

University of Houston Master Specification

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SECTION 23 2000 - HVAC PIPING SYSTEMS

Maintain Section format, including the UH master spec designation and version date in bold in the center columns of the header and footer. Complete the header and footer with Project information.

Edit and finalize this Section, where prompted by Editor's notes, to suit Project specific requirements. Make selections for the Project at text identified in **bold**.

Verify that Section titles referenced in this Section are correct for this Project's Specifications; Section titles may have changed.

Delete hidden text after this Section has been edited for the Project.

PART 1 - GENERAL

1.1 RELATED DOCUMENTS:

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. The Contractor's attention is specifically directed, but not limited, to the following documents for additional requirements:
 - 1. The current version of the *Uniform General Conditions for Construction Contracts*, State of Texas, available on the web site of the Texas Facilities Commission.
 - 2. The University of Houston's *Supplemental General Conditions and Special Conditions for Construction*.

1.2 DESCRIPTION OF WORK:

- A. Work Included: Provide complete operating HVAC piping systems including pipe, tube, fittings, and appurtenances as indicated and in compliance with these Specifications.
- B. Applications: Applications of piping systems include, but are not limited to, the systems as listed below:

<u>System</u>	<u>Working Pressure</u>	<u>Operating Temperatures</u>
Chilled Water		
High	300 psig	40°F to 60°F
Medium	300 psig	40°F to 60°F
Low	150 psig	40°F to 60°F
Condenser Water		
High	300 psig	65°F to 100°F
Medium	300 psig	65°F to 100°F
Low	150 psig	65°F to 100°F
Heating Hot Water		
High	300 psig	100°F to 180°F
Medium	300 psig	100°F to 180°F
Low	150 psig	100°F to 180°F

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Steam/Steam Relief	[150 psig]	[212°F to 375°F]
Steam Condensate/Condensate Vent	[150 psig]	[150°F to 250°F]
Condensate Drainage	--	40°F to 60°F
Temperature Control Air	20 to 200 psig	
Diesel Engine Exhaust	--	900°F to 1400°F
Refrigerant	--	--
HVAC System Fill	Match System Served	Match System Served
Chemical Treatment	Match System Served	Match System Served
HVAC Vents	Match System Served	Match System Served
HVAC Drains	50 psig	40°F to 100°F
Heat Recovery	[EDIT TO SUIT]	[EDIT TO SUIT]
Process Cooling Water	[EDIT TO SUIT]	[EDIT TO SUIT]

* Pressures

High = Floors [] through []
 Medium = Floors [] through []
 Low = Floors [] through []

- C. Basic Materials and Methods: Refer to Section 23 0300, "Basic Materials and Methods", for additional HVAC piping system requirements.
- D. Valves and Accessories: Refer to Section 23 2010, "HVAC Piping Valves and Accessories", for additional HVAC piping system components.
- E. Vibration Isolation: Refer to Section 23 0548, "Vibration Isolation", for piping system isolation.
- F. Insulation: Refer to Section 23 0700, "System Insulation", for piping system insulation.

1.3 QUALITY ASSURANCE:

- A. Welding: Qualify welding procedures, welders, and operators in accordance with ASME B31.1 or B31.9 for shop and job site welding of piping work. Make welded joints on the piping system with continuous welds, without backing rings and with pipe ends beveled before welding. Gas cuts shall be true and free from burned metal. Before welding, surfaces shall be thoroughly cleaned. The piping shall be carefully aligned and no weld metal shall project inside the pipe.

1.4 SUBMITTALS:

- A. Cut sheets marked to clearly indicate all HVAC piping system materials.
- B. Shop drawing submittals shall include, but not be limited to, the following:
 1. Piping fabrication drawings for all main piping runs **[including connections to existing piping]**. Fabrication drawings shall include plan views and suitable elevations and shall include all accessories and equipment.
 2. Pipe fabrication drawings for all pre-insulated underground piping showing location and sizes of all expansion/contraction loops, thrust block location, anchors and guides. Manufacturer shall provide detailed drawings and calculations for review by the Engineer prior to fabrication and installation of systems.

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3. Pipe fabrication drawings and cutsheets for all refrigerant piping showing all required fittings and accessories, pipe lengths and pipe sizes. Submit line sizing calculations approved by compressor unit manufacturer's application engineering department prior to installation of systems.
 4. Pipe shop drawings shall be submitted for all piping in the Central Plant, **[Utility Tunnel,]** Mechanical Rooms, Penthouse and for Equipment connections and all other areas requiring coordination with other trades.
 5. Pipe shop drawings shall be double line drawings to scale on 1/4" scale building floor plans and shall indicate pipe size, fittings, valves, accessories, connections, system type, insulation, support requirements, pipe elevations and other information required for coordination with other trades and fabrication of piping.
 6. Pipe shop drawings shall be coordinated with other trades and building construction prior to submittal for approval. Refer to Section 23 0100, "Mechanical Scope of Work" for additional shop drawing requirements.
- C. Delegated-Design Submittal for Expansion Compensation:
1. Design calculations and detailed fabrication and assembly of pipe anchors and alignment guides, expansion joints and loops, and attachments of the same to the pipe and building structure.
 2. Dimensioned locations of pipe anchors, alignment guides and expansion joints and loops in piping system.
 3. If Contractor opts to use mechanical grooved couplings for expansion compensation, provide design calculations, drawings and installation instructions for expansion joints.
- D. Additional items as required in Section 23 0100, "Mechanical Scope of Work."

1.5 PRODUCT DELIVERY, STORAGE AND HANDLING:

- A. Deliver components in factory-fabricated water-resistant packaging, as applicable.
- B. Handle components carefully to avoid damage to components, enclosures, and finish.
- C. Store components in a clean, dry space and protect from the weather.

PART 2 - PRODUCTS

2.1 PIPING MATERIALS:

- A. General: Provide pipe and tube of type, joint, grade, size, and weight (wall thickness, schedule or class) indicated for each service. Comply with applicable governing regulations and industry standards.
 1. Steel Pipe: ASME B36.10M black steel ASTM A53 with beveled or plain ends, **[electric resistance weld] [or] [seamless]** longitudinal joints, Grade B; or ASME B36.10M black steel ASTM A106 with beveled or plain ends, seamless longitudinal joints and Grade B. **[Piping shall be domestically manufactured by one of the manufacturers listed in the latest edition of the American Petroleum Institute (API) approved manufacturers listing.]**
 2. Copper Tube: ASTM B88, Types "K", or Type "L" copper tube.
 3. [Underground Cased Pipe]:

Consider using a carbon steel pipe for chilled water applications in lieu of PVC.

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- a. **Low Temperature Cased Piping:** Factory fabricated carrier pipe, insulation and casing for low temperature hydronic applications shall be Perma-Pipe Chil-Gard or an approved equal. Pre-insulated piping composed of integral sealed units of PVC plastic outer jacket, Class 160 minimum PVC plastic carrier pipe, bell and spigot type carrier pipe joints and insulated with polyurethane foam completely filling the annular space between the pipe and jacket. Jacket ends shall be protected with factory applied moisture barrier. Carrier pipe maximum pressure shall be 160 psig at 70 degrees F. Fluid temperature range is 32 degrees F to 90 degrees F.
- B. **High Temperature Cased Piping:** Factory fabricated carrier pipe, insulation and casing for high temperature hydronic applications shall be Perma-Pipe XTRU-Therm or an approved equal. Cased piping shall be composed of integral sealed units of an extruded high density polyethylene (HDPE) outer jacket, ASTM A53 Grade B, Type E or S black steel schedule 40 carrier pipe in accordance with ASME B36.10. The piping system shall be insulated with polyurethane foam completely filling the annular space between the pipe and jacket. Jacket ends shall be protected with factory applied moisture barrier. Piping shall be seamless or electric resistance welded (fully normalized after welding). All piping shall be a butt welded system in accordance with ASME B31.1 or B31.9. Carrier pipe maximum pressure shall be determined by the piping system working pressure. Fluid temperature range is up to 250 degrees F.
- C. **Steam and Steam Condensate Cased Piping:** Factory fabricated carrier pipe, insulation and casing for steam and steam condensate applications shall be Perma-Pipe Multi-Therm 750 or an approved equal. New piping system shall be fully compatible with the existing piping system which is being connected to. Cased piping shall be composed of integral sealed units of a fiberglass reinforced plastic (FRP) outer jacket, ASTM A53 Grade B, Type E or S black steel schedule 40 carrier pipe for steam and schedule 80 for steam condensate in accordance with ASME B36.10. The piping system shall be insulated with a silica aeogel type insulation completely filling the annular space between the pipe and jacket. Jacket ends shall be protected with factory applied moisture barrier. All piping shall be a butt welded system in accordance with ASME B31.1 or B31.9. Carrier pipe maximum pressure shall be determined by the piping system working pressure. The system supplier shall have fabricated systems of the composition defined herein for at least 10 years. All straight sections, fittings, anchors and other accessories shall be factory-prefabricated to job dimensions and designed to minimize the number of field welds. Each system layout shall be computer analyzed by the piping system manufacturer to determine stresses on the carrier pipe and anticipated thermal movement of the service pipe. The system design shall be in strict conformance with ASME B31.1, latest edition. Factory-trained field supervision shall be provided for the critical periods of installation, i.e., unloading, field joint instruction and testing.]

2.2 PIPE/TUBE FITTINGS:

- A. **General:** Provide factory-fabricated fittings of type, materials, grade, class, and pressure rating indicated for each service and pipe size. Provide sizes and types matching pipe, tube, valve, and equipment connections. Where not otherwise indicated, comply with governing regulations, industry standards, and where applicable, with pipe manufacturer's instructions for selections.

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1. Cast Iron Flanged Fittings: ASME B16.1, Class 125 or Class 250 as required by piping system working pressure and temperature, black including bolting and gasketing.
2. Ductile-Iron Flanged Fittings: ASME B16.42, Class 150 or 300 as required by piping system working pressure and temperature, including bolting and gasketing.
3. Malleable Iron Threaded Fittings: ASME B16.3, Class 150 or Class 300 as required by piping system working pressure.
4. Cast Iron: ASME B16.4, Class 125 and 250 as required by piping system by piping system working pressure and temperature.
5. Malleable Iron Threaded Unions: ASME B16.39, Class 150, 250 or 300 as required by piping system working pressure and temperature, select for proper piping fabrication and service requirements including style, end connections, and metal-to-metal seats (iron, bronze, or brass), plain or as specified.
6. Cast and Malleable Iron Threaded Pipe Plugs: ASME B16.14, matching material and Class of connected threaded fittings.
7. Forged Carbon Steel: ASME B16.11, matching material and Class of connected threaded fittings.
8. Forged Steel Flanges/Fittings: ASME B16.5 and B16.9, Class 150 or 300 as required by piping system working pressure and temperature, including bolting, gasketing, and butt weld end connections.
9. Forged Steel Socket-welding: ASME B16.11, rated to match schedule of connected pipe but not less than Class 3000, ASTM A105.
10. Forged Steel Threaded Fittings: ASME B16.11: ASME B16.11, Class 2000 or 3000 as required by piping system working pressure and temperature, ASTM A105.
11. Wrought Steel Butt-welding Fittings: ASME B16.9, ASTM A 234/A 234M, Grade WPB, seamless or welded, wall thickness to match adjoining pipe.
12. Pipe Nipples: ASTM A 733, Fabricated from same pipe as used for connected pipe, except do not use less than Schedule 80 pipe where length remaining unthreaded is less than 1/2". Do not thread nipples full length (no all-thread nipples).
13. Wrought Copper/Bronze Brazed or Solder-joint Fittings: ASME B16.22 suitable for working pressure up to 250 psig.
14. Copper/Bronze Pipe Nipples: ASTM B 687, extra strong wall thickness, made of same materials as pipe in which they are installed.
15. Wrought Copper/Bronze Unions: ASME B16.22.
16. Grooved End Fittings (Sizes 2-1/2" through 12"): ASTM A536 joined with Victaulic Style 177 flexible coupling or Style 107 rigid couplings and Grade "EHP" gaskets on steel systems or equal. **[On copper systems, ASTM B-75 with Style 607 coupling or equal.]**
17. Grooved End Fittings (Sizes 14" through 24"): ASTM A536 joined with Victaulic Style W07 rigid couplings and Style W77 flexible coupling and Grade "EHP" gaskets on steel systems or equal. Two (2) segment couplings shall have a wide key profile, flat bolt pads and lead-in chamfer on each coupling segment to allow for uniform tightening of the joint. Gaskets shall be wide, pressure responsive suitable for temperature associated with the piping system.
18. Grooved Expansion Joints: ASTM A536 Victaulic Style 105 or 155 for sizes or equal specifically designed for linear and axial expansion and compression in a piping system.

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19. Flanged Fittings: Comply with ASME B16.15 for bolt-hole dimensioning, materials, and flange-thickness.
 20. Flange Bolts: Bolts shall be carbon steel ASTM A307 Grade A hexagon head bolts and hexagonal nuts. Where one or both flanges are cast iron, furnish Grade B bolts. Cap screws utilized with flanged butterfly valves shall be ASTM A307 Grade B with hexagon heads.
 21. Flange Bolt Thread Lubricant: Lubricant shall be an anti-seize compound designed for temperatures up to 1000°F.
- B. Miscellaneous Piping Materials/Products:
1. Welding Materials: Comply with ASME Boiler and Pressure Vessels Code, Section II, Part C, for welding materials appropriate for wall thickness and for chemical analysis of pipe being welded.
 2. Welding Filler Metals: Comply with AWS D10.12M/D10.12 for welding materials appropriate for wall thickness and chemical analysis of pipe being welded.
 3. Brazing Materials: American Welding Society, AWS A5.B, BCup Series.
 4. Flange Gasket: Gaskets shall be suitable for service, temperature range and pressure class of system as confirmed in writing by gasket manufacturer. Consult gasket manufacturer and confirm supplied product will provide superior performance for intended application prior to installation. Where gasket manufacturer recommends a different product than specified, provide a signed letter from factory engineer with supporting documentation to justify deviation.
 - a. Flat Face Flange Gaskets for Services up to 140 deg. F: 1/16" thick for all pipe size 12" and smaller and 1/8" thick for all pipe size larger than 12". Non-metallic flat gaskets shall comply with ASME B16.21, Ring-type with punched bolt holes and pipe opening, Non-asbestos synthetic fiber with butyl rubber binder. Gaskets shall be Garlock Blue-Gard Style 3400 or equal.
 - b. Flat Face Flange Gaskets for Services over 140 deg. F: 1/16" thick for all pipe size 12" and smaller and 1/8" thick for all pipe size larger than 12". Non-metallic flat gaskets shall comply with ASME B16.21, Ring-type with punched bolt holes and pipe opening, Graphite with 316 stainless steel foil insert. Gaskets shall be Garlock Graph-Lock 3125SS or equal.
 - c. Raise Face Flange Gaskets: 0.09375" thick for all pipe size 12" and smaller and 1/8" thick for all pipe size larger than 12". Spiral wound gaskets shall comply with ASME B16.20, Ring-type with punched bolt holes and pipe opening, steel or stainless steel outer and inner ring with stainless steel winding metal and flexible graphite filler metal. Gaskets shall be Garlock FlexSeal RW series or equal.
 5. Dielectric Unions: Provide dielectric unions at all pipe connections between ferrous and nonferrous piping. Complying with ASSE 1079 and suitable for piping system working pressure and temperature.
 - a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1) A. Y. McDonald Mfg. Co.
 - 2) Capitol Manufacturing Company.
 - 3) Central Plastics Company.
 - 4) Hart Industries International, Inc.
 - 5) Jomar Valve.

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- 6) Matco-Norca.
 - 7) Watts; a Watts Water Technologies company.
 - 8) Wilkins.
 - 9) Zurn Industries, LLC.
6. Solder: All solder used for sweating of joints shall be lead free, antimony free, non-toxic solder. Provide Alloy grade E according to ASTM B 32.
 7. Thread-sealing Tape: Thread-sealing tape used for chilled and hot water applications up to 150 psi shall be stretched or non-stretched teflon tape. Thread-sealing tape used for chilled and hot water applications over 150 psi and all steam applications shall be non-stretched 0.003" thick teflon tape and shall be color-coded for identification.

PART 3 - EXECUTION

3.1 PIPING INSTALLATION:

A. General:

1. Industry Practices: Install pipe, tube, and fittings in accordance with recognized industry practices which will achieve permanently leakproof piping systems, capable of performing each indicated service without failure or degradation of service. Install each run with a minimum of joints and couplings, but with adequate and accessible unions or flanged connections to permit disassembly for maintenance/replacement of valves and equipment. Reduce sizes (where indicated) by use of reducing fittings. Align accurately at connections, within 1/16" misalignment tolerance. Coordinate piping locations with other trades to avoid conflict. Give ductwork preference unless directed otherwise by the Engineer.
 2. Systems: Install piping parallel or perpendicular to lines of building, true to line and grade, and with sufficient hangers to prevent sags between hangers. Provide fittings at changes in direction. Piping in finished areas shall be concealed, except in mechanical rooms. Where pipes of different sizes join, provide reducing elbows, tees, or couplings. Bushings will not be acceptable.
 3. Expansion and Contraction: Install anchors, loops, offsets, sizing joints, and expansion joints, as necessary, to avoid strain resulting from expansion and contraction of piping systems on fixtures and equipment.
 - a. Expansion Loops and Offsets: Provide expansion loops and offsets in piping systems for not less than one-inch (1") expansion or contraction per one hundred feet (100') of pipe.
 - b. Mechanical Grooved Couplings: Provide mechanical grooved connections where indicated on the Drawings and Specifications to reduce vibration at equipment connections. Provide expansion joints in piping systems by mechanical grooved connections where specifically indicated on the Drawings. All locations shall be approved and reviewed by the manufacturer's engineer. Delegated design drawings and calculations shall be provided and stamped by a licensed engineer. Submit delegated design for approval prior to installation.
- B. Steel Pipe: Ream steel pipe after cutting and before threading. Clean off scale, rust, oxide, dirt, inside and outside, before assembly. Thread with clean-cut taper threads of length to engage all threads in fittings and leave no full-cut threads exposed after make-up. Use

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John Crane, or approved equal, or teflon thread tape applied only to male threads to make-up joints.

- C. Copper Pipe: Cut copper pipe square and ream to remove burrs. Clean fitting socket and pipe ends with sand cloth, No. 00 cleaning pads or wire brush.
- D. Final Connections to Equipment Furnished by Owner or Under Other Divisions of These Specifications: Where Drawings show equipment to be furnished under other Divisions of these Specifications or by the Owner, such equipment will be delivered to the site, uncrated, assembled, and set in-place under those other Divisions of these Specifications or under the separate contracts. Any required automatic control valves shall also be provided under those other Divisions of these Specifications or other separate contracts. Make all final connections of chilled water, hot water, and condenser water as shown. Provide valves, unions, strainers, check valves, and traps as required for proper operation of systems and equipment. Equipment not shown or noted on the piping drawings shall not be included in the scope of this requirement.
- E. Excavation, Installation and Backfill for Underground Pipe:
 - 1. Layout: Pipes shall be laid and pipe joints made in presence of the Architect and field measurements, layouts, batter board alignment, grade establishments, and similar locations shall be performed by a Professional Engineer in the employ of the Contractor. The Contractor's engineer shall be on the job during all underground work. A "Bench-Mark" reference for use by the Contractor shall be provided by the Architect.
 - 2. Pipe Grading: Lay and maintain all pipes at required lines and grades during the course of the Work to comply with the Drawings.
 - 3. Trenching Backfilling and Compaction: Refer to Section 31 2333, "Trenching, Backfilling and Compaction" for requirements.
 - 4. Excavation and Fill: Refer to 31 2300, "Excavation and Fill" for requirements.
 - 5. Anchors: Pipes shall have concrete anchors/thrust blocks at each change in direction and/or as directed. Any change in direction exceeding 15 degrees shall be anchored. Concrete anchors shall rest against solid (virgin) ground with the required area of bearing on pipe and ground to provide suitable anchoring.
 - 6. Backfill: Backfill trenches only after piping has been inspected, tested, and approved by the Architect. Place backfill material in the trench either by hand or approved mechanical methods. The compaction of backfill material shall be accompanied by tamping with hand tools or approved pneumatic tampers, by using vibratory compactors, by puddling, or by any combination of the three. The method of compaction shall be approved and all compaction shall be done to the satisfaction of the Architect. Backfill completely around pipe, including 18" above the pipe, with suitable bank sand, tamped in 4" layers under, around, and over pipe. Water down backfill as required. The remainder of the backfill for pipes shall be select backfill material tamped at intervals of no more than 12" depths, to attain a 95% Proctor Compaction Density. All materials to be used as select material backfill shall be approved by the Architect. If, in the opinion of the Architect, the excavated material does not meet the requirements of select material, the Contractor shall be required to screen the material prior to its use as select material backfill. Material used in the upper portion of the backfill or subgrade shall not contain stone, rock, or other material larger than 6" in its longest dimension. No wood, vegetable matter, or other material, which in the opinion of the Architect is unsuitable, shall be included in

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the backfill. The upper 24" of backfill may be water jetted, if desired. Bring backfill up to finish grade identified on the Drawings, including additional backfill required to offset settlement during consolidation. When removal of unsuitable, excavated material creates a shortage of backfill material, the Contractor shall, at no change in Contract amount, furnish material as specified in this Section in the amount required to complete the backfill.

7. Existing Surfaces: Restore existing streets, driveways, and sidewalks damaged during the excavation work to acceptable condition, subject to approval by the Architect.
8. Safety: Provide street and sidewalk excavations with approved barricades, warning lights, and cover plates as required by the City of Houston. Refer to Section 23 0300, "Basic Materials and Methods and Division 1 for additional requirements.
- F. Basic Materials and Methods: Refer to Section 23 03 00 for additional requirements related to HVAC piping.

3.2 CHILLED WATER, CONDENSER WATER AND HEATING HOT WATER PIPING SYSTEMS [**ABOVE GROUND**]:

- A. Pipe: Black steel, ASTM A53, [**Schedule 40**][**Schedule 80**], 10" and below, and [**Standard Weight**][**Schedule 80**], 12" and above.
- B. Fittings:
 1. Service Pressure at or Less Than 150 psig:
 - a. Fittings, 2" in diameter and smaller, threaded, Class 150 rated, black, banded, malleable iron.
 - b. Fittings, 2-1/2" in diameter and larger, factory-fabricated, Class 150, weld-type.
 - c. Flanges, Class 125, forged steel weld neck.
 2. Taps and Branches: "Weld-O-Lets", "Thread-O-Lets", or "Branch-Lets" may be employed at locations where taps or branches join line pipe, provided the tap or branch does not exceed 1/3 the size of the line pipe. Factory-fabricated wye and tee fittings may be welded into the main. "Weld-O-Lets", "Thread-O-Lets", or "Branch-Lets" shall comply with ASME B16.9.
 3. Service Pressure Greater Than 150 psig:
 - a. Fittings, 2" in diameter and smaller, threaded, 300 psig, black, banded, malleable iron.
 - b. Fittings, 2-1/2" in diameter and larger, factory-fabricated, weld-type, rated for greater than 300 psig.
 - c. Flanges, Class 250, weld neck, welding flanges at valves and all flanged connections.
4. Provide dielectric fitting whenever dissimilar materials are used.
5. Option: At the Contractor's option, for piping 4" or larger, a grooved piping connection system with "roll-grooves" or "cut-grooves" may be used. Rigid couplings shall be used at valves and in other areas where piping system rigidity is required. The use of boltless couplings, reducing couplings and Mechanical "T" fittings with U-bolts is prohibited. Grooved couplings shall be capable of visual inspection and verification for correct installation without minimum torque requirements. A manufacturer's representative shall provide on-site training of field personnel on the proper installation of grooved products. Manufacturer's representative shall provide a minimum of [4] visits to construction site to review product installation. Contractor shall remove and replace and improperly installed products. Manufacturer's representative shall submit a written report for each site visit.

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- C. All piping shall be a butt-welded system in accordance with ASME B31.1 or ASME B31.9 except with flanges where required for service or equipment connections. All flanged or screwed connections shall be accessible for repair and shall not be permitted in inaccessible locations. Screwed fittings and flanges may be used on pipe sizes up thru 2" IPS. All taps shall be made using factory-manufactured fittings.
- D. Welded fittings shall be factory made wrought steel in accordance with ASME B16.9 with wall thickness and material identical to pipe being fitted. Flanges shall be ASME B16.5 forged steel with beveled edge weld type neck. All butt weld fittings shall have wall thickness as specified by ASME B31.1, ASME B31.9 and ASME B36.10 standards and they shall be suitable for the working pressure and temperature of the piping that they are installed in. No branch piping tap to the main shall be made by burning a hole in the main, inserting the end of the branch piping and then welding the branch piping to the main.
- E. Cold-springing: Cold-springing of piping will not be permitted.
- F. Pitch: Install chilled, hot, and condenser water piping with an upward pitch in direction of flow and to air vents of not less than one inch (1") in forty feet (40').
- G. Basic Piping Installation: Refer to Section 23 0300, "Basic Materials and Methods".

3.3 [CHILLED WATER PIPING SYSTEMS UNDERGROUND:]

- A. **[Piping: Underground chilled water piping shall be a cased piping system designed for low temperature fluids.]**
- B. **[Connections: Units and fittings shall be joined with integral bell and spigot joints, including a rubber sealing ring. All pipe shall be suitable for use as a pressure conduit. Provisions shall be made for expansion and contraction at each joint with an elastomeric ring. The bell shall consist of an integral wall section with a solid cross-section elastomeric ring which meets the requirements of ASTM D1869 and ASTM E477. The bell section shall be designed to be as least as strong as the pipe wall. Standard laying lengths shall be 20'. Each length of pipe shall be tested to four times the class pressure of the pipe for a minimum of 5 seconds. The integral bell shall be tested with the pipe.]**
- C. **[All steel piping adjoining this system shall be anchored at or near the point of connection. Connection between PVC and steel pipe shall be made by inserting steel pipe into PVC end or with a flexible expansion coupling as recommended by the manufacturer. The Contractor shall pour concrete thrust blocks, prior to testing pipe, at every change of direction. The block size shall be in accordance with normal water line installation for the existing soil conditions and in accordance with the manufacturer's recommendations.]**
- D. **[Expansion and contraction shall be taken up as recommended by pipe manufacturer.]**
- E. **[All required calculations for the sizing and placement of concrete thrust blocks at all changes in direction shall be provided by the pre-insulated piping manufacturer. Soil loading information shall be provided by the Structural Engineer. The Mechanical Contractor shall submit thrust block sizing calculations for review by the Engineer prior to installation of below grade pipe. Calculations shall include thrust in pounds, bearing area of thrust block in square feet and direction of thrust. General Contractor shall furnish and install all required concrete formwork and shall pour all concrete for thrust blocks.]**

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- F. [Immediately after the system is installed in the trench, a partial backfill shall be made in the middle of each unit, leaving the joints exposed for inspection during the hydrostatic testing. After all thrust blocks are poured, a hydrostatic test as specified hereinbelow shall be performed. After successful hydrostatic testing, backfill trench as specified.]

3.4 HEATING HOT AND CONDENSER WATER PIPING SYSTEMS UNDERGROUND:]

- A. [**Piping:** Underground heating hot water piping shall be a cased piping system designed for high temperature fluids.]
- B. [**Connections:** All elbows, tees, couplings, will be prefabricated and insulated by manufacturer. Insulation and vapor barrier shall be installed over welded areas in accordance with manufacturer's published data and shall be of the same material and thickness as the adjacent straight section.]
- C. [Expansion and contraction shall be taken up as recommended by pipe manufacturer.]
- D. [All required calculations for the sizing and placement of concrete thrust blocks at all changes in direction shall be provided by the pre-insulated piping manufacturer. Soil loading information shall be provided by the Structural Engineer. The Mechanical Contractor shall submit thrust block sizing calculations for review by the Engineer prior to installation of below grade pipe. Calculations shall include thrust in pounds, bearing area of thrust block in square feet and direction of thrust. General Contractor shall furnish and install all required concrete formwork and shall pour all concrete for thrust blocks.]
- E. [The Contractor shall pour concrete thrust blocks, prior to testing pipe, at every change of direction. The block size shall be in accordance with normal water line installation for the existing soil conditions and in accordance with the manufacturers recommendations.]
- F. [Immediately after the system is installed in the ditch, a partial backfill shall be made in the middle of each unit, leaving the joints exposed for inspection prior to the hydrostatic test. After all thrust blocks are poured, a hydrostatic test as specified in Section 23 05 93, "Operational Test-Adjust-Balance", shall be performed.]

[OR]

3.5 [CHILLED, CONDENSER AND HEATING HOT WATER PIPING SYSTEMS UNDERGROUND:]

- A. [**General:** Underground chilled and heating hot water piping shall be a cased piping system.]
- B. [**Internal Piping:** All joints shall be butt-welded for sizes 2-1/2" and greater, and socket-welded for 2" and below. Straight sections shall be supplied with 8" of piping exposed at each end for field joint fabrication. End seals, gland seals, and anchors shall be designed and factory-fabricated to prevent the ingress of moisture into the system.]
- C. [**Insulation:** Carrier pipe insulation shall be spray-applied nominal 2 pounds per cubic foot density, polyurethane foam for straight sections and performed polyurethane foam for all fittings. To ensure no voids are present, all insulation shall be inspected by one of the following three methods: visually checked prior to application of the protective jacket, infrared inspection of the entire length, or x-ray inspection of entire length. The insulation shall be applied to a minimum thickness of [3"] [____].]
- D. [**Field Joints:** After the internal pipe has be hydrostatically pressure tested. Insulation shall then be poured in place into the field weld area. All field-applied insulations shall

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be placed only in straight sections. The joint area shall be backfilled only after the jacket has hardened, and has been visually inspected. All insulation and coating materials for making the field-joint shall be furnished by the piping system manufacturer.]

- E. **[Backfill:** A 4" layer of sand or fine gravel shall be placed and tamped in the trench to provide a uniform bedding for the pipe. The entire trench width shall be evenly backfilled with a similar material as the bedding is 6" compacted layers to a minimum height of 6" to 12" above the top of the insulated piping system. The remaining trench shall be evenly and continuously backfilled in uniform layers with suitable excavated soil.]
- F. **[All piping shall be clean when it is installed. Before installation it shall be checked, upended, swabbed, if necessary, and all rust or dirt from storage or from laying on the ground shall be removed. The Contractor is cautioned to exercise rigid control of the interior cleanliness of the pipe as it will be impossible to flush clean after assembly.]**
- G. **[Thrust Blocks:** Thrust blocks shall be provided at all changes in direction of underground water piping, as shown on the Drawings or recommended by the manufacturer.]

[SELECT ONE OF THE FOLLOWING]

3.6 [UNDERGROUND STEAM AND CONDENSATE PIPING SYSTEMS:]

- A. **[General:** Underground steam and condensate piping shall be cased piping system specifically designed for steam and steam condensate piping.
- B. **[External Piping:** All joints shall be butt-welded for sizes 2-1/2" and greater, and socket welded for 2" and below. Straight sections shall be supplied with 6" of piping exposed at each end for field joint fabrication. Gland seals and anchors shall be designed and factory-prefabricated to prevent the ingress of moisture into the system. All sub-assemblies shall be designed to allow for complete draining and drying of the conduit system.]
- C. **[Insulation:** The insulation shall have passed the most recent boiling test and other requirements specified in the Federal Agency Guidelines Specifications FCGS 15705. The insulation shall be applied to a thickness of inches.]
- D. **[Outer Conduit:** Conduit casing shall be a 180 mil airtight, pressure testable, multi-layered composite fiberglass reinforced thermosetting resin pipe comprised of a two-part corrosion barrier not less than 45 mils thick and a filament wound structural wall. The glass to resin ratio for the inner surface, corrosion barrier and structural wall shall be not greater than 20:80, 30:70 and 70:30, respectively. The outer layer shall contain 0.2 to 0.3% by weight of ultraviolet inhibitors for protection during outdoor storage.]
- E. **[Pipe Supports:** All pipes within the outer casing shall be supported at not more than 10' intervals. These supports shall be designed to allow for continuous airflow and drainage of the conduit in place. The straight supports shall be designed to occupy not more than 10% of the annular air space. Supports shall be of the type where insulation thermally isolates the carrier pipe from the outer conduit. The surface of the insulation shall be protected at the support by a sleeve not less than 12" long, fitter with traverse, and, where required, rotational arresters.]
- F. **[Expansion Loops, Ells and Tees:** Prefabricated ells, loops and tees shall be furnished and installed where shown on Drawings or recommended by the piping system manufacturer and shall consist of pipe, insulation, and conduit conforming to the same specification as

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hereinbefore specified for straight runs. Expansion loops shall be of proper design in accordance with stress limits indicated by ASME Code for Pressure Piping, District Heating Section. Loop piping shall be installed in conduit suitably sized to handle indicated pipe movement. All inner pipe loops and expansion bends shall be cold sprung 50% in the field by the Contractor.]

- G. **[Anchors:** Prefabricated plate anchors shall be furnished and installed where shown on Drawings or as recommended by the manufacturer and shall consist of a steel plate welded to pipe and conduit. The steel plate shall be 3/8" thick for 6-5/8" to 10-3/4" conduit, 1/2" thick for 12" to 22" conduit and 3/4" thick for conduit over 22". A concrete block shall be cast over the plate and conduit shall be large enough for firm anchorage into undisturbed trench sidewalls and/or bottom. The concrete block to be at least 30" in length and extend a minimum of 9" beyond the top and bottom of anchor plate.]
- H. **[Conduit Air Test:** All field joints in conduit closures shall be tested for leaks before backfill. During test all field joints shall be checked with soap suds and resealed if necessary until air tight at 15 pounds pressure. The Contractor shall furnish all necessary equipment and labor to perform the air test, including air compressor, gauges, conduit caps, temporary pipe and connections, etc., and complete the test to the satisfaction of the Architect and/or Engineer.]
- I. **[Manufacturer's Field Service Instructor:** Who is technically qualified to determine whether or not the installation is being made in accordance with the manufacturer's recommendations shall be present during critical periods of installation and test of the system. On completion of the installation, the Contractor shall deliver to the Owner a certificate from the manufacturer stating that the installation has been made in accordance with the manufacturer's recommendations.]
- J. **[Installation:** The installing contractor shall handle the system in accordance with the directions furnished by the manufacturer and as approved by the Architect and Engineer. The casing shall be air-tested at 8 psig and the service piping shall be hydrostatically hammer tested to 150 psig or 1-1/2 times the operating temperature, or as specified in the contract documents. The test pressure shall be held for not less than 24 hours.]
- K. **[Backfill:** A 4" layer of sand or fine gravel shall be placed and tamped in the trench to provide a uniform bedding for the conduit. The entire trench shall be evenly backfilled with a similar material as the bedding in 6" compacted layers to a minimum height of 6" above the top of the insulated piping system. Bedding and backfill materials shall be as recommended by the manufacturer.]
- L. **[Thrust Blocks:** Provided at all changes in direction of underground steam and condensate piping, as shown on the Drawings. Pipe expansion loops and anchors shall be provided in underground steam and condensate piping as recommended by the manufacturer. All required calculations for the sizing and placement of concrete thrust blocks at all changes in direction shall be provided by the pre-insulated piping manufacturer. Soil loading information shall be provided by the Structural Engineer for the Mechanical Contractor to forward to the manufacturer. The Mechanical Contractor shall submit thrust block sizing calculations for review by the Engineer prior to installation of below grade pipe. Calculations shall include thrust in pounds, bearing area of thrust block in square feet and direction of thrust. Mechanical Contractor shall furnish and install all required concrete formwork and shall pour all concrete for thrust blocks.]

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3.7 CONDENSATE DRAINAGE:

- A. General: Drain piping shall be provided from each air handling unit, fan coil unit, water chilling unit, heat exchanger, pump base drain, vessel overflow, auxiliary drain pan, piping system drain, and elsewhere where drains are required and shall extend to the nearest floor drain, hub drain or condensate drainage system. Drains shall be sized as indicated but not less than the drain connection size. Air handling unit and fan coil unit drains shall have deep seal traps at each blow-through or draw-through unit to maintain water seal. Provide cleanouts on each change of direction on deep seal traps.
- B. Drain piping shall be fabricated of Schedule 40 black steel pipe and threaded fittings or Type "L" hard drawn copper tubing and wrought copper solder type fittings.
- C. **[Drain piping exposed on the roof shall be insulated and jacketed in an aluminum jacketing.]**

3.8 REFRIGERANT PIPING:

- A. General: Refrigerant piping shall be fabricated of Type K or L hard drawn "ACR" tubing that has been cleaned and capped for refrigeration service. Fittings shall be wrought copper and shall be installed with solder or brazed joints, depending on the refrigerant working pressure. The end of all pipe and the inside of all fittings shall be carefully cleaned before joining. No acid shall be used in cleaning or as a flux in soldering joints. Bleed nitrogen through all piping while soldering.
- B. Furnish, size, install and insulate refrigerant pipe for the system as required. Provide all valves and accessories required to provide a complete and function refrigeration system. Manufacturer shall size all refrigerant piping. Be sure to account for losses due to piping, fittings and other accessories.
- C. Provide replaceable core type liquid line filter dryer sized for system capacity at 2 psig pressure drop per ARI Standard 710, sight glass-moisture indicator, thermal expansion valve with adjustable superheat, refrigerant shutoff, relief and solenoid valves recommended by the equipment manufacturer and any other required accessories to provide a complete and function system.
- D. Install and insulate all refrigerant piping per unit manufacturers recommendations. Slope all lines to facilitate oil return to compressor. Provide suction line traps per manufacturers recommendations. Refrigerant piping shall be installed as shown except that modifications shall be made as recommended by the manufacturer. Such modifications shall be made at no cost to the Owner.
- E. Test and dehydrate all refrigerant piping as specified hereinbelow.
- F. After dehydration, introduce the manufacturers recommended type and quantity of refrigerant into system through a filter/dryer.

3.9 DIESEL ENGINE EXHAUST PIPING:

- A. Pipe: Black steel, ASTM A53, Schedule 40.
- B. Fittings: Factory-fabricated Class 150, weld-type.
- C. All connections shall be welded and all weld type fittings shall be smooth radius type as recommended by the diesel engine manufacturer (minimum center line radius shall be 1.5 times the pipe diameter. Provide weld neck flanges where required for connection to

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diesel engine, muffler, and flexible connection supplied with the emergency generator by Division 16.

- D. Contractor shall install and insulate complete diesel exhaust system. All required accessories; muffler, flex connector, roof or wall thimble and weatherproof discharge flapper shall be provided with the generators **[and with the fire pump(s)]**.
- E. Size of the diesel exhaust piping shall be coordinated with the generator **[and with the fire pump(s)]** furnished and the actual field routing and installation shall be in accordance with the drawings. This coordination shall be performed prior to any fabrication or installation.

3.10 PIPING SYSTEM PRESSURE TESTS

A. General:

1. Pressure test piping and prove free of leaks before beginning insulation work and before flushing, cleaning, rinsing and treating procedures.
 2. Pressure test piping as indicated below:
 - a. Chilled Water: 150 psig or 1-1/2 times working pressure, whichever is greater.
 - b. Heating Hot Water: 150 psig or 1-1/2 times working pressure, whichever is greater.
 - c. Condenser Water: 150 psig or 1-1/2 times working pressure, whichever is greater.
 - d. Steam: 150 psig or 1-1/2 times working pressure, whichever is greater.
 - e. Steam Condensate: 150 psig or 1-1/2 times working pressure, whichever is greater.
 - f. Drain and Vent: Test hydraulically by filling system to its highest point plus an additional static head of 10 feet.
 - g. Compressed Air Piping: Test with compressed air or nitrogen to a pressure at 150% of the expected maximum service pressure, but not less than 150 psig.
 3. Provide equipment, materials and test connections required to execute tests.
 - a. Furnish air and water for test purposes.
 - b. Remove temporary connections upon completion of testing.
 4. Make tests before piping surfaces are concealed and insulated.
 5. Increase hydrostatic test pressure in incremental steps, with rest periods, to permit stress stabilization. Final hydrostatic test pressure shall be as indicated.
 6. Remove components from piping systems during testing whenever component may sustain damage due to test pressure or test media. After completion of test, reinstall the component and reapply test at component pressure rating.
 7. Check system components such as valves for functional operation under system test pressure. If hydrostatic test pressure exceeds valve manufacturer's rating for hydrostatic seat test, termination block valves shall remain open during test and determine other means and methods to block system.
- #### B. Piping System Acceptance: Perform pressure testing for each piping system as follows:
1. Chilled Water, Heating Hot Water and Condenser Water Systems: Hydro test at test pressure indicated for a continuous period of not less than 24 hours while staying within a maximum allowable pressure drop of **[2]** **<Insert value>** psig with allowable corrections for changes in temperature.

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2. Steam and Steam Condensate Systems: Hydro test at test pressure indicated for a continuous period of not less than 24 hours while staying within a maximum allowable pressure drop of **[2]** **<Insert value>** psig with allowable corrections for changes in temperature.
3. Drain and Vent Systems: Test pressure shall remain constant during testing, after stabilization, for a continuous period of not less than 4 hours without addition of water or air.
4. Compressed Air Systems: Test at test pressure indicated for a continuous period of not less than 24 hours while staying within a maximum allowable pressure drop of **[2]** **<Insert value>** psig with allowable corrections for changes in temperature.
- C. Refrigerant Piping Pressure Test: After completion of the system installation but prior to charging the piping with the refrigerant, perform the following:
 1. Test system with dry carbon dioxide at 250 psig or 1-1/2 times working pressure, whichever is greater prior to charging the system.
 2. Test joints under pressure with soap solution. During the test, isolate expansion valves and other auxiliary devices to prevent damage due to high pressure.
 3. After the initial pressure test has been completed and the system proved tight, introduce a mixture of refrigerant and dry carbon dioxide into the system at 150 psig and test all devices and fittings for leaks using a halide torch.
 4. Following the satisfactory completion of all tests, evacuate the system by means of a vacuum pump connected to the liquid line. After 20" of vacuum is obtained, close the suction and discharge valves at the compressor and continue evacuation for 24 hours. Vacuum shall be measured with a mercury column vacuum gauge.
 5. Test at test pressure indicated for a continuous period of not less than 24 hours while staying within a maximum allowable pressure drop of **[2]** **<Insert value>** psig with allowable corrections for changes in temperature. This shall be completed for each step listed.
- D. If testing indicates leaks, determine sources of leaks, repair or replace defective materials and workmanship, and retest installation to the specified requirements.
- E. Witness Tests: Test in presence of Testing, Adjusting and Balancing agent. Invite Commissioning Agent, Architect and Owner to witness testing with attendance being optional.
 1. Provide written notification at least five (5) business days before each test.
- F. Test Reports: Prepare and maintain test records of piping systems tests.
 1. Records indicating test personnel names with contract information and test responsibilities, dates and times, test gauge identification numbers, signature and company affiliation of individuals witnessing testing.
 2. Record test water temperature, ambient temperature, test pressure, actual and allowable pressure drop, and time at not less hourly intervals.
 3. Submit acceptance test reports for record purposes.
 4. Receive approval of proposed test procedures before proceeding with work.

3.11 VISUAL PIPE INSPECTION

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- A. Before pressure testing, Contractor shall visually inspect each run of each system for completion of joints, adequate hangers, supports, and inclusion of accessories and appurtenances. Be sure to visually inspect [100] <Insert value> percent of field welds.
- B. Visual Inspection shall be done by a qualified testing agent according to ASME Piping Code.
- C. Provide report to Architect and Owner indicated any deficiencies found and actions taken to remediate deficiencies.

3.12 EXTERIOR PIPE CLEANING

- A. Exterior Piping Cleaning: Clean exterior surfaces of installed piping systems and prepare surface for application of any required coatings.

3.13 FLUSHING, CLEANING, RINSING AND TREATING

- A. Chemical Treating: Refer to Section 23 2500, "Water Treatment Systems", for flushing and cleaning systems.
- B. Refer to Section 23 0300, "Basic Materials and Methods for additional pipe flushing and cleaning requirements.
- C. Do not use permanent house pumps for flushing process. Provide temporary pumps.
- D. Steam systems may be flushed with steam in lieu of following the specified procedure.
- E. During the flushing, cleaning, rinsing and treating process, at no point shall the water velocity in the piping drop below six (6) feet per second.
 - 1. If six feet per second cannot be maintained in large diameter pipe sizes by portable equipment, provide an alternative procedure to obtain similar results and submit to Architect and Owner for approval.
- F. Chemicals and Chemical Waste: Chemicals shall be received, handled, stored, dispensed, and together with resultant waste water, shall be deactivated or disposed of according to requirements of environmental authorities having jurisdiction, laws, codes, and regulations.
- G. Witness Tests: Test in presence of chemical treatment representative. Invite Commissioning Agent, Test and Balance Agent, Architect and Owner to witness testing with attendance being optional.
 - 1. Provide written notification at least five (5) business days before each test.
- H. Reports: Prepare and maintain records of flushing, cleaning, rinsing and treating work.
 - 1. Records shall show personnel responsibilities, dates, ambient temperature, results and signature with company affiliation of individuals witnessing testing.
 - 2. Submit for information and record purposes.
 - 3. Receive approval of proposed procedures before proceeding with work.

3.14 IDENTIFICATION:

- A. Refer to Division 23 Section "Basic Materials and Methods" for applicable painting, nameplates, and labeling requirements.

END OF SECTION 23 2000

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