SECTION 23 21 13
HYDRONIC PIPING

PART 1 – GENERAL

1.01 WORK INCLUDED

A. The work of this Section shall include, but is not limited to, the following:

1. Piping
2. Fittings
3. Jointing Materials
4. Unions and Couplings
5. Mechanically Coupled Pipe
6. Heat Tracing
7. Welding and Jointing Procedures
8. Cleaning of Piping Systems
9. Testing of Piping Systems

1.02 RELATED DOCUMENTS

A. Section 23 05 01 – HVAC General Provisions

B. Section 23 05 16 – Expansion Fittings and Loops for HVAC Piping

C. Section 23 05 23 – General-Duty Valves for HVAC Piping

D. Section 23 05 29 – Hangers and Supports for HVAC

E. Section 23 05 48 – Vibration and Seismic Controls for HVAC

F. Section 23 07 00 – Insulation for HVAC

G. Section 23 25 00 – HVAC Water Treatment

H. Section 23 82 16 – Air Coils

1.03 REFERENCE STANDARDS

Published specifications standards, tests or recommended methods of trade, industry or governmental organizations apply to work in this Section where cited below:

A. ASME/ANSI – American Society of Mechanical Engineers/American National Standards Institute

1. ASME/ANSI B16.9 Factory-Made Wrought Steel Buttwelding Fittings
2. ANSI/ASME B31.1 Power Piping

B. AHRI – Air Conditioning and Refrigeration Institute

C. ASHRAE – American Society of Heating, Refrigeration, and Air Conditioning Engineers

D. ASME – American Society of Mechanical Engineers

1. Standard for Boiler and Pressure Vessel Code – Section VIII, Division 1
2. Standard for Boiler and Pressure Vessel Code – Section IX
3. ASME B1.20.1 Pipe Threads, General Purpose (Inch)
4. ASME B16.1 Gray Iron Pipe Flanges and Flanged Fittings Classes 25, 125, and 250
5. ASME B16.3 Malleable Iron Threaded Fittings Classes 150 and 300
6. ASME B16.4 Gray Iron Threaded Fittings Classes 125 and 250
7. ASME B16.5 Pipe Flanges and Flanged Fittings NPS 1/2 through NPS 24 Metric/Inch Standard
8. ASME B16.15 Cast Copper Alloy Threaded Fittings Classes 125 and 250
9. ASME B16.18 Cast Copper Alloy Solder Joint Pressure Fittings
10. ASME B16.21 Nonmetallic Flat Gaskets for Pipe Flanges
11. ASME B16.22 Wrought Copper and Copper Alloy Solder-Joint Pressure Fittings
12. ASME B16.24 Cast Copper Alloy Pipe Flanges, Flanged Fittings, and Valves Classes 150, 300, 600, 900, 1500, and 2500
13. ASME B16.26 Cast Copper Alloy Fittings for Flared Copper Tubes
14. ASME B18.2.1 Square, Hex, Heavy Hex, and Askew Head Bolts and Hex, Heavy Hex, Hex Flange, Lobed Head, and Lag Screws (Inch Series)

E. ASTM – American Society for Testing and Materials

1. ASTM A47/A47M-99(2014) Standard Specification for Ferritic Malleable Iron Castings
2. ASTM A53/A53M-12 Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
3. ASTM A105/A105M-14 Standard Specification for Carbon Steel Forgings for Piping Applications
4. ASTM A106/A106M-15 Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service
5. ASTM A120-84 Specification for Pipe, Steel, Black and Hot-Dipped Zinc-Coated (Galvanized) Welded and Seamless for Ordinary Uses
6. ASTM A153/A153M-16a Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
7. ASTM A181/A181M-14 Standard Specification for Carbon Steel Forgings, for General-Purpose Piping
8. ASTM A182/A182M-17 Standard Specification for Forged or Rolled Alloy and Stainless Steel Pipe Flanges, Forged Fittings, and Valves and Parts for High-Temperature Service
9. ASTM A183-14 Standard Specification for Carbon Steel Track Bolts and Nuts
10. ASTM A312/A312M-17 Standard Specification for Seamless, Welded and Heavily Cold Worked Austenitic Steel Pipes
11. ASTM A376/A376M-17 Standard Specification for Seamless Austenitic Steel Pipe for High-Temperature Service
12. ASTM A403/A403M-16 Standard Specification for Wrought Austenitic Stainless Steel Piping Fittings
13. ASTM A536-84(2014) Standard Specification for Ductile Iron Castings
14. ASTM A674-10(2014) Standard Practice for Polyethylene Encasement for Ductile Iron for Water or Other Liquids

15.	ASTM B32-08(2014)	Standard Specification for Solder Metal
16.	ASTM B43-15	Standard Specification for Seamless Red Brass Pipe, Standard Sizes
17.	ASTM B88-16	Standard Specification for Seamless Copper Water Tube
18.	ASTM B633-15	Standard Specification for Electrodeposited Coatings of Zinc on Iron and Steel
19.	ASTM B813-16	Standard Specification for Liquid and Paste Fluxes for Soldering of Copper and Copper Alloy Tube
20.	ASTM B828-16	Standard Practice for Making Capillary Joints by Soldering of Copper and Copper Alloy Tube and Fittings
21.	ASTM C591-17	Standard Specification for Unfaced Preformed Rigid Cellular Polyisocyanurate Thermal Insulation
22.	ASTM D638-14	Standard Test Method for Tensile Properties of Plastics
23.	ASTM D1330-04(215)e1	Standard Specification for Rubber Sheet Gaskets
24.	ASTM D1784-11	Standard Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds
25.	ASTM D1785-15	Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120
26.	ASTM D2464-15	Standard Specification for Threaded Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80
27.	ASTM D2466-17	Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40
28.	ASTM D2467-15	Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80
29.	ASTM D2609-15	Standard Specification for Plastic Insert Fittings for Polyethylene (PE) Plastic Pipe
30.	ASTM D2657-07(2015)	Standard Practice for Heat Fusion Joining of Polyolefin Pipe and Fittings
31.	ASTM D2846/D2846M-17a	Standard Specification for Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Hot- and Cold-Water Distribution Systems
32.	ASTM D3261-16	Standard Specification for Butt Heat Fusion Polyethylene (PE) Plastic Fittings for Polyethylene (PE) Plastic Pipe and Tubing
33.	ASTM F1290-98a(2011)	Standard Practice for Electrofusion Joining Polyeolefin Pipe and Fittings

F. AWS – American Welding Society

1.	AWS A5.8M/A5.8	Specification for Filler Metals for Brazing and Braze Welding
2.	AWS C3.4M/C3.4	Specification for Torch Brazing
3.	AWS D10.12M/D10.12	Guide for Welding Mild Steel Pipe

G. R. AWWA – American Water Works Association

1.	AWWA C104/A21.4-03	Cement-Mortar Lining for Ductile Iron Pipe and Fittings
2.	AWWA C105-10	Polyethylene Encasement for Ductile-Iron Pipe Systems

3.	AWWA C106/A21.6-80	Cast-Iron Pipe Centrifugally Cast in Metal Molds
4.	AWWA C111/A21.11-17	Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings
5.	AWWA C900-16	Polyvinyl Chloride (PVC) Pressure Pipe and Fabricated Fittings, 4 in. through 12 in. (100 mm through 300 mm), for Water Transmission and Distribution

H. ISO – International Organization for Standardization

1.	ISO 9001	Quality Management Systems

I. NFPA – National Fire Protection Association

1.	NFPA 70	National Electrical Code

J. UL – Underwriters Laboratories Inc.

1.	UL 719	Standard for Nonmetallic-Sheathed Cables
2.	UL 910	Standard for Safety Test for Flame-Propagation and Smoke-Density Values for Electrical and Optical-Fiber Cables Used in Spaces Transporting Environmental Air

1.04 QUALITY ASSURANCE

A. Comply with the applicable provisions and recommendations of the standards and codes listed in Paragraph 1.03 and the requirements of the listed related documents.

B. Welding materials and labor to conform to ASME Code and applicable state Labor Regulations.

C. All welders shall be certified by ANSI/ASME B31.1 “Power Piping” or “Qualification Tests” in Section IX of the ASME Boiler and Pressure Vessel Code: Welding and Brazing Qualifications.

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

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

F. Each length of pipe, fitting, trap, fixture or device used in any piping system shall be stamped or indelibly marked with type, weight, quality and manufacturer’s name or mark.

G. Leak detection systems shall comply with all codes having jurisdiction. The manufacturer shall guarantee the system for one year from the date the system is accepted by the Owner. Contractor shall replace all equipment found to be defective during this period.

1.05 SUBMITTALS

A. Submit the following for review:

1. Product Data: Submit manufacturer's latest information on construction details, rated capacity data, operating characteristics and installation data.

2. Submit, for all equipment provided under this Section, dimensions, accessories, required clearances, electrical requirements and wiring diagrams specific to this project that clearly differentiates between manufacturer-installed and field-installed wiring and location and size of all required field connections.
3. Submit manufacturer's installation instructions, operation data, start-up instructions, maintenance data, parts list and controls specific to this project, accessories and maintenance data.
4. Submit schedule indicating the ANSI, ASME, ASTM, AWWA Standard Specification number of the pipe being proposed along with its type and grade and sufficient information to indicate the type and rating of fittings for each service.
5. Submit ISO 9001 certifications where required by specifications.
6. Submit shop drawings indicating anchoring details, anchor points, guide details, etc.
7. Submit manufacturer's data for strainers and fittings.

    a. Grooved joint couplings and fittings shall be shown on the Drawings and product submittals, and shall be specifically identified with the applicable style or series designation.

8. Submit dimensioned drawings locating pipe penetrations through walls, slabs and other structural elements, anchor and guide locations, etc.
9. Submit pipe expansion and flexibility calculations.
10. Submit test reports on all systems tested. Tests required by Authorities Having Jurisdiction over the work shall be submitted on appropriate forms to the satisfaction of such authorities.

B. Heat Tracing: Equipment sizes, locations, performance data, installation details, wiring diagrams and controls. Manufacturer's latest published data for materials, equipment and installation.

PART 2 – PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Strainers:

1. Y-type and Basket: Mueller Hammond, Muessco, Spirax-Sarco, Bailey Div. of CMB Industries, Zurn Industries, Victaulic Company (all grooved end strainers)
2. Handwheel Operated Type: Hellan Fluid Strainer, Eaton, Yale-Towne
3. Tee Type Grooved End: Victaulic Company (all grooved end strainers)
4. Basket Type: Viking

B. Welding Fittings: Hackney, Bonney Forge Foundry, (Weld-o-lets), Weldbend

C. Mechanical Couplings and Fittings: Victaulic Company, Anvil International Gruvlok

D. Stainless Steel Pressed Fittings: Victaulic Company, Viega

E. Dielectric Fittings:

1. Unions: Watts, Perfection, Central Plastics, EPCO, Zurn, Hart
2. Insulating Flanges: Watts, Capital, Central Plastics, EPCO, Walter Vallett Co., V-Line
3. Flange Kits: Calpico, Central Plastics, Advanced Plastics
4. Couplings: Calpico, Lochinvar
5. Nipples: Perfection, Sioux Chief, Victaulic Company

F. Flange Gaskets: John Crane, Garlock, Manville, Goodrich

G. Pre-Insulated Pipe and Fittings: Ricwil, Rovanco

H. Heat Tracing: Raychem Type XL, Thermon Type FLX, Nelson Electric Type LT

I. Cleaning of Piping Systems: Use chemicals as recommended by the water treatment specialist engaged under Section 23 25 00: Water Treatment

J. Testing of Piping Systems: American Gas and Chemicals “Leak-Tee”, Cosgille Scientific “Sho Gas”, Flamort Chemical “Detect-A-Leak”, Highside Chemicals “Leak Finder Foam”

K. Plastic Pipe Fittings: J-M Ring Tight

2.02 SCHEDULE OF PIPING SYSTEMS

Service	**Material**	**Type**	**Weight**
Pumped condensate, boiler feed, steam	Steel	Black	Schedule 40
Hot water runouts (fan coils, VAV terminal units)	Copper	Type L	Hard
Chilled water, hot water heating (under 250 degrees F)*, diesel/fire pump engine exhaust safety relief valve discharge	Steel	Black	Schedule 40, 0.375-inch wall for 12-inch and larger
Chilled water, hot water heating (under 250 degrees F), safety relief valve discharge, equipment drains, and overflows	Stainless Steel	Type 304/304L	Schedule 10S
Hot water heating (under 250 degrees F), chilled water runouts	Copper	Type L	Hard
		Type K (buried)	Soft
Equipment drains and overflows, condensate drains, atmospheric vents, make-up water	Steel	Galvanized	Schedule 40
	Copper	Type L	Hard
Refrigerant	Copper	Type L	Hard, capped and nitrogen filled
Refer to specific Mechanical Division sections for services not listed above, e.g., domestic water – refer to Section 22 11 00 “Domestic Water Systems”.			
* *Maximum 230 degrees F for mechanical couplings on piping 10-inch and larger.*			

2.03 SCHEDULE OF PIPING FITTINGS

Service	**Size**	**Material**	**Type**	**Weight**
Chilled, heating hot water	Up to 2-inch	Cast iron	Threaded	250 pound
		Wrought copper	Solder	Standard
		Stainless Steel	Vic-Press™	200 psi CWP
	2½-inch to 10-inch	Steel	Welded, mechanical coupling	Standard

Service	Size	Material	Type	Weight
	12-inch and larger	Steel	Welded, mechanical coupling	Standard ASTM A53/ A53M, Grade B
Fan coil or terminal unit hot and chilled water runouts, coil condensate drains	All	Wrought copper	Solder	Standard
	Up to 2-inch	Stainless Steel	Vic-Press™	200 psi CWP
Drains, vent and relief	All	Steel, galvanized	Threaded	Standard
Diesel/fire pump engine exhaust pipe	All	Steel, black	Welded	Standard
Refrigerant	All	Wrought copper	Silver solder, copper-phosphorus alloy	Standard
Refer to specific Mechanical Division sections for services not listed above, e.g. domestic water – refer to Section 22 11 00 “Domestic Water Systems”.				

2.04 PRESSURE PIPING AND FITTINGS

A. Pressure piping shall conform to requirements of ANSI/ASME B31.1 Power Piping. Pressure ratings herein are steam, unless specifically designated as “WOG” (Water, Oil or Gas) or “WWP” (Water Working Pressure).

B. Black Steel, Threaded, 2 inches and smaller: Schedule 40, ASTM A120 or A53/A53M:

1. Cast iron banded fittings, ASME B16.4, 125-pound class.
2. Malleable iron, ASME B16.3, 150-pound class.

C. Black Steel, Welded, 2.5 inches and larger: Schedule 40, ASTM A53/A53M:

1. Steel welding-neck fittings, ANSI/ASME B16.9.
2. Steel welding-neck flanges and flanged fittings, ASME B16.5, 150-pound class.

D. Black Steel, Grooved End: ASTM A120 or A53/A53M:

1. Rolled groove – Schedule 10 to Schedule 40.
2. Machined groove – Schedule 40.
3. Fusion epoxy factory coating where indicated.
4. Fittings as herein after specified.

E. Galvanized Steel, Threaded: Schedule 40, ASTM A120 or ASTM A53/A53M:

1. Fittings: Where weld fittings or mechanical grooved fittings are used, use only long radius elbows having a centerline radius of 1.5 pipe diameters:

a. Threaded, galvanized malleable iron fittings and ground-joint unions, ASME B16.3, 150 pounds per square inch class, 2 inches and smaller.
b. Cast iron flanges and flanged fittings ASME B16.1 125 pounds per square inch class, at values and piping specialties 2.5 inches and larger.

F. Copper Tubing, ASTM B88:

1. Wrought copper, solder joint fittings, ASME B16.22, in sizes available with AWS A5.8/A5.8M or ASTM B32 filler metals per Article 2.4, C.
2. Cast bronze solder-joint fittings, ASME B16.18, only in sizes not available in wrought copper.
3. Cast bronze, threaded, ground-joint unions, ASME B16.18, 2 inches and smaller.
4. Cast bronze, flanged unions, ASME B16.24, 150 pounds per square inch class, 2.5 inches and larger.
5. Copper tubing flared fittings: Bronze castings for flared type joints, ASME B16.26.
6. Refrigerant piping shall be especially cleaned, dehydrated and capped by the piping manufacturer.

7. Grooved end copper fittings conforming to ASME B16.18 and ASME B16.22, and couplings conforming to ASTM A536. Copper tubing dimensioned. Flaring of tube or fitting ends is not permitted.

G. Brass:

1. Standard weight and red brass pipe, 85 percent copper, 15 percent zinc, ASTM B43.
2. 125 pounds per square inch threaded brass fittings, ASME B16.15.

H. Cast Iron, Mechanical – Joints:

1. AWWA C104/A21.4, AWWA C106/A21.6.
2. 150 pounds per square inch class.
3. Centrifugally cast, coated, cement lined.
4. Mechanical-joints, AWWA C111/A21.11.

I. Cast Iron, Flanged, AWWA C104/A21.4, AWWA C106/A21.6, 150 psi class:

1. Centrifugally cast, coated, cement lined.
2. Cast iron flanges and flanged fittings, ASME B16.1, 125 pounds per square inch class.
3. Flanges integrally cast for long straight pipe runs.
4. Flanges may be threaded in areas requiring many fittings. Where field joints require close dimensional tolerance for make-up length of piping.

J. Pre-Insulated Pipe and Fittings:

1. Insulation: Polyurethane foam with the following minimum characteristics:

   a. Thermal Conductivity (K) Factor: 0.14.
   b. Density: 2 pounds per cubic foot.
   c. Closed Cell Content: 90-95 percent in conformance with MIL-I-24172 and ASTM C591 completely filling the annular space between carrier pipe and jacketing. Minimum insulation thickness shall be in accordance with Table 1.

2. Jacketing Material: Provide 10-gauge black steel having all surfaces, both inside and outside, sandblasted to remove all foreign material, coated with an epoxy

resin primer, coated on the inside with a single epoxy finish coat of not less than 6 mils, coated on the outside with two or more epoxy resin coats and glass cloth to a total thickness of not less than 20 mils. Oven cure each epoxy layer. Jacketing material shall be large enough to allow expansion and contraction of the system without having the insulation touch the outer conduit.

3. Expansion Loops and Elbows: Expansion loops or expansion elbows shall be furnished and enclosed in the same type of jacketing as those furnished for the standard section of the piping system. They shall be of a size to permit the inner pipe or pipes to move without damage to the insulation material. Provide flexible polyurethane insulation for all expansion loops and the first section of straight pipe upstream and downstream. All expansion loops or expansion elbows shall be prefabricated and shipped to the job site in as few pieces as possible (manufacturer's recommendations to govern). All inner pipe loops and expansion bends shall be cold sprung in the field as required.
4. Weld fittings: All changes in direction shall be made with factory-fabricated and pre-insulated and jacketed welded fittings. Where tee branches are smaller than the mains they join, weld-o-lets may be used. All weld fittings shall be long radius with the same wall thickness as adjacent piping.
5. Anchors: Refer to Section 23 05 29 – Hangers and Supports for HVAC. Insulate anchor per manufacturer's recommendations. Provide prefabricated plate anchors using ⅜-inch thick steel plate welded to the carrier pipe and sealed to the outer jacket.

    a. End Seals: Terminal ends of conduits inside manholes, pit, or building walls shall be equipped with end seals as recommended by conduit manufacturer.
    b. Carrier Pipe: Provide Schedule 40 ASTM A53/A53M, Grade B, electric resistance welded black steel with beveled ends for field-welded joints.

K. Stainless Steel Piping:

1. 2-inch and smaller:

    a. ASTM A312 or A 376, Schedule 40, seamless stainless steel, Type 304 pipe with ASTM A182, Gr. F304, 3,000-pound socket-weld fittings.
    b. ASTM A312, Schedule 5S, precision, cold drawn, austenitic stainless steel with elastomer O-ring seals, rated to 200 psig CWP. Victaulic Vic-Press 304™.

2. 2.5-inch and larger: ASTM A312 or ASTM A376, Schedule 40, seamless stainless steel, Type 304 pipe with ASTM A403, Gr. WP304, butt-weld fittings.
3. Use 3,000-pound socket-weld, stainless steel ground joint unions.
4. Use ASTM A182, Gr. F304, 150-pound flanges with $^{1}/_{16}$-inch raised face, serrated face finish and weld neck pattern.

2.05 JOINING MATERIALS

A. Flange gaskets shall be rated ASME B16.21, non-metallic, flat, asbestos-free full faced or flat ring type to suit flange facings. Selected from one of the following materials:

1. General service, water, air, natural gas: $^{1}/_{16}$-inch thick, non-asbestos. Crane Style 333 or approved equal.
2. PVC piping applications: ⅛-inch thick, Durometer 65 to 75; Goodrich "Koroseal",

Grade 116 polyvinyl chloride or approved equal.

3. Hot water: Red rubber, ASTM D1330, $^{1}/_{16}$-inch thick; Crane Style 555 or approved equal.
4. Gaskets shall be coated with thread lubricant when being installed.

B. Pipe threads shall be ANSI/ASME B1.20.1.

C. Pipe grooved ends shall be in conformance with ASME/AWWA C606 (or similar).

D. Flange bolts and nuts shall be rated ASME B18.2.1, carbon steel.

E. Plastic, Pipe-Flange Gasket, Bolts, and Nuts: Type and material recommended by piping system manufacturer.

F. Solder Filler Metals: ASTM B32, lead-free alloys. Include water-flushable flux according to ASTM B813.

1. 100 percent lead free, silver bearing solders equivalent to:

a. “Silverflo” by Canfield
b. “Stay-Safe Bridget” by J.W. Harris

2. 95-percent tin and 5-percent antimony composition.

G. Brazing Filler Metals:

1. General Duty: AWS A5.8/A5.8M, BCuP Series, copper-phosphorus alloys, unless otherwise indicated equivalent to:

a. “Stay-Silv 15” by J.W. Harris
b. “Sil Can 15” by Canfield

2. Refrigerant Piping: AWS A5.8/A5.8M, BAg1, silver alloy for refrigerant piping, unless otherwise indicated equivalent to:

a. “Safety-Silv 45” by J.W. Harris
b. “Sil Can 45” by Canfield

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

2.06 UNIONS

A. Steel piping 2 inches and smaller: ASME B16.3 malleable iron unions with brass seats. Use unions of a pressure class equal to or higher than that specified for the fittings of the respective piping service but not less than 250 pounds square inch, ground joint.

B. Stainless steel piping 2 inches and smaller: 200 psi CWP, fully stainless steel hexagonal threaded-type union with Vic-Press 304™ ends. Victaulic Style 584.

C. Steel Piping 2.5 inches and larger: ASTM A181/A181M or ASTM A105/A105M, Grade 1 hot forged steel flanges of threaded, welding neck, or slip-on pattern and of a pressure class compatible with that specified for valves, piping specialties and fittings of the

respective piping service. Flanges smaller than 2.5 inches may be used as required for connecting to equipment and piping specialties. Use raised face flanges ASME B16.5 for mating with other raised face flanges on equipment with flat ring or full-face gaskets. Use ASME B16.1 flat face flanges with full-face gaskets for mating with other flat face flanges on equipment. Gasket material to be non-asbestos and suitable for pressures and temperatures of the piping system.

D. Unions and flanges for disconnect and servicing are not required in installations using grooved mechanical joint couplings. (The couplings shall serve as unions and disconnect points.)

E. Copper Piping: Nibco No. 633.

2.07 DIELECTRIC FITTINGS

A. Unions:

1. 1.25 inches and smaller: EPCO Model FX or approved equal:

    a. 250 pounds per square inch WOG
    b. Provide standard gaskets for plumbing, high temperature gaskets for heating
    c. Female pipe thread by solder end connections, non-asbestos gaskets, having a minimum pressure rating of 250 psig at not less than the design operating temperature of the fluid being conveyed
    d. Clearflow dielectric waterways

2. 1.5 inches and larger: EPCO Model X or approved equal:

    a. Brass half-union, ASME B16.1, 175 pounds per square inch WOG
    b. Clearflow dielectric waterways
    c. Steel weld neck by copper solder joint end connections, non-asbestos gaskets, having a minimum pressure rating of 125 psig at not less than the design operating temperature of the fluid being conveyed

B. Insulating Flanges:

1. Dielectric-Flange Kits: Provide 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.
2. Provide separate companion flanges and steel bolts and nuts, 150 or 300 psig minimum working pressure where required to suit system pressures.
3. 2 inches and smaller: Walter Vallett Company, V line or approved equal.
4. 2.5 inches and larger: Brass half-union, ASME B16.1, 175 pounds per square inch WOG, EPCO Model X or approved equal.

C. Couplings: Provide galvanized-steel coupling with inert and non-corrosive, thermoplastic lining, threaded ends and 300-psig minimum working pressure at 225 degrees F.

D. Nipples: Provide electroplated steel nipple or ductile iron casing with inert and non-corrosive, thermoplastic lining; plain, threaded, or grooved ends; and 300-psig minimum working pressure at 225 degrees F. Victaulic Style 47.

2.08 MECHANICALLY COUPLED GROOVED END PIPING SYSTEM

A. Provide mechanically coupled grooved end fittings and pipe similar to Victaulic roll grooved products manufactured under ISO 9001 certification.

B. The following services may use mechanical grooved pipe connections within the building in mechanical spaces and above accessible ceilings, and in other locations as approved by the engineer.

1. Heating hot water
2. Chilled water

C. Piping Components:

1. Grooved couplings shall consist of two pieces of ductile or malleable iron housings. Coupling gaskets shall be a synthetic rubber gasket with a central cavity pressure responsive design. Coupling bolts and nuts shall be heat-treated electroplated carbon steel, trackhead conforming to physical and chemical properties of ASTM A449 and physical properties of ASTM A183. Use Style 77 couplings for all joints within 10 feet of riser connections. Grooved fittings, couplings, valves and gaskets must be manufactured under ISO 9001.
   All grooved joint couplings, fittings, valves and specialties shall be the products of a single manufacturer. Grooving tools shall be of the same manufacturer as the grooved components. All castings used for coupling housings, fittings, valve bodies, etc., shall be date stamped for quality assurance and traceability.
   Reducing couplings are not acceptable.

   a. Rigid Type: Housings shall be cast with offsetting angle-pattern bolt pads to provide rigidity and system support and hanging in accordance with ANSI/ASME B31.1 and B31.9.

   1) 2 through 8 inches: Installation-Ready, for direct stab installation without field disassembly, with grade EHP gasket rated to +250 degrees F. Victaulic Style 107.

   b. Flexible Type: For use in locations where vibration attenuation and stress relief are required. Three flexible couplings may be used in lieu of a flexible connector. The couplings shall be placed in close proximity to the source of the vibration.

   2) 2 through 6 inches: Installation-Ready, for direct stab installation without field disassembly, with grade EHP gasket rated to +250 degrees F. Victaulic Style 177.

2. Couplings for Steel Piping 14 through 24 inches: Victaulic AGS series with lead-in chamfer on housing key and wide width FlushSeal® gasket.

   a. Rigid Type: Housing key shall fill the wedge shaped AGS groove and provide rigidity and system support and hanging in accordance with ANSI/ASME B31.1 and B31.9. Victaulic Style W07.
   b. Flexible Type: Housing key shall fit into the wedge shaped AGS groove and allow for linear and angular pipe movement. Victaulic Style W77.

3. Make full size branch connections for piping 2.5 inches and larger with manufactured grooved end tees. Branch connections for less than full size shall be made with Victaulic reducing tees or hole cut products. Style 920/920N or

Style 921 branch connections with locating collar engaging into hole or Style 72 outlet coupling used to joint grooved pipe and to create a branch connection. Provide gaskets for branch connection using Grade "E" EPDM Compound (or as required for the intended service) with working temperature of minus 30 degrees to 230 degrees F. Gaskets must be ISO 9001 certified. Gaskets shall be provided by the same manufacturer that provides the coupling housing.

4. Provide flanges for all connections to flanged components as follows:

   a. Style 741 (2 through 12 inches) for connection to ANSI Class 125 and 150 flanged components
   b. Style 743 (2 through 12 inches) for connection to ANSI Class 300 flanged components
   c. Style W741 (14 through 24 inches) for connection to ANSI Class 125 and 150 flanged components

5. Provide full-flow cast fittings, manufactured under ISO 9001 with grooves to accept grooved end couplings as recommended by the manufacturer:

   a. Standard Fittings: Cast or ductile iron conforming to ASTM A536 (Grade 65-45-12), painted with a rust inhibiting modified vinyl alkyd enamel or hot-dip galvanized to ASTM A153/A153M or zinc electroplated to ASTM B633, as required.
   b. Standard Steel Elbow Fittings (14-24 inches): Forged steel conforming to ASTM A234, Grade WPB (0.375 inch wall) painted with rust-inhibiting modified vinyl alkyd enamel or hot-dip galvanized to ASTM A153/A153M.

   c. Standard Segmentally Welded Fittings: Factory fabricated, by fitting manufacturer, of carbon and steel pipe as follows: ¾ inches – 4 inches conforming to ASTM A53/A53M, Type F; 5 inches – 6 inches Schedule 30 conforming to ASTM A53/A53M, Type E or S, Grade B; 8 inches – 12 inches Schedule 30 conforming to ASTM A53/A53M, Type E or S, Grade B, painted with rust-inhibiting modified vinyl alkyd enamel or hot-dip galvanized ASTM A153/A153M, as required.
   d. Mechanical-Tee: Style 920/920N fittings with ductile or malleable iron housings may be used for up to 4-inch outlet size.

D. Piping Components for Copper Tubing Systems:

1. Grooved joint systems for copper tubing shall be manufactured to copper tube dimensions. (Flaring of tube or fitting ends to accommodate alternate sized coupling is not allowed.)
2. Grooved joint couplings shall consist of two ductile iron housings cast with offsetting angle-pattern bolt pads. Coupling gaskets shall be a FlushSeal® synthetic rubber gasket with a central cavity pressure responsive design. Coupling bolts and nuts shall be heat-treated electroplated carbon steel, trackhead conforming to physical and chemical properties of ASTM A449 and physical properties of ASTM A183.

   a. 2 through 4 inches: Installation-Ready, for direct stab installation without field disassembly, with grade EHP gasket rated to +250 degrees F. Victaulic Style 607.

3. Fittings shall be manufactured with copper-tube dimensioned grooved ends; of cast bronze conforming to ASME B16.18 or wrought copper conforming to ASME B16.22.

2.09 STRAINERS

A. Provide screwed ends up to 2-inch size, flanged or grooved end 2.5-inch and larger.

B. Body:

1. Up to 150 pounds per square inch: Y-type; ductile or cast iron body; bolted, coupled or threaded screen retainer tapped for a blow-off valve; threaded body in sizes through 2-inch and rated at not less than 175 psi WOG; flanged or grooved end body in sizes over 2-inch and rated at not less than 125 psi WOG at 230 degrees F. Cast iron body with clamped cover, tapped for a blow-off valve; 125 psig flanged body for 2.5-inch and larger.
2. Up to 150 pounds square inch, basket type: Cast iron body with clamped cover; body tapped for a blow-off valve; 125 psig flanged body for 2.5-inch and larger.
3. Over 150 pounds per square inch: Y type; ductile or cast iron or cast steel body; stainless steel screens; bolted, coupled or threaded screen retainer tapped for a blow-off valve; threaded or socket weld body in sizes through 2-inch and rated at not less than 300 psi WOG at 150 degrees F; flanged, grooved end or butt weld body in sizes over 2-inch and rated at not less than 300 psi WOG at 150 degrees F.

C. Strainer screen shall be Type 316 stainless steel or monel, reinforced, with free area not less than 2.5 times inlet area.

1. Perforations:

a. Water:
3) Up to 2-inch: $^{1}/_{32}$ inches
4) 2.5-inch to 8 inch: $^{1}/_{16}$ or ⅛ inches
5) 10-inch and larger: ⅛ or $^{5}/_{32}$ inches

2. Magnets, except for handwheel operated type:

a. Water strainers:
6) All 8-inch and larger
7) Each pump suction

b. Provide continuous magnetic field around entire circumference of screen.
c. Removable cast Alnico No. 5 channel magnets or approved baskets constructed of magnetic alloy.
d. Secure magnets with stainless steel retaining lugs and threaded rods.

D. Y-Type:

1. Soldered: Bronze, straight thread gasketed cap, Mueller 3521/2MM, Hammond 3040, or approved equal
2. Screwed:

a. Steel: Faced cap, straight thread and gasket, Muessco No. 11M or approved equal

b. Bronze: Straight thread and gasketed cap, Mueller 351M or 352M, Hammond 3010 or 3020, or approved equal

3. Flanged: Bolted cover, Muessco No. 751 or No. 752 or approved equal
4. Grooved: Coupled over, Victaulic Series 732

E. T-Type:

1. Grooved, through 12 inches: Coupled cover, Victaulic Series 730
2. Grooved, 14 through 24 inches: T-bolt hinged closure, Victaulic Series W730

F. Basket Type: Bolted cover, bottom drain connection.

1. Up to 6-inch: Provide cast iron or steel body with bolted cover, stainless steel ball valve and integral mechanism to permit servicing without interrupting flow; Muessco 792FD or approved equal.
2. 8-inch and larger: Diverting type, cast iron body with stainless steel basket and integral mechanism to permit servicing without interrupting flow; Muessco 692 MFA, or approved equal

G. Grooved End Type: Wye or Tee type grooved joint for vertical or horizontal installation with blow-off plug.

2.10 HEAT TRACING

A. Heat tracing cable shall consist of two (2) 16 AWG tinned copper bus wires, embedded in parallel, in a self-regulating semi-conductive core that varies its power output to respond to temperature along its length.

B. Heater to be capable of being crossed over itself without overheating and of being cut to length in the field.

C. Cover cable with a cross-linked modified polyolefin dielectric jacket. Protect cable with a tinned copper braid. Cable shall be approved for use without ground fault protection of the electric branch circuit.

D. Heat tracing cable shall operate on line voltage of 120 volts without the use of transformers.

E. Manufacturer shall provide power connection, end seals, splice and tee kits for a complete Underwriters' Laboratories listed system. Heat tracing cable shall be sized using manufacturer's standard procedure and shall maintain fluid within pipe at 40 degrees F when outside temperature is minus 10 degrees F.

F. Provide a line voltage thermostat for on-off control of heat tracing cable by sensing ambient temperature at the traced pipe and turn heat tracing on when outside temperature is below 35 degrees F and turn the heat tracing off when outside temperature is above 35 degrees F.

G. Provide and install manufacturer's recommended glass cloth adhesive tape and "Electrically Heat-Traced Pipe" labels at maximum of 30-foot centers.

H. Each circuit shall be protected with a 30-milliamp ground-fault protection device.

I. Required output rating is in watts per foot at 50 degrees F, based on 1-inch fiberglass insulation on metal piping. Minimum Ambient minus 10 degrees F.

1. 4-inch pipe or less: 5 watts per foot
2. 6-inch pipe: 8 watts per foot
3. 8- and 10-inch pipe: 2 strips at 5 watts per foot each

2.11 UNDERGROUND PIPE WRAP

A. Use a flexible polymer film with a coal tar and synthetic elastomeric coating of 36 mil thickness and dielectric strength exceeding 12 kilovolts. Use a compatible primer below the polymer film.

PART 3 – EXECUTION

3.01 APPLICATION

A. In addition to applicable portions of the PART 3, refer to the following specification sections for installation, testing and cleaning requirements for specific piping systems identified in these sections.

1. Section 23 05 29 – Hangers and Supports for HVAC

3.02 INSTALLATION

A. General:

1. Except as otherwise indicated, protect piping as specified below:

a. Allowance for thermal expansion and contraction shall be provided for piping passing through a wall, floor, ceiling or partition by wrapping with an approved tape or pipe insulation, and by installing through an appropriately sized sleeve to allow for thermal movement.
b. No ashes, cinders, refuse, stones, boulders or other materials that can damage or break the piping or promote corrosive action shall be used in backfilling any trench or excavation in which piping is installed.

2. Install piping at indicated slope free of sags, bends, and kinks. Install components having pressure rating equal to or greater than system operating pressure. Support all piping per Section 23 05 29 – Hangers and Supports for HVAC.
3. Brace all piping per Section 23 05 48 – Vibration and Seismic Controls for HVAC.
4. Clean off scale, rust and dirt, inside and outside, before assembly. Remove welding slag or other foreign material from piping.

5. Install (at traps, humidifiers, instruments, etc., and wherever else directed) approved unions, to permit easy connection and disconnection.
6. After systems are in operation, if coils do not circulate quickly and noiselessly (due to trapped or airbound connections), make all necessary corrections to the work including altering finished construction and refinishing without additional cost.

7. Make piping connections to coils, and equipment with offsets provided with

screwed or flanged unions so arranged that the equipment can be serviced or removed without dismantling the piping. Do not screw unions directly to coil header piping connections.

8. Use main sized saddle type branch connections for directly connecting branch lines to main piping lines in steel piping if main is at least one pipe size larger than the branch for up to 6-inch main and if main is at least two pipe sizes larger than branch for 8-inch and larger main. Do not project branch pipes inside the main pipe.
9. Cap all openings in pipes during progress of the work.
10. Do not connect bottom of pipe risers until riser is complete. Rod or tap to clear loose material before making bottom connection.
11. Correct leaks in piping immediately using new materials. Leak-sealing compounds or peening is not permitted.
12. Install drains throughout the systems to permit complete drainage.
13. Not acceptable: mitered ells, bullhead tees, notched tees, bushings on threaded piping.
14. Do not allow any other subcontractor (electrical, telephone company, BMS, elevator, etc.) to electrically ground to any mechanical system.
15. 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. Encase underground piping with polyethylene film according to ASTM A674 or AWWA C105/A21.5.

B. Arrangement:

1. Except for large-scale details, piping is diagrammatically indicated. Install generally as shown.
2. Do not scale the Drawings for exact location of piping.
3. Install piping to best suit field conditions and coordinate with other trades.
4. Piping arrangement: Arrange piping along walls in horizontal groups in an organized, orderly, well executed manner. Each group shall be in one plane if possible. Maintain required slope.
5. Do not sleeve structural members without consent of Architect.
6. Maintain 1-inch clearance from adjacent work, including insulation, except as noted or approved.
7. Install piping concealed above as high as possible above ceilings or in walls unless otherwise indicated. Install all piping parallel to building walls and ceilings and at heights that do not obstruct any portion of a window, doorway, stairway, or passageway. Where interferences develop in the field, offset or reroute piping as required to clear such interferences. In all cases, consult the Drawings for exact location of pipe spaces, ceiling heights, door and window openings, or other architectural details before installing piping.

C. Expansion, Contraction and Bending:

1. Install piping with provisions for expansion and contraction. Provide expansion loops, swing joints, anchors and/or expansion joints where indicated or otherwise required so that piping may expand and contract without damage to itself, equipment, or building.
2. Do not spring or force piping during installation.
3. Do not bend piping without use of pipe-bending machine.
4. For water systems, adequate numbers of Victaulic Style 77 flexible couplings in header piping may be used to accommodate thermal growth and contraction, and

for the elimination of expansion loops. In accordance with Victaulic instructions and as approved by the engineer. Where expansion loops are required, use Victaulic Style 77 couplings on the loops.

5. Refer to Section 23 05 16 – Expansion Fittings and Loops for HVAC Piping.

D. Sloping, Air Venting and Draining:

1. Slope piping as indicated, true to line and grade, and free of traps and air pockets.
2. Unless indicated otherwise, slope piping in direction of flow as follows:

Service	Inclination in Direction of Flow	Slope
Heating Water	Up	1 inch per 40 feet
Chilled Water	Up	1 inch per 40 feet
Condensate Drain	Down	⅛ inch per foot

3. Slope up-feed steam and condensate runouts up toward equipment ½ inch per foot.
4. Slope air line up 1 inch per 10 feet towards storage tank.

5. Reducers:

a. Eccentric:

8) In horizontal steam and condensate piping, bottom side flat
9) Heating water and chilled water piping, top side flat
10) Between water piping and pump suction, top side flat

b. Concentric:

11) In vertical piping
12) May be used as increasers in horizontal piping

6. Connect steam and condensate branch piping to top of mains.
7. Connect heating water and chilled water branch piping to bottom of mains.
8. Provide drain valves and hose adapters at all low points in piping.
9. Provide drain valves for float type controllers.
10. Provide manual air vents at all high points in condenser water, heating water and chilled water piping:

a. ¼-inch copper tube
b. Discharge vented water into nearest janitor's sink or floor drain
c. If no fixture is near provide 180-degree bend to discharge into portable container

E. Strainers:

1. Install at following locations:

a. Ahead of pump suctions
b. Ahead of control and regulating valves
c. Elsewhere as indicated on Drawings

2. In water service, up to 250 degrees F maximum; and compressed air:

a. Install globe valve for blow-off with full outlet size and same pressure rating as piping system.
b. Hose-end fittings are acceptable for water service only.

F. Piping Specialties:

1. Locate thermometers and gauges to permit observation by personnel standing on floor.
2. Provide instrument cocks at pressure gauges.
3. Provide continuous lengths of straight runs of piping upstream and downstream from balancing devices as recommended by manufacturer. No joints, welds, fittings or taps are permitted in the straight runs.

G. Copper:

1. Crimping of copper tubing prohibited.
2. Isolate copper pipe and tubing from contact with ferrous materials.
3. Remove all slivers and burrs remaining from the cutting operation by reaming and filing both pipe surfaces. Clean fitting and tube with emery cloth or sandpaper. Remove residue from the cleaning operation, apply flux, and assemble joint. Use 95-5 solder or brazing to secure joint as specified for the specific piping service.

H. Coatings: Reapply mastic coating on buried piping, after installation, to surfaces from which coating has been removed or scraped.

I. Care of Floors:

1. Do not set pipe vises or threading machines on unprotected concrete floors.
2. Cover floor when making plumbing connections to avoid staining floors with oil, white or red lead or other substances. Bear cost of removing any stains.

J. Heat Trace Cable:

1. Provide heat trace cable for piping systems, where indicated on the Drawings.
2. Install cable and components per manufacturer’s instructions.
3. Apply “Electric Traced” labels to heat trace cables covered in insulation.

3.03 SYSTEMS INSTALLATION

A. Pre-Insulated Pipe and Fittings:

1. The installation shall be made in accordance with plans and specifications, and manufacturer’s installation instructions. Provide a manufacturer’s field service instructor on site to train the Contractor in all phases of installation.
2. Earth or sand backfill shall be hand-placed and hand-tamped compactly in place to assure a stable surface. No rock shall be used in the first foot of backfill. The 30 inches from top of pipe to grade shall be compacted fill meeting AASHTO standards for Highway Loading – Class H20.
3. After all anchor blocks are poured and cured, the inner pipes of this system shall be tested hydrostatically to 150 pounds per square inch for four hours of duration. If a leak is found, it shall be repaired and the test repeated.

4. Do not locate pipe joints under roadways or areas subject to motorized vehicular traffic.

B. Refrigerant:

1. Clean, dehydrate, and cap refrigerant piping. Ensure that entire system is clean and dry during installation. Clean tubing by means of swab saturated in methyl alcohol. Draw through tubing as many times as necessary to thoroughly clean and dry interior of tubing and to eliminate formation of copper oxide.
2. Before refrigerant lines are silver brazed, flush all air from tubing and pass slow-running stream of dry nitrogen through system during brazing process. Purge lines completely and maintain nitrogen flow at steady rate of not less than three cubic feet per hour.
3. Refrigeration piping shall be installed in accordance with the requirements of AHRI (ARI), ASHRAE and ASTM.
4. All solder joints shall be ASTM Grade 4 or 5 and have a melting point of approximately 1,250 degrees F. Solder impurities shall not exceed 0.15 percent. Tubing shall be new and delivered to the job site with the original mill end caps in place. Clean and polish all joints before soldering. Avoid prolonged heating and burning during soldering. Purge all lines with nitrogen during soldering. Provide manual shut-off and check valves as required. After brazing, interior of refrigerant lines must be clean and bright.
5. Comply with EPA Section 608 requirements: Prohibition of Venting and Regulation of CFC Requirements. No refrigerant shall be vented directly to the atmosphere except that which may escape through leaks in the system during leak testing. During evacuation procedures, use equipment designed to recover and allow recycling of the refrigerant.
6. Install core in filter dryer after leak test but before evacuation.
7. Evacuate refrigerant system with vacuum pump until temperature of 35 degrees F is indicated on vacuum dehydration indicator.
8. During evacuation, apply heat to pockets, elbows, and low spots in piping.
9. Maintain vacuum on system for minimum of 5 hours after closing valve between vacuum pump and system.
10. Break vacuum with refrigerant gas; allow pressure to build up to 2 psi.
11. Complete charging of system, using new filter dryer core in charging line. Provide full operating charge.
12. After completion of the leak test, evacuate the system with a vacuum pump to an absolute pressure not exceeding 1,500 microns while the system ambient temperature is above 60 degrees F. Break the vacuum to 2 psig with the refrigerant to be used in the system. Repeat the evacuation process, again breaking the vacuum with refrigerant. Install a drier of the required size in the liquid line, open the compressor suction and discharge valves, and evacuate to an absolute pressure not exceeding 500 microns. Leave the vacuum pump running for not less than two hours without interruption. Raise the system pressure to 2 psig with refrigerant and remove the vacuum pump.
13. Charge refrigerant directly from original drums through a combination filter-drier. Each drier may be used for a maximum of three cylinders of refrigerant and then must be replaced with a fresh drier. Charge the system by means of a charging fitting in the liquid line. Weigh the refrigerant drum before charging so that an accurate record can be kept of the weight of refrigerant put in the system. If refrigerant is added to the system through the suction side of the compressor, charge in vapor form only.
14. Install branch tie-in lines to parallel compressors equal length, and pipe

identically and symmetrically.

15. Slope refrigerant piping as follows

    a. Install horizontal hot gas discharge piping with ½-inch per 10 feet downward slope away from the compressor.
    b. Install horizontal suction lines with ½-inch per 10 feet downward slope to the compressor, with no long traps or dead ends that may cause oil to separate from the suction gas and return to the compressor in damaging slugs.
    c. Liquid lines may be installed level.

16. Install traps and double risers where indicated, and where required to entrain oil in vertical runs.
17. Install strainers immediately ahead of each expansion valve, solenoid valve, hot gas bypass valve, compressor suction valve, and as required to protect refrigerant piping system components.
18. Install moisture/liquid indicators in liquid lines between filter/driers and thermostatic expansion valves and in liquid line to receiver.
19. Install moisture/liquid indicators in lines larger than 2-⅛ inch OD, using a bypass line.
20. Install unions to allow removal of solenoid valves, pressure regulating valves, expansion valves, and at connections to compressors and evaporators.
21. Install flexible connectors at the inlet and discharge connection of compressors.
22. Verify actual evaporator applications and operating conditions, and adjust thermostatic expansion valve to obtain proper evaporator superheat requirements. Adjust controls and safeties. Replace damaged or malfunctioning controls and equipment with new materials and products.

C. Underground Pipe Wrap:

1. Provide for all underground metallic piping that is not encased in a non-metallic conduit and for underground metallic gas conduit.
2. Remove all dirt and other foreign material from exterior of pipe. Apply primer as recommended by the manufacturer.
3. Use a spiral wrap process for applying tape to the pipe. Repair any breaks in the tape coating caused by the installation process.

D. Underground Piping:

1. Install piping where indicated and according to manufacturer’s instructions.
2. Install closures at points of field joints between straight units or fabricated fittings by welding them centrally over conduit ends between such adjacent units.
3. After welding, conduct a 25-psig air pressure test on the outer casing and examine for leaks with a soap solution.
4. Repair any leaks and retest until the system is airtight at 25 psig air pressure for a two-hour period.
5. Clean closures of all welding slag, burned coating, mud, etc. by wire brushing.
6. Finish coat in accordance with the system manufacturer’s instructions, using materials supplied. Final outside coating to be subjected to a spark test and be capable of maintaining dielectric strength at 5,000 volts.
7. Contractor shall furnish all necessary equipment and labor to perform the spark test and the air test, including air compressor, gauges, conduit caps, temporary pipe and connections, etc., and complete the tests to the satisfaction of the

Architect.

E. Heat Trace Cable:

1. Cable shall be secured to piping with cable ties or fiberglass tape.
2. Install heater cable linearly along the pipe's lower quadrants after pipe has been successfully pressure tested.
3. Wrap extra cable around fittings and valves as required to offset heat loss at these areas.

3.04 PIPE JOINTING

A. Fittings:

1. Provide standard, manufactured fittings in all cases.
2. Prohibited fittings:

   a. Field fabricated
   b. Bushings on pressure piping
   c. Clamp-on branch connections

3. Dielectric separation:

   a. Provide insulating couplings or dielectric fittings at all connections or metal-to-metal contact of ferrous materials to non-ferrous materials.
   b. Locations shall be accessible. Coordinate with General Contractor.

4. Branch connections, steel piping:

   a. Equal to main and to two pipe sizes smaller: Weld or grooved end tees, same weight as piping.
   b. Three or more pipe sizes smaller than main, but 2.5 inches and larger: Bonney Weld-o-lets or Victaulic Mechanical T-fittings.
   c. Up to two inches and smaller: Bonney Weld-o-lets, Thread-o-lets, threaded Nip-o-lets, steel couplings, or Victaulic Mechanical T-fittings.

B. Unions: Provide unions, grooved joint couplings, or flanges to render all items in systems easily removable, including:

1. Valves
2. Piping specialties
3. Both sides of pumps and equipment
4. Where indicated on the Drawings

C. Pipe Ends: Perform pipe cutting and end preparation to result in clean ends with full inside diameter. Grind and ream ends of pipe and tube and remove burrs to restore full inside diameter.

D. Nipples: Provide extra heavy pipe for nipples where unthreaded portion is less than 1.5 inches long. Close nipples not permitted.

E. Threaded Joints: Ream threaded pipe ends to remove burrs and restore full inside diameter. Join pipe fittings and valves as follows:

1. Note the internal length of threads in fittings or valve ends, and proximity of internal seat or wall, to determine how far pipe should be threaded into joint.
2. Apply appropriate tape or thread compound to external pipe threads (except where dryseal threading is specified).
3. Align threads at point of assembly.
4. Tighten joint with wrench and back-up wrench as required.
5. Damaged threads: Do not use pipe or pipe fittings having threads that are corroded or damaged.
6. Sealed with sealant compounds or Teflon tape. Hard setting pipe thread cement or caulking shall not be allowed.
7. Sealant compounds: John Crane or Rector Seal:

    a. General service: John Crane JC-40
    b. Refrigerant: John Crane No. 2 Plastic Lead Seal
    c. Chemicals and corrosive service piping: John Crane JC-30

F. Flanged Joints: Align flange surfaces parallel. Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Assemble joints by sequencing bolt tightening to make initial contact of flanges and gaskets as flat and parallel as possible. When required, use suitable lubricants on bolt threads. Tighten bolts gradually and uniformly using a torque wrench.

G. Mechanical Joints: Grooved copper tube and grooved-tube fitting joints shall be assembled with coupling, gasket, lubricant, and bolts per coupling and fitting manufacturer's standard written procedure at copper tube dimensions. Grooved ends on copper and copper alloy tube shall be roll-formed only using the appropriate roll-groove tool to construct a groove meeting the coupling and fitting manufacturer's written specifications. Cut grooving methods shall not be used on copper and copper alloy tube.

1. The grooved coupling manufacturer's factory-trained representative shall provide on-site training for contractor's field personnel in the use of grooving tools and installation of grooved joint products. The representative shall periodically visit the jobsite and review contractor is following best recommended practices in grooved product installation.

H. Flared Tube Joints: Flared copper tube joints shall be made by the appropriate use of cast copper alloy fittings conforming to ASME B16.26. Flared ends of copper tube shall be of the 45-degree flare type and shall only be made with a flaring tool designed specifically for that purpose. Copper alloy tube shall be reamed to remove burrs and restore full inside diameter prior to forming the flared end.

I. Welded Joints:

1. Where required, peen and wheel-grind welds.
2. Ends of pipe may be burned for welding:

    a. Grind, bevel and remove scale between welding joint.
    b. Ragged edges with metal beads, poor alignment or other inferior work shall be rejected.
    c. Preparation of pipe ends: For wall thickness up to $^{3}/_{16}$-inch, ends shall be finished square or with 37.5-degree bevel with a $^{1}/_{16}$-inch band; for wall thickness $^{3}/_{16}$-inch to ¾-inch inclusive, ends shall be machined or ground to have a 37.5-degree bevel with a $^{1}/_{16}$-inch band per latest edition of

ANSI/ASME B31.1.

3. Perform welding with oxyacetylene or electric arc process.
4. Welding shall be from outside only on pipe configurations.
5. Tack welds shall be of same quality as required in the completed weld and shall be visually examined for defects before applying any complete passes. The ends (starts and stops) of the tacks shall blend in smoothly with the base metal so that subsequent passes can be applied without interruption.
6. Inspection: Visual inspection shall be done by the welder after each pass.
7. Inspection Criteria: Cracks, cold laps, open porosity and tungsten inclusions shall not be allowed. If the above occurs, the weldment shall be removed and rewelded per this specification. Weld beads shall be applied in such a manner that they are smooth into adjacent beads and the base metal with no areas, such as crevices, undercuts, or overlaps, that would weaken the structure or prevent adequate penetration of subsequent weld passes. Undercut of the final pass, which reduces the initial material thickness, shall be repaired by additional welding.
8. Repair: All materials welded using this procedure or which fall within the requirements of this procedure may also be repair welded using this procedure.

J. Grooved End Joints:

1. Pipe Preparation: The pipe ends must be clean from indentations, projections and roll marks in the area from pipe end to groove for proper gasket sealing. The dimensions must be according to the standard roll groove specifications as recommended by the manufacturer. Cut grooves are not acceptable.
2. Pipe Preparation Plain End: Black pipe must be thoroughly cleaned down to bare metal for one-inch from the pipe end to receive mechanically coupled fittings; removed pipe coatings, mill scale, rust and raised weld beads.
3. Tighten all nuts to assure firm metal contact of the coupling pads.
4. Groove width depth and outside diameter must conform to the standard groove specifications in the latest “Field Assembly and Installation Instruction Pocket Handbook”.
5. Before assembly of couplings, lightly coat pipe ends and outside of gasket with cup grease or graphite paste to facilitate installation.
6. Support branch pipes independently to eliminate stress on coupled joint.
7. Determine that gasket material and lubricant are compatible with service of pipe.
8. The grooved coupling manufacturer’s factory-trained representative shall provide on-site training for contractor’s field personnel in the use of grooving tools and installation of grooved joint products. The representative shall periodically visit the jobsite and review Contractor is following best recommended practices in grooved product installation.
9. Hammer welds to remove slag and weld beads.

K. Soldered and Brazed Joints: Construct soldered joints per ASTM B828. Construct brazed joints per AWS C3.4M/C3.4.

1. Install solder-joint to male-thread adapters, or solder-joint to male-thread unions meeting the requirements of ASME B16.18 or ASME B16.22, adjacent to each threaded valve and threaded equipment connection in a copper tube system.
2. Install ASME B16.24 cast copper alloy pipe flanges adjacent to each flanged valve and flanged equipment connection in a copper tube system.
3. Provide brazing for refrigerant piping system using AWS A5.8/A5.8M, BAg1 with

15 percent silver, 80 percent copper and 5 percent phosphorous.

4. Provide solder joint for building heating hot water supply and return systems, and chilled water systems.
5. Clean surfaces to be jointed of oil, grease, rusts and oxides.

    a. Remove grease from fittings by washing in solution of $^{1}/_{16}$ sodium carbonate and three gallons hot water except as otherwise specified for refrigerant piping.
    b. Clean socket of fitting and end of pipe thoroughly with emery cloth to remove rust and oxides. After cleaning and before assembly or heating, apply Handy or Aircosil flux to joint surface and spread evenly.

6. Any joints showing evidence of overheating, cracking, poor penetration, or other defects of fit-up or workmanship shall be replaced as directed by the Architect at the Contractor's expense.

L. Plastic Piping, General:

1. Threaded joints only at terminal connections or when specifically approved.
2. Threaded joints only on Schedule 80 pipe or with socket-threaded adapters.
3. Teflon joint thread tape.
4. Approved adapters for connections to metallic piping.
5. Heat-Fusion Joints: Make polyolefin pressure-piping joints according to ASTM D2657.
6. Plastic-Piping Electrofusion Joints: Make polyolefin drainage-piping joints according to ASTM F1290.
7. Fiberglass Piping Joints: Make joints with piping manufacturer's bonded adhesive.
8. Dissimilar-Material Piping Joints: Make joints using adapters compatible with both system materials.

M. Pressed Joint Piping:

1. Install pressed fittings in accordance with manufacturer's recommendations. Pipe shall be certified for use with the manufacturer's system, square cut (plus or minus 0.030 inches, properly deburred, and cleaned. Pipe ends shall be marked with a gauge supplied by the manufacturer. Use manufacturer's recommended tools with the proper sized jaw for pressing.

3.05 CHEMICAL CLEANING

A. General:

1. During construction:

    a. Keep openings in piping closed to prevent entrance of foreign matter.
    b. Clean pipe, fittings and valves internally.
    c. Hammer welds to remove slag and weld beads.

2. After completion of pressure testing, chemically clean internally each heating or cooling piping system.
3. Proceed with chemical cleanout within 4 hours of completion of pressure testing.

B. Water Systems:

1. Upon start-up, flush and then fill with clean water, and vent as required.
2. Install temporary filter bags in hydronic system strainers at all pumps during start-up. Replace as often as necessary until they are relatively clean after 48 hours of service from last change.

C. Add chemical cleaning compound: Supplied and supervised by water treatment company. Refer to Section 23 25 00 – HVAC Water Treatment.

1. Temporary equipment for condenser water system:

a. Remove from condenser water piping system and replace after cleaning:
13) Straightening vanes
14) Metering orifices

2. Circulate water of each system at respective design flow rates.

a. Three (3) 8-hour days.
b. At end of each 8-hour period remove and clean strainers and blow off low points.
c. After third day of pumping, completely drain out entire systems of cleaning solution.
d. Refill systems immediately (within 2 hours) with clean water and circulate for additional 8-hour period at end of which interval, completely drain systems.
e. Immediately (within 2 hours) refill with clear water; circulate, vent air and add chemical treatment.
f. Test for alkalinity: Not more than 200 ppm in excess of alkalinity of water supply.
g. Repeat circulation of water of each system at respective minimum design flow rate as described above, until 200 ppm or less, maintained for 10 days.

3. Protect against damage from freeze-up or discharge of water.

4. Provide by-pass valves for all risers to by-pass fan coil units, space terminal heating units, hydronic coils and between supply and return risers to avoid flushing water coils or control valves.

3.06 FIELD QUALITY CONTROL

A. General:

1. Any deviation from the cleaning, installation, testing, and certification requirements herein shall be approved in writing by the Architect.
2. All materials and workmanship shall be subject to inspection and examination by the Architect at any place where fabrication or erection occurs.
3. The Architect reserves the right to reject all or any part of the system that does not conform to the requirements herein. Rejected materials or equipment shall be returned at the Contractor’s expense for re-cleaning and certification.
4. The Architect reserves the right to remove random samples of the installed work sufficient to establish the quality of materials and workmanship. If such samples

indicate materials and workmanship do not meet the contract specification, the Contractor shall be required to replace or re-clean the installed work at no expense to the Owner. The Owner shall reimburse the Contractor on a time and materials basis for such work if the system proves to be installed to specification.

5. The grooved coupling manufacturer's factory trained representative shall provide on-site training for contractor's field personnel in the use of grooving tools and installation of grooved joint products. The representative shall periodically visit the jobsite and review the Contractor is following best recommended practices in grooved product installation.
6. The pressed fitting manufacturer's factory-trained representative shall provide on-site training for contractor's field personnel in the use of pressing tools and installation of pressed joint products. The representative shall periodically visit the jobsite and review the Contractor is following best recommended practices in pressed product installation.
7. All testing shall be done in the presence of the Owner's Representative.
8. Upon completion of this work, all systems shall be adjusted for use. Should any piece of apparatus or any material or work fail in any of the required pressure tests, it shall be immediately removed any replaced by new materials. The defective portion of the work shall be replaced by new materials. The defective portion of the work shall be replaced by the Contractor in the presence of the Owner at no expense to the Owner.
9. Test gauges shall be installed and test medium source connections shall be made to convenient process connections. After completion of testing, the gauges and source connection shall be removed and the specified process attachments replaced.
10. Any leaks found shall be repaired in the following manner:

    a. Welded joint – Grind out defect and re-weld.
    b. Brazed and/or Soldered joint – Cut out and re-braze/solder.
    c. Plastic joint – Remove/re-weld.
    d. Screw joint – Taken apart and re-do (do not use compound).

B. Test Preparation:

1. Clean new piping internally by flushing with water before the application of pressure tests procedures as specified in Section 23 25 00 are performed. Provide temporary strainers at the inlet to the hot water, chilled water, and condenser water pumps before the start of cleaning procedures.
2. Block off and isolate circulating pumps, fixtures, condensers and hydronic coils and heating coils during the preliminary flushing and draining process.
3. Thoroughly flush piping with water under pressure, clear of foreign matter, and then drain before proceeding with pressure testing. Blow down accumulations of grit, dirt and sediment at each strainer and each low point in the piping systems.
4. Leaks and Defects:

    a. Repair or replace as directed.
    b. Repair damage caused by test failure without additional cost.
    c. Retest repaired and/or damaged systems until tests are accomplished successfully.

5. Refer to other sections and divisions for tests to plumbing systems and other special piping systems.
6. Notify Architect in writing one week before test.

7. Maintain a log book of all pressure tests showing dates, personnel performing test, test observer and test results.
8. Furnish written report and certification that tests have been satisfactorily completed.

C. Pressure Tests:

1. Less than 100 pounds per square inch operating pressure: Test hydrostatically to 150 pounds per square inch.
2. Over 100 psi operating pressure:

    a. Test hydrostatically to 1.5 times operating pressure.
    b. Never exceed test pressure ASME B16.1 basis.

3. With system valves capped and pressure apparatus disconnected, a 4-hour duration pressure test shall exhibit:

    a. No pressure change (zero).
    b. Compensate for temperature change.

4. Hot water heating piping shall be heat stressed by raising temperature to operating level from ambient two times before pressure test.
5. For air tests, gradually increase the pressure to not more than one half of the test pressure; then increase the pressure in steps of approximately one-tenth of the test pressure until the required test pressure is reached. Examine all joints and connections with a soap bubble solution or equivalent method. The piping system exclusive of possible localized instances at pump or valve packing shall show no evidence of leaking.
6. Heat Tracing: After initial installation, and before and after installing the thermal insulation, subject heat tracing to testing using a 2,500 volt DC megaohm meter (megger). Minimum insulation resistance shall be between 20 to 1,000 megaohms regardless of length. Consult manufacturer if conditions test outside this range; if necessary, new heat tracing and insulation shall be installed to meet test criteria, at no cost to Owner.
7. Leak test refrigerant piping systems by charging to a pressure of 10 psig with an HFC refrigerant, with the compressor suction and discharge valves closed and with all other system valves open. Increase pressure to 300 psig with dry nitrogen. Rap all joints with a mallet and check for leaks with an electric leak detector having a certified sensitivity of at least one ounce per year. Seal any leaks that may be found and retest.
8. Testing Certification: Certify that specified tests, inspections, and procedures have been performed and certify report results. Include the following:

    a. Inspections performed
    b. Procedures, materials, and gases used
    c. Test methods used
    d. Results of tests

END OF SECTION 23 21 13