("clean") face of the filter is allowed provided that an engineered system shall be installed in the filter system at the time the system is built.
   b. The scan test apparatus must be qualified by demonstrating it can measure leaks along the entire filter sealing gasket and the perimeter of the filter support/duct housing structure as well as leaks in the filter itself.
   c. The scanning system shall consists one or more funnel shaped collectors attached to an apparatus that can traverse over the duct section at one inch from the face of the HEPA filter in an overlapping fashion as prescribed in IEST-RPCC034.1. 6.0 Acceptance Criteria for In-Place Leakage Tests.
   d. The scan leak test measuring instrument shall be discrete particle measuring type with the ability to record and integrate individual leak test.
   e. Engineer and Owner shall review and approve any proposed alternative.

3.3 CLEANING

A. After completing system installation and testing, adjusting, and balancing air-handling and air-distribution systems, clean filter housings and install new filter media.

END OF SECTION
1.1 SUMMARY

A. This Section includes custom and variable aspect ratio air-handling units with coils for indoor installations.

B. Related Sections include the following:
   1. Division 23 Section "Hydronic Piping" for chilled, heating, and condensate piping.
   2. Division 23 Section "Instrumentation and Control for HVAC" for controls components.
   3. Division 23 "HVAC Air Cleaning Devices" for performance of filters.
   4. Division 23 Section "Refrigerant Piping" for DX piping within equipment.
   5. Division 26 "Variable Frequency Drives" for VFDs.
   6. Division 23 Section "Vibration Isolation" for seismic criteria and restraint performance.

1.2 SITE PERFORMANCE REQUIREMENTS

A. Wind-Restraint Performance: AHUs shall withstand the effects of wind determined according to ASCE 7. AHUs shall remain intact and operational after a wind event.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of custom air-handling unit indicated. Include the following:

   1. Dimensional drawings by unit section, including plan and elevation views.
   2. Certified fan-performance curves with system operating conditions indicated.
   3. Certified fan-sound power ratings.
   4. Certified coil-performance ratings with system operating conditions indicated.
   5. Curbs as provided by manufacturer.
   6. Dampers, including housings, linkages, and operators.
   7. Filters with performance characteristics.
   8. Motor ratings, electrical characteristics, and motor and fan accessories.
   11. Weights by section, total unit, and anticipate operating weights.

B. Shop Drawings: Signed and sealed by a qualified professional engineer.
1. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
2. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include auxiliary motor slides and rails, and base weights.
4. Short-circuit current rating of equipment assembly.

1.4 INFORMATIONAL SUBMITTALS
A. Coordination Drawings: Submit with Shop Drawings. Show mechanical-room layout and relationships between components and adjacent structural and mechanical elements. Show support locations, type of support, and weight on each support. Indicate and certify field measurements.

1.5 CLOSEOUT SUBMITTALS
A. Operation and Maintenance Data: For each unit to include in emergency, operation, and maintenance manuals.

1.6 QUALITY ASSURANCE
A. Source Limitations: Obtain custom air-handling units through one source from a single manufacturer.
B. Product Options: Drawings indicate size, profiles, and dimensional requirements of custom air-handling units and are based on the specific system indicated. Refer to Division 01 Section "Product Requirements."
C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
D. NFPA Compliance: Custom air-handling units and components shall be in compliance with NFPA 70 and 90A.
E. ARI Certification: Custom air-handling units and their components shall be factory tested according to ARI 430, "Central-Station Air-Handling Units," and shall be listed and labeled by ARI.
F. AHU Factory Testing
1. Units with cabinet mounted fans shall be tested and certified at rated conditions using AMCA 210 and AMCA 300 procedures with fan mounted in the cabinet. Bare fan data will not be accepted. All, Testing shall be documented and signed by an officer in the company and sent to the Engineer owner's representative.
2. Unit shall be tested for casing leakage by sealing all openings and pressurizing to 10" wg. Maximum allowable leakage rate is 1% of rated unit flow. Test is to be performed by the manufacturer using flow measurement.
devices and shall be witnessed by the Engineer and the Owner's authorized 

witnesses. Deflection limit of L/200 will also be demonstrated at this time and 

fan/motor vibration limits will be confirmed.  

3. Failure of the leakage and or/ deflection test shall require sealing and bracing 
of the unit and retesting until criteria is met. Furthermore, failure of the trim 
balance to confirm vibration limit shall require rebalancing and re-testing until 
criteria is met. AHU Manufacturer shall bear all costs involved in the 
modifications, balancing, and re-testing, including travel and hourly costs 
associated with the Owner's authorized witnesses. 

1.7 COORDINATION 

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

B. Coordinate installation of roof curbs, equipment supports, and roof penetrations. 
These items are specified in Division 07 Section "Roof Accessories."  

C. Coordinate size and location of structural-steel support members.  

1.8 WARRANTY 

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to 
replace components of units that fail in materials or workmanship within specified 

warranty period. 

1. Warranty Period for Compressors: Manufacturer's standard, but not less 
than five years from date of Substantial Completion.  

2. Warranty Period for Gas Furnace Heat Exchangers: Manufacturer's standard, 
but not less than five years from date of Substantial Completion.  

3. Warranty Period for Solid-State Ignition Modules: Manufacturer's standard, 
but not less than three years from date of Substantial Completion.  

4. Warranty Period for Control Boards: Manufacturer's standard, but not less 
than three years from date of Substantial Completion.  

5. OEM shall provide quarterly, annual, and bi-annual maintenance in 
compliance with or exceeding ASHRAE Standard 180-2008.  

6. Complete Warranty: Provide one a five year warranty to include both parts 
and labor. Warranty shall cover the entire unit and factory accessories, 
including the following: 

1. Compressors  

2. Coils  

3. Dampers and damper actuators  

4. Fans  

5. Motors  

6. Motor starters  

7. VFDs  

8. Heat exchangers  

9. Condenser fans  

10. Control panel
1.9 EXTRA MATERIALS

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

1. Filters: Two sets for each custom air-handling unit.
2. Fan Belts: Two sets for each custom air-handling unit fan.
3. Gaskets: One set for each access door.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

1. CES Group Inc.; Governair, Hunt, Mammoth, Temtrol.
2. ClimateCraft.
3. Daikin.
4. Energy Labs.
5. Engineered Air.
6. YORK, a Johnson Controls company.
7. Trane.

2.2 GENERAL

A. Custom air-handling units shall be factory assembled and consist of fans, motor and drive assembly, coils, damper, plenums, filters, condensate pans, air blenders, mixing dampers, control devices, silencers, and other accessories, sections, or components.

B. Provide protection for all openings and components during equipment transport. Externally mounted components shall be protected during all phases of transport from exposure, including moisture and ambient temperatures outside of any component’s operating range. Externally mounted components include, but are not limited to, VFD’s, actuators, sensors, and weather hoods.

2.3 UNIT CONSTRUCTION

A. Casing Performance

1. Unit air leakage shall not exceed 1.0% of design cfm at maximum 8” w.g. operating. Leakage shall be calculated by totaling all leakage either in to or out of the unit.
2. Casing deflection shall not exceed L/200 at 8” w.g., where L is defined as the panel span.
3. Insulation: units shall have a minimum effective insulating value of R-13.

B. Bases & Floors
1. Base shall be constructed from clear-coated galvanized steel channels around the perimeter and minimum 10-gage clear-coated galvanized steel cross members.

2. Each shipping section shall be provided with removable lifting lugs. Structural framework shall fully support the unit casing and all components during installation such that no section deflects more than L/1000 during rigging of that section, where L is defined as the distance between lifting lugs.

3. Floor shall be double wall constructed from smooth galvanized steel. The floor surface and all spaces and joints shall be completely sealed with dams around all bottom penetrations. Floor deflection shall not exceed L/200 under a point load of 500 pounds, where L is defined as the floor span.

4. Foam insulation shall be provided underneath the entire unit floor. Insulation shall completely fill the panel cavity in all directions so that no voids exist. Base assemblies shall comply with NFPA 90A or 90B.

C. Walls

1. Wall assemblies shall be double-wall construction with galvanized steel solid exterior and galvanized steel interior. All spaces and joints of wall assemblies shall be completely sealed.

2. Insulation shall be provided throughout all unit wall assemblies. Insulation shall completely fill the panel cavity in all directions so that no voids exist and settling of insulation is prevented. Wall assemblies shall comply with NFPA 90A.

3. Removable walls, access panels, or doors shall be provided in all sections for service and removal of components.

D. Perforated Panel Sections

1. Double wall sections, identical in thermal and leakage performance described above shall be provided at the following locations:
   a. Intake plenums.
   b. Discharge plenums.
   c. Fan sections.

2. Insulation at perforated panels shall be separated from the air stream with a healthcare grade barrier similar to mylar.

3. In no case shall insulation fibers be exposed to the air stream, nor shall the insulation material or separation material ablate.

E. Access Doors

1. Access doors shall be provided at all sections.

2. Access doors shall be double wall construction. Interior and exterior door panels shall be of the same construction as the interior and exterior wall panels, respectively.

3. All doors shall have a complete thermal break from the panel that it is installed in.

4. Insulation shall be provided throughout all door assemblies. Insulation shall completely fill the panel cavity in all directions so that no voids exist and settling of insulation is prevented. Door assemblies shall comply with NFPA 90A.
5. All doors shall be a minimum of 60” high if sufficient height is available, or the maximum height allowed by the unit height and minimum 24” wide. All doors shall open against pressure to ensure an airtight seal and to prevent a safety hazard.
6. Door hinges shall be 304 stainless steel continuous type. All handles shall fasten against the door frame with a roller cam to eliminate wear of the door frame.
7. Windows shall be provided in all section doors. Windows shall be mounted in a metal frame and shall be a minimum of 8” x 8”, with safety glass. Windows shall be thermal, double-pane type.

F. Roofs
1. Roof assemblies shall be double wall construction. Exterior roof panels and interior ceiling panels shall be of the same construction as the exterior and interior wall panels, respectively. Sections in units with perforated interior wall liners shall have perforated interior ceiling liners. All spaces and joints of roof assemblies shall be completely sealed. In addition to meeting the casing deflection limits contained herein, roof deflection shall not exceed L/200 under a point load of 200 pounds, where L is defined as the roof panel span.
2. Insulation shall be provided throughout all roof assemblies. Insulation shall completely fill the panel cavity in all directions so that no voids exist. Roof assemblies shall comply with NFPA 90A.

G. Unit Paint
1. External surfaces of all unit casings shall be prepared and painted resulting in a minimum 1.5 mil thick coating when dry.
2. Paint shall be able to withstand a salt spray test in accordance with ASTM B117 for a minimum of 500 consecutive hours.
3. Paint shall be AHU Manufacturer’s standard color, unless otherwise indicated.
4. For units requiring a color other than the AHU Manufacturer’s standard color, the Architect shall provide a quantity of four 2” x 2” paint samples to the AHU Manufacturer at the time of submittal approval.

H. Condensate Drain Pans: Formed sections of stainless-steel sheet complying with requirements in ASHRAE 62. Fabricate pans with slopes in two planes to collect condensate from cooling coils (including coil piping connections and return bends) and humidifiers.
1. Fill space between walls with foam insulation and seal moisture tight.
2. Drain Connections: Threaded nipple on both ends of pan.
3. Units with stacked coils shall have an intermediate drain pan or drain trough to collect condensate from top coil.
4. Extend pan minimum 30 inches beyond face of cooling coil.
2.4 FAN SECTION

A. Fan-Section Construction:

1. Centrifugal fans consisting of housing, wheel, fan shaft, bearings, motor and disconnect switch, drive assembly, and support structure and equipped with formed-steel channel base for integral mounting of fan, motor, and casing panels.
2. Provide access door or removable panel for fan access.
3. Mount fan with vibration isolation.
4. Performance Class: AMCA 99-2408, Class II or III.
5. No fan shall be selected greater than 85% of its construction class’ maximum RPM.
6. Fan is to be IRD balanced at design RPM to a total displacement less than 1.5 mil measured at each bearing pad prior to shipment with belts and drives in place.
7. The fan drive is to be fixed QD type cast iron sheave rated a minimum of 150 percent of motor nameplate horsepower.

B. Centrifugal Fan Housings: Formed- and reinforced-steel panels to make curved scroll housings with shaped cutoff, spun-metal inlet bell, and access doors or panels to allow entry to internal parts and components.

1. Panel Bracing: Steel angle- or channel-iron member supports for mounting and supporting fan scroll, wheel, motor, and accessories.
2. Horizontal Flanged Split Housing: Bolted construction.

C. Fan Wheels:

1. Backward-Inclined: Steel construction with curved inlet flange, backplate, and backward-inclined blades.
2. Airfoil: Steel construction with smooth-curved inlet flange, heavy backplate, and hollow die-formed airfoil-shaped blades continuously welded at tip flange and backplate; cast-iron or cast-steel hub riveted to backplate and fastened to shaft with set screws.

D. Shafts: Statically and dynamically balanced and designed for continuous operation at maximum rated fan speed and motor horsepower, with final alignment and belt adjustment made after installation.

1. Turned, ground, and polished hot-rolled steel with keyway. Ship with a protective coating of lubricating oil.
2. Designed to operate at no more than 70 percent of first critical speed at top of fan's speed range.

E. Bearings:

2. Bearing Rating Life:
a. Ball-Bearings: ABMA 9, L10 at 200,000.

b. Roller-Bearings: ABMA 11, L10 at 200,000.

F. Direct Drives: Factory mounted, with final alignment and belt adjustment made after installation and with 1.5 service factor based on fan motor. Shafts and bearings shall be compliant with performance described above.

G. Fan Assemblies: Statically and dynamically balanced and designed for continuous operation at maximum rated fan speed and motor horsepower.

H. Vibration Control: Install fans on open-spring vibration isolators having a minimum of 2-inch static deflection and side snubbers.

I. Fan-Section Source Quality Control:


2. Factory test fan performance for flow rate, pressure, power, air density, rotation speed, and efficiency. Establish ratings according to AMCA 210, "Laboratory Methods of Testing Fans for Rating."

J. Fan Arrays: For fan sections where 2 or more fans serve a single air stream or unit section, each individual fan shall comply with all parts of this section and the following.

1. Each fan shall be independently driven.
2. All fans shall be factory wired to a single enclosure.
3. For VAV services, the factory supplied enclosure shall:

   a. Include at least two VFD’s, with automatic change-over for drive failure, for controlling and monitoring fan speed.
   b. Fans shall either modulate speed, or stage individual fans on/off to achieve balanced airflow through the fan array and meet scheduled performance.
   c. Provide contacts in a common terminal strip to monitor all fans.

4. In the event of the failure of any single fan the remaining fans shall be able to supply to design CFM and ESP as scheduled.
5. Provide motorized damper to isolate each individual fan from array upon fan or motor failure. Isolation damper shall prevent bypass air through the fan array.

2.5 MOTORS

A. General: Comply with requirements in Division 23 Section "Common Motor Requirements for HVAC Equipment."

B. Noise Rating: Quiet.
2.6 COILS

A. Coil Sections: Common or individual, insulated casings for heating and cooling coils. Design and construct to facilitate removal and replacement of coil, for maintenance, and to ensure full airflow through coils.

B. Hydronic Coils: Continuous circuit coil fabricated according to ARI 410.

1. Piping Connections: Threaded or flanged, on same end.
2. Tubes:
   a. Material: Copper.
   b. Dimensions: 5/8" o.d. x.020" wall.
   c. Bends: 0.035" thick wall for all coil bends.
3. Fins: Aluminum with a thickness of.010" (0.25 mm).
6. Casings:
   a. Cooling coils: Stainless steel, 0.0625 inch.
   b. Heating Coils:
      1) Preheat coils shall have stainless steel, 0.0625 inch minimum thick.
      2) Reheat coils shall have galvanized-steel, 16 ga.
7. Ratings: Design tested and rated according to ASHRAE 33 and ARI 410.
   a. Working-Pressure Ratings: 200 psig, 325 deg F.
8. Source Quality Control: Test to 300 psig.

2.7 REFRIGERANT CIRCUIT COMPONENTS FOR DX SYSTEMS

A. Minimum Number of Refrigerant Circuits: 2.

B. Compressor: Hermetic, scroll, mounted on vibration isolators; with internal overcurrent and high-temperature protection, internal pressure relief, and crankcase heater.

1. Tip seals to provide efficient axial sealing while preventing scroll tip to base contact.
2. Controlled Orbit Design for radial sealing to incorporate minimum flank to flank contact for long service life.
3. Refrigerant flow through the compressor with 100% suction cooled motor.
4. Large suction side free volume and oil sump to provide liquid handling capability.
5. Annular discharge check valve and reverse vent assembly to provide low pressure drop, silent shutdown and reverse rotation protection.
6. Initial Oil charge.
7. Oil Level sight glass.
8. Vibration isolator mounts for compressors.

C. Refrigeration Specialties:

1. Refrigerant Charge: R-407C, R-410A, or equivalent.
2. Expansion valve with replaceable thermostatic element.
3. Refrigerant filter/dryer.
5. Automatic-reset low-pressure safety switch.
8. Brass service valves installed in compressor suction and liquid lines.
9. Hot-gas bypass solenoid valve with a replaceable magnetic coil.
   a. Bypass shall permit stable operation at capacities below minimum compressor unloading to 5% capacity.
   b. Hot-gas bypass shall be installed on a minimum of two circuits per condenser assembly.
10. Four-way reversing valve with a replaceable magnetic coil, thermostatic expansion valves with bypass check valves, and a suction line accumulator.
13. Hail guards of galvanized steel, painted to match casing.

2.8 DAMPERS

A. Description: Double-skin, airfoil-blade aluminum or galvanized-steel dampers with compressible jamb seals and extruded-vinyl blade edge seals, in opposed parallel-blade arrangement with steel operating rods rotating in either stainless-steel sleeve or sintered bronze with nylon bearings mounted in a single galvanized-steel frame, and with operating rods connected with a common linkage. Leakage rate shall not exceed 5 cfm/sq. ft. at 1-inch wg and 9 cfm/sq. ft. at 4-inch wg.

B. Performance: Leakage rate, according to AMCA 500, "Laboratory Methods for Testing Dampers for Rating," shall not exceed 2 percent of air quantity at 2000-fpm face velocity through damper and 4-inch wg pressure differential.

C. Damper Operators: Electric specified in Division 23 Section "Instrumentation and Control for HVAC."
2.9 FILTER SECTION

A. Filter Section: Provide filter holding frames arranged for flat or angular orientation, with access doors. Pre- and final filters shall be face loading.


C. Filter Gage: Each Filter bank shall be furnished with magnehelic air filter gauge per Division 23 “HVAC Air Cleaning Devices” and “Instrumentation and Control for HVAC”.

D. Quality Assurance: Comply with NFPA 90A or 90B as required.

2.10 ELECTRICAL

A. The electrical connections for all electrical components in each unit shall be wired by the AHU manufacturer to the exterior of the unit for field connection.

B. Provide disconnect at each motor internal to the unit.

C. Marine Lights

1. Marine lights shall be provided throughout AHUs, but no less than one per section with an access door.
2. Lights shall be compact fluorescent type to minimize amperage draw and shall produce lumens equivalent to a minimum 64 W, instant-start bulb.
3. Lights shall be constructed of safety glass and shall be suitable for wet locations.

D. Marine Light Switches

1. All lights on a unit shall be wired in the factory to a single on-off switch with an integral timer adjustable for up to forty five minutes.
2. Lighting circuit(s) shall be wired by the AHU Manufacturer to a common junction box separate from the VFD or starter so the lights can remain on when the main disconnect to the unit is on or off.

E. Convenience Outlet

1. Manufacturer shall provide at least one duplex 120-V convenience outlet per fan section.
2. Outlets shall be wired by AHU Manufacturer to a common junction box separate from VFD or starter so the outlet can remain on when the main disconnect to the unit is on or off.

F. Ratings

1. Short-Circuit Current: Match rating of overcurrent protective device serving the equipment assembly.
PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions for compliance with requirements for installation tolerances and other conditions affecting performance.

B. Examine roughing-in of steam, hydronic, and condensate drainage piping systems and electrical services to verify actual locations of connections before installation.

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

3.2 INSTALLATION

A. Concrete Bases: Install floor mounted units on 6-inch-high concrete bases. See Division 23 Section "Common Work Results for HVAC" for concrete base materials and fabrication requirements.

B. Vibration and seismic-control devices are specified in Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment."


C. Arrange installation of units to provide access space around custom air-handling units for service and maintenance.

D. Install temperature sensor on the leaving side of all cooling and heating coils in AHUs.

3.3 CONNECTIONS

A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

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

C. Condensate Piping: Comply with applicable requirements in Division 23 Section "Hydronic Piping." Connect condensate drain pans and extend to nearest equipment or floor drain. Construct deep trap at connection to drain pan and install cleanouts at changes in direction.

D. Hydronic Piping: Comply with applicable requirements in Division 23 Section "Hydronic Piping."

E. Refrigerant Piping: Final connections to all refrigerant piping shall be by manufacturer’s trained personnel and according to the manufacturer’s direction.
F. Duct installation and connection requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connections.

G. Electrical: Comply with applicable requirements in Division 26 Sections for power wiring, switches, and motor controls.

H. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

I. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

3.4 FIELD QUALITY CONTROL

A. Do not operate unit without all filters in place.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect field-assembled components and equipment installation, including piping and electrical connections. Report results in writing.

1. Leak Test: After installation, fill water and steam coils with water and test coils and connections for leaks. Repair leaks and retest until no leaks exist.

2. Fan Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation. Remove malfunctioning units, replace with new units, and retest.

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

3.5 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

B. Final Checks before Startup: Perform the following:

1. Verify that shipping, blocking, and bracing are removed.

2. Verify that unit is secure on mountings and supporting devices and that connections to piping, ducts, and electrical systems are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.

3. Perform cleaning and adjusting specified in this Section.

4. Disconnect fan drive from motor, verify proper motor rotation direction, and verify free fan wheel rotation and smooth bearing operations. Reconnect fan drive system, align belts, and install belt guards.

5. Lubricate bearings, pulleys, belts, and other moving parts with factory-recommended lubricants.

6. Set outside- and return-air mixing dampers to minimum outside-air setting.

7. Comb coil fins for parallel orientation.

8. Install clean filters.
9. Verify that manual and automatic volume control and fire and smoke dampers in connected duct systems are in fully open position.

C. Starting procedures for custom air-handling units include the following:

1. Energize motor; verify proper operation of motor, drive system, and fan wheel. Adjust fan to indicated rpm. Replace fan and/or motor pulleys as required to achieve design conditions.
2. Measure and record motor electrical values for voltage and amperage.
3. Manually operate dampers from fully closed to fully open position and record fan performance.

D. Refer to Division 23 Section "Testing, Adjusting, and Balancing for HVAC" for custom air-handling system testing, adjusting, and balancing.

3.6 ADJUSTING

A. Adjust damper linkages for proper damper operation.

3.7 CLEANING

A. Clean custom air-handling units internally, on completion of installation, according to manufacturer's written instructions. Clean fan interiors to remove foreign material and construction dirt and dust. Vacuum clean fan wheels, cabinets, and coils entering air face.

B. After completing system installation and testing, adjusting, and balancing custom air-handling and air-distribution systems, clean filter housings and install new filters.

3.8 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain custom air-handling units. Refer to Division 01 Section "Demonstration and Training."

END OF SECTION
SECTION 237513

CUSTOM PACKAGED OUTDOOR CENTRAL-STATION AHU’S

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes custom and variable aspect ratio air-handling units with coils for outdoor installations.

B. Related Sections include the following:
   1. Division 23 Section "Hydronic Piping" for chilled, heating, and condensate piping.
   2. Division 23 Section "Instrumentation and Control for HVAC" for controls components.
   3. Division 23 "HVAC Air Cleaning Devices” for performance of filters.
   4. Division 23 Section "Refrigerant Piping" for DX piping within equipment.
   5. Division 26 “Variable Frequency Drives” for VFDs.
   6. Division 23 Section "Vibration Isolation” for seismic criteria and restraint performance.

1.2 SITE PERFORMANCE REQUIREMENTS

A. Wind-Restraint Performance: AHUs shall withstand the effects of wind determined according to ASCE 7. AHUs shall remain intact and operational after a wind event.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of custom air-handling unit indicated. Include the following:
   1. Dimensional drawings by unit section, including plan and elevation views.
   2. Certified fan-performance curves with system operating conditions indicated.
   3. Certified fan-sound power ratings.
   4. Certified coil-performance ratings with system operating conditions indicated.
   5. Curbs as provided by manufacturer.
   6. Dampers, including housings, linkages, and operators.
   7. Filters with performance characteristics.
   8. Motor ratings, electrical characteristics, and motor and fan accessories.
   10. Sound attenuators integral to units.
   12. Weights by section, total unit, and anticipate operating weights.

B. Shop Drawings: Signed and sealed by a qualified professional engineer.
1. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.

2. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include auxiliary motor slides and rails, and base weights.


4. Short-circuit current rating of equipment assembly.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Submit with Shop Drawings. Show mechanical-room layout and relationships between components and adjacent structural and mechanical elements. Show support locations, type of support, and weight on each support. Indicate and certify field measurements.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For each unit to include in emergency, operation, and maintenance manuals.

1.6 QUALITY ASSURANCE

A. Source Limitations: Obtain custom air-handling units through one source from a single manufacturer.

B. Product Options: Drawings indicate size, profiles, and dimensional requirements of custom air-handling units and are based on the specific system indicated. Refer to Division 01 Section "Product Requirements."

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

D. NFPA Compliance: Custom air-handling units and components shall be in compliance with NFPA 70 and 90A.

E. ARI Certification: Custom air-handling units and their components shall be factory tested according to ARI 430, "Central-Station Air-Handling Units," and shall be listed and labeled by ARI.

F. AHU Factory Testing

1. Units with cabinet mounted fans shall be tested and certified at rated conditions using AMCA 210 and AMCA 300 procedures with fan mounted in the cabinet. Bare fan data will not be accepted. All, Testing shall be documented and signed by an officer in the company and sent to the Engineer owner's representative.

2. Unit shall be tested for casing leakage by sealing all openings and pressurizing to 10" wg. Maximum allowable leakage rate is 1% of rated unit flow. Test is to be performed by the manufacturer using flow measurement.
devices and shall be witnessed by the Engineer and the Owner's authorized witnesses. Deflection limit of L/200 will also be demonstrated at this time and fan/motor vibration limits will be confirmed.

3. Failure of the leakage and or/ deflection test shall require sealing and bracing of the unit and retesting until criteria is met. Furthermore, failure of the trim balance to confirm vibration limit shall require rebalancing and re-testing until criteria is met. AHU Manufacturer shall bear all costs involved in the modifications, balancing, and re-testing, including travel and hourly costs associated with the Owner's authorized witnesses.

1.7 COORDINATION

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

B. Coordinate installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Division 07 Section "Roof Accessories."

C. Coordinate size and location of structural-steel support members.

1.8 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to replace components of units that fail in materials or workmanship within specified warranty period.

1. Warranty Period for Compressors: Manufacturer's standard, but not less than five years from date of Substantial Completion.
2. Warranty Period for Gas Furnace Heat Exchangers: Manufacturer's standard, but not less than five years from date of Substantial Completion.
3. Warranty Period for Solid-State Ignition Modules: Manufacturer's standard, but not less than three years from date of Substantial Completion.
4. Warranty Period for Control Boards: Manufacturer's standard, but not less than three years from date of Substantial Completion.
5. OEM shall provide quarterly, annual, and bi-annual maintenance in compliance with or exceeding ASHRAE Standard 180-2008.
6. Complete Warranty: Provide one a five year warranty to include both parts and labor. Warranty shall cover the entire unit and factory accessories, including the following:

1. Compressors
2. Coils
3. Dampers and damper actuators
4. Fans
5. Motors
6. Motor starters
7. VFDs
8. Heat exchangers
9. Condenser fans
10. Control panel
1.9 EXTRA MATERIALS

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

1. Filters: Two sets for each custom air-handling unit.
2. Fan Belts: Two sets for each custom air-handling unit fan.
3. Gaskets: One set for each access door.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

1. CES Group Inc.; Governair, Hunt, Mammoth, Temtrol.
2. ClimateCraft.
3. Daikin.
4. Energy Labs.
5. Engineered Air.
6. Haakon.
7. YORK, a Johnson Controls company.
8. Trane.

2.2 GENERAL

A. Custom air-handling units shall be factory assembled and consist of fans, motor and drive assembly, coils, damper, plenums, filters, condensate pans, air blenders, mixing dampers, control devices, silencers, and other accessories, sections, or components.

B. Provide protection for all openings and components during equipment transport. Externally mounted components shall be protected during all phases of transport from exposure, including moisture and ambient temperatures outside of any component’s operating range. Externally mounted components include, but are not limited to, VFD’s, actuators, sensors, and weather hoods.

2.3 UNIT CONSTRUCTION

A. Casing Performance

1. Unit air leakage shall not exceed 1.0% of design cfm at maximum 8” w.g. operating. Leakage shall be calculated by totaling all leakage either in to or out of the unit.
2. Casing deflection shall not exceed L/200 at 8” w.g., where L is defined as the panel span.

B. Insulation: units shall have a minimum effective insulating value of R-13.

Bases & Floors
1. Base shall be constructed from clear-coated galvanized steel channels around the perimeter and minimum 10-gage clear-coated galvanized steel cross members.
2. Each shipping section shall be provided with removable lifting lugs. Structural framework shall fully support the unit casing and all components during installation such that no section deflects more than L/1000 during rigging of that section, where L is defined as the distance between lifting lugs.
3. Floor shall be double wall constructed from smooth galvanized steel. The floor surface and all spaces and joints shall be completely sealed with dams around all bottom penetrations. Floor deflection shall not exceed L/200 under a point load of 500 pounds, where L is defined as the floor span.
4. Foam insulation shall be provided underneath the entire unit floor. Insulation shall completely fill the panel cavity in all directions so that no voids exist. Base assemblies shall comply with NFPA 90A or 90B.

C. Walls

1. Wall assemblies shall be double-wall construction with galvanized steel solid exterior and galvanized steel interior. All spaces and joints of wall assemblies shall be completely sealed.
2. Insulation shall be provided throughout all unit wall assemblies. Insulation shall completely fill the panel cavity in all directions so that no voids exist and settling of insulation is prevented. Wall assemblies shall comply with NFPA 90A.
3. Removable walls, access panels, or doors shall be provided in all sections for service and removal of components.

D. Perforated Panel Sections

1. Double wall sections, identical in thermal and leakage performance described above shall be provided at the following locations:
   a. Intake plenums.
   b. Discharge plenums.
   c. Fan sections.

2. Insulation at perforated panels shall be separated from the air stream with a healthcare grade barrier similar to mylar.
3. In no case shall insulation fibers be exposed to the air stream, nor shall the insulation material or separation material ablate.

E. Access Doors

1. Access doors shall be provided at all sections.
2. Access doors shall be double wall construction. Interior and exterior door panels shall be of the same construction as the interior and exterior wall panels, respectively.
3. All doors shall have a complete thermal break from the panel that it is installed in.
4. Insulation shall be provided throughout all door assemblies. Insulation shall completely fill the panel cavity in all directions so that no voids exist and settling of insulation is prevented. Door assemblies shall comply with NFPA 90A.
5. All doors shall be a minimum of 60” high if sufficient height is available, or the maximum height allowed by the unit height and minimum 24” wide. All doors shall open against pressure to ensure an airtight seal and to prevent a safety hazard.

6. Door hinges shall be 304 stainless steel continuous type. All handles shall fasten against the door frame with a roller cam to eliminate wear of the door frame.

7. Windows shall be provided in all section doors. Windows shall be mounted in a metal frame and shall be a minimum of 8” x 8”, with safety glass. Windows shall be thermal, double-pane type.

F. Roofs

1. Roof assemblies shall be double wall construction. Exterior roof panels and interior ceiling panels shall be of the same construction as the exterior and interior wall panels, respectively. Sections in units with perforated interior wall liners shall have perforated interior ceiling liners. All spaces and joints of roof assemblies shall be completely sealed. In addition to meeting the casing deflection limits contained herein, roof deflection shall not exceed L/200 under a point load of 200 pounds, where L is defined as the roof panel span.

2. Insulation shall be provided throughout all roof assemblies. Insulation shall completely fill the panel cavity in all directions so that no voids exist. Roof assemblies shall comply with NFPA 90A.

G. Unit Paint

1. External surfaces of all unit casings shall be prepared and painted resulting in a minimum 1.5 mil thick coating when dry.

2. Paint shall be able to withstand a salt spray test in accordance with ASTM B117 for a minimum of 500 consecutive hours.

3. Paint shall be AHU Manufacturer’s standard color, unless otherwise indicated.

4. For units requiring a color other than the AHU Manufacturer’s standard color, the Architect shall provide a quantity of four 2” x 2” paint samples to the AHU Manufacturer at the time of submittal approval.

H. Condensate Drain Pans: Formed sections of stainless-steel sheet complying with requirements in ASHRAE 62. Fabricate pans with slopes in two planes to collect condensate from cooling coils (including coil piping connections and return bends) and humidifiers.

1. Fill space between walls with foam insulation and seal moisture tight.

2. Drain Connections: Threaded nipple on both ends of pan.

3. Units with stacked coils shall have an intermediate drain pan or drain trough to collect condensate from top coil.

4. Extend pan minimum 30 inches beyond face of cooling coil.

2.4 FAN SECTION

A. Fan-Section Construction:
1. Centrifugal fans consisting of housing, wheel, fan shaft, bearings, motor and disconnect switch, drive assembly, and support structure and equipped with formed-steel channel base for integral mounting of fan, motor, and casing panels.
2. Provide access door or removable panel for fan access.
3. Mount fan with vibration isolation.
4. Performance Class: AMCA 99-2408, Class II or III.
5. No fan shall be selected greater than 85% of its construction class’ maximum RPM.
6. Fan is to be IRD balanced at design RPM to a total displacement less than 1.5 mil measured at each bearing pad prior to shipment with belts and drives in place.
7. The fan drive is to be fixed QD type cast iron sheave rated a minimum of 150 percent of motor nameplate horsepower.

B. Centrifugal Fan Housings: Formed- and reinforced-steel panels to make curved scroll housings with shaped cutoff, spun-metal inlet bell, and access doors or panels to allow entry to internal parts and components.
1. Panel Bracing: Steel angle- or channel-iron member supports for mounting and supporting fan scroll, wheel, motor, and accessories.
2. Horizontal Flanged Split Housing: Bolted construction.

C. Fan Wheels:
1. Backward-Inclined: Steel construction with curved inlet flange, backplate, and backward-inclined blades.
2. Airfoil: Steel construction with smooth-curved inlet flange, heavy backplate, and hollow die-formed airfoil-shaped blades continuously welded at tip flange and backplate; cast-iron or cast-steel hub riveted to backplate and fastened to shaft with set screws.

D. Shafts: Statically and dynamically balanced and designed for continuous operation at maximum rated fan speed and motor horsepower, with final alignment and belt adjustment made after installation.
1. Turned, ground, and polished hot-rolled steel with keyway. Ship with a protective coating of lubricating oil.
2. Designed to operate at no more than 70 percent of first critical speed at top of fan's speed range.

E. Bearings:
2. Bearing Rating Life:
   a. Ball-Bearings: ABMA 9, L10 at 200,000.
   b. Roller-Bearings: ABMA 11, L10 at 200,000.
F. Direct Drives: Factory mounted, with final alignment and belt adjustment made after installation and with 1.5 service factor based on fan motor. Shafts and bearings shall be compliant with performance described above.

G. Fan Assemblies: Statically and dynamically balanced and designed for continuous operation at maximum rated fan speed and motor horsepower.

H. Vibration Control: Install fans on open-spring vibration isolators having a minimum of 2-inch static deflection and side snubbers.

I. Fan-Section Source Quality Control:
   2. Factory test fan performance for flow rate, pressure, power, air density, rotation speed, and efficiency. Establish ratings according to AMCA 210, "Laboratory Methods of Testing Fans for Rating."

J. Fan Arrays: For fan sections where 2 or more fans serve a single air stream or unit section, each individual fan shall comply with all parts of this section and the following.
   1. Each fan shall be independently driven.
   2. All fans shall be factory wired to a single enclosure.
   3. For VAV services, the factory supplied enclosure shall:
      a. Include at least two VFD’s, with automatic change-over for drive failure, for controlling and monitoring fan speed.
      b. Fans shall either modulate speed, or stage individual fans on/off to achieve balanced airflow through the fan array and meet scheduled performance.
      c. Provide contacts in a common terminal strip to monitor all fans.
   4. In the event of the failure of any single fan the remaining fans shall be able to supply to design CFM and ESP as scheduled.
   5. Provide motorized damper to isolate each individual fan from array upon fan or motor failure. Isolation damper shall prevent bypass air through the fan array.

2.5 MOTORS

A. General: Comply with requirements in Division 23 Section "Common Motor Requirements for HVAC Equipment."

B. Noise Rating: Quiet.
2.6 COILS

A. Coil Sections: Common or individual, insulated casings for heating and cooling coils. Design and construct to facilitate removal and replacement of coil, for maintenance, and to ensure full airflow through coils.

B. Hydronic Coils: Continuous circuit coil fabricated according to ARI 410.
   1. Piping Connections: Threaded or flanged, on same end.
   2. Tubes:
      a. Material: Copper.
      b. Dimensions: 5/8" o.d. x.020" wall.
      c. Bends: 0.035” thick wall for all coil bends.
   3. Fins: Aluminum with a thickness of.008" (0.20 mm).
   6. Casings:
      a. Cooling coils: Stainless steel, 0.0625 inch.
      b. Heating Coils:
         1) Preheat coils shall have stainless steel, 0.0625 inch minimum thick.
         2) Reheat coils shall have galvanized-steel, 16 ga.
   7. Ratings: Design tested and rated according to ASHRAE 33 and ARI 410.
      a. Working-Pressure Ratings: 200 psig, 325 deg F.
   8. Source Quality Control: Test to 300 psig.

C. DX Coils:
   1. General: Common or individual, insulated, galvanized-steel casings for cooling coils. Design and construct to facilitate removal and replacement of coil for maintenance and to ensure full airflow through coils.
   2. Supply-Air Refrigerant Coil:
      a. Copper-plate fin and seamless copper tube in steel casing with equalizing-type vertical distributor.
      b. Polymer strip shall prevent all copper coil from contacting steel coil frame or condensate pan.
      c. Coil Split: Each coil shall be no longer than half of the AHU’s width to minimize service aisle for coil removal.
      d. Baked phenolic or cathodic epoxy coating.
      e. Refrigeration Circuits: Each refrigeration circuit shall interlace each coil equally.
2.7 REFRIGERANT CIRCUIT COMPONENTS FOR DX SYSTEMS

A. Minimum Number of Refrigerant Circuits: 2.

B. Compressor: Hermetic, scroll, mounted on vibration isolators; with internal overcurrent and high-temperature protection, internal pressure relief, and crankcase heater.

1. Tip seals to provide efficient axial sealing while preventing scroll tip to base contact.
2. Controlled Orbit Design for radial sealing to incorporate minimum flank to flank contact for long service life.
3. Refrigerant flow through the compressor with 100% suction cooled motor.
4. Large suction side free volume and oil sump to provide liquid handling capability.
5. Annular discharge check valve and reverse vent assembly to provide low pressure drop, silent shutdown and reverse rotation protection.
6. Initial Oil charge.
7. Oil Level sight glass.
8. Vibration isolator mounts for compressors.

C. Refrigeration Specialties:

1. Refrigerant Charge: R-407C, R-410A, or equivalent.
2. Expansion valve with replaceable thermostatic element.
3. Refrigerant filter/dryer.
5. Automatic-reset low-pressure safety switch.
8. Brass service valves installed in compressor suction and liquid lines.
9. Hot-gas bypass solenoid valve with a replaceable magnetic coil.
   a. Bypass shall permit stable operation at capacities below minimum compressor unloading to 5% capacity.
   b. Hot-gas bypass shall be installed on a minimum of two circuits per condenser assembly.

10. Four-way reversing valve with a replaceable magnetic coil, thermostatic expansion valves with bypass check valves, and a suction line accumulator.
13. Hail guards of galvanized steel, painted to match casing.

2.8 DAMPERS

A. Description: Double-skin, airfoil-blade aluminum or galvanized-steel dampers with compressible jamb seals and extruded-vinyl blade edge seals, in opposed parallel-blade arrangement with steel operating rods rotating in either stainless-steel sleeve or sintered bronze with nylon bearings mounted in a single galvanized-steel frame,
and with operating rods connected with a common linkage. Leakage rate shall not exceed 5 cfm/sq. ft. at 1-inch wg and 9 cfm/sq. ft. at 4-inch wg.

B. Performance: Leakage rate, according to AMCA 500, "Laboratory Methods for Testing Dampers for Rating," shall not exceed 2 percent of air quantity at 2000-fpm face velocity through damper and 4-inch wg pressure differential.

C. Damper Operators: Electric specified in Division 2315 Section "Instrumentation and Control for HVAC."

2.9 FILTER SECTION

A. Filter Section: Provide filter holding frames arranged for flat or angular orientation, with access doors. Pre- and final filters shall be face loading.

B. Filtration: Provide as scheduled. Refer to Division 23, "HVAC Air Cleaning Devices," for filtration system performance.

C. Filter Gage: Each Filter bank shall be furnished with magnehelic air filter gauge per Division 23 "HVAC Air Cleaning Devices" and "Instrumentation and Control for HVAC."

D. Quality Assurance: Comply with NFPA 90A or 90B as required.

2.10 ELECTRICAL

A. The electrical connections for all electrical components in each unit shall be wired by the AHU manufacturer to the exterior of the unit for field connection.

B. Provide disconnect at each motor internal to the unit.

C. Marine Lights

   1. Marine lights shall be provided throughout AHUs, but no less than one per section with an access door.
   2. Lights shall be compact fluorescent type to minimize amperage draw and shall produce lumens equivalent to a minimum 64 W, instant-start bulb.
   3. Lights shall be constructed of safety glass and shall be suitable for wet locations.

D. Marine Light Switches

   1. All lights on a unit shall be wired in the factory to a single on-off switch with an integral timer adjustable for up to forty five minutes.
   2. Lighting circuit(s) shall be wired by the AHU Manufacturer to a common junction box separate from the VFD or starter so the lights can remain on when the main disconnect to the unit is on or off.

E. Convenience Outlet
1. Manufacturer shall provide at least one duplex 120-V convenience outlet per fan section.
2. Outlets shall be wired by AHU Manufacturer to a common junction box separate from VFD or starter so the outlet can remain on when the main disconnect to the unit is on or off.

F. Ratings

1. Short-Circuit Current: Match rating of overcurrent protective device serving the equipment assembly.

2.11 ACCESSORIES

A. In addition to the above, units shall also include the following:

1. Unit roofs shall incorporate a standing seam on the exterior to ensure a rigid roof construction and shall be sloped, not less than 1/8” per foot for water drainage. Where outdoor units are shipped in multiple sections, provide standing-seam joiners at each split with adhesive, hardware, and cover strips for field joining by the installing contactor. On outdoor units, rain gutters shall be provided over all doors to direct rain away from the door assembly.

2. On outdoor units, the light switch shall be mounted inside the service aisle or on the casing exterior in a NEMA 4 enclosure next to the fan access door.

3. The bottom of outside air intakes shall be minimum 3'-0” above finished roof.

4. Roof Curbs:
   a. Roof curbs with vibration isolators and wind or seismic restraints are specified in Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment."
   b. Materials: Galvanized steel with corrosion-protection coating, watertight gaskets, and factory-installed wood nailer; complying with NRCA standards.

1) Curb Insulation and Adhesive: Comply with NFPA 90A or NFPA 90B.
   a) Materials: ASTM C 1071, Type I or II.
   b) Thickness: Insulation performance shall be identical to roof performance.

2) Application: Factory applied with adhesive and mechanical fasteners to the internal surface of curb.
   a) Liner Adhesive: Comply with ASTM C 916, Type I.
   b) 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 cabinet.
c) Liner materials applied in this location shall have air-stream surface coated with a temperature-resistant coating or faced with a plain or coated fibrous mat or fabric depending on service air velocity.

d) Liner Adhesive: Comply with ASTM C 916, Type I.

c. Curb Height: Minimum 12 inches and accounting for roof slope to keep unit plumb and level. Coordinate with Division 07.
d. Wind and Seismic Restraints: Metal brackets compatible with the curb and casing, painted to match RTU, used to anchor unit to the curb, and designed for loads at Project site. Comply with requirements in Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment" for wind-load requirements.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions for compliance with requirements for installation tolerances and other conditions affecting performance.

B. Examine roughing-in of steam, hydronic, and condensate drainage piping systems and electrical services to verify actual locations of connections before installation.

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

3.2 INSTALLATION

A. Concrete Bases: Install floor mounted units on 6-inch-high concrete bases. See Division 23 Section "Common Work Results for HVAC" for concrete base materials and fabrication requirements.

B. Vibration and seismic-control devices are specified in Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment."

1. Support on concrete bases using neoprene pads or manufacturer provided curbs. Secure units to anchor bolts installed in concrete bases.

C. Arrange installation of units to provide access space around custom air-handling units for service and maintenance.

D. Install temperature sensor on the leaving side of all cooling and heating coils in AHUs.

3.3 CONNECTIONS

A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
B. Install piping adjacent to equipment to allow service and maintenance.

C. Condensate Piping: Comply with applicable requirements in Division 23 Section "Hydronic Piping." Connect condensate drain pans and extend to nearest equipment or floor drain. Construct deep trap at connection to drain pan and install cleanouts at changes in direction.

D. Hydronic Piping: Comply with applicable requirements in Division 23 Section "Hydronic Piping."

E. Refrigerant Piping: Final connections to all refrigerant piping shall be by manufacturer’s trained personnel and according to the manufacturer’s direction.

F. Duct installation and connection requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connections.

G. Electrical: Comply with applicable requirements in Division 26 Sections for power wiring, switches, and motor controls.

H. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

I. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer’s torque values are not indicated, use those specified in UL 486A and UL 486B.

3.4 FIELD QUALITY CONTROL

A. Do not operate unit without all filters in place.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect field-assembled components and equipment installation, including piping and electrical connections. Report results in writing.

1. Leak Test: After installation, fill water and steam coils with water and test coils and connections for leaks. Repair leaks and retest until no leaks exist.
2. Fan Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation. Remove malfunctioning units, replace with new units, and retest.
3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

3.5 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

B. Final Checks before Startup: Perform the following:

1. Verify that shipping, blocking, and bracing are removed.
2. Verify that unit is secure on mountings and supporting devices and that connections to piping, ducts, and electrical systems are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.
3. Perform cleaning and adjusting specified in this Section.
4. Disconnect fan drive from motor, verify proper motor rotation direction, and verify free fan wheel rotation and smooth bearing operations. Reconnect fan drive system, align belts, and install belt guards.
5. Lubricate bearings, pulleys, belts, and other moving parts with factory-recommended lubricants.
6. Set outside- and return-air mixing dampers to minimum outside-air setting.
7. Comb coil fins for parallel orientation.
8. Install clean filters.
9. Verify that manual and automatic volume control and fire and smoke dampers in connected duct systems are in fully open position.

C. Starting procedures for custom air-handling units include the following:
1. Energize motor; verify proper operation of motor, drive system, and fan wheel. Adjust fan to indicated rpm. Replace fan and/or motor pulleys as required to achieve design conditions.
2. Measure and record motor electrical values for voltage and amperage.
3. Manually operate dampers from fully closed to fully open position and record fan performance.

D. Refer to Division 23 Section "Testing, Adjusting, and Balancing for HVAC" for custom air-handling system testing, adjusting, and balancing.

3.6 ADJUSTING
A. Adjust damper linkages for proper damper operation.

3.7 CLEANING
A. Clean custom air-handling units internally, on completion of installation, according to manufacturer's written instructions. Clean fan interiors to remove foreign material and construction dirt and dust. Vacuum clean fan wheels, cabinets, and coils entering air face.
B. After completing system installation and testing, adjusting, and balancing custom air-handling and air-distribution systems, clean filter housings and install new filters.

3.8 DEMONSTRATION
A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain custom air-handling units. Refer to Division 01 Section "Demonstration and Training."