

SECTION 23 20 00 - HVAC PIPING SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS:

- A. The Conditions of the Contract and applicable requirements of Division 1, "General Requirements", and Section 23 01 00, "Mechanical General Provisions", govern this Section.

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
Steam/Steam Relief	[150 psig]	[212°F to 375°F]
Steam Condensate/Condensate Vent	[150°F]	[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	--	--

* Pressures

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

- C. Basic Materials and Methods: Refer to Section 23 03 00, "Basic Materials and Methods", for additional HVAC piping system requirements.
- D. Valves and Accessories: Refer to Section 23 20 10, "HVAC Piping Valves and Accessories", for additional HVAC piping system components.
- E. Vibration Isolation: Refer to Section 23 05 48, "Vibration Isolation", for piping system isolation.
- F. Insulation: Refer to Section 23 07 00, "System Insulation", for piping system insulation.

1.3 QUALITY ASSURANCE:

- A. Welding: Qualify welding procedures, welders, and operators in accordance with ANSI B31.1, Paragraph 127.5, 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. Shop drawing submittals shall include, but not be limited to, the following:
 - 1. Cut sheets marked to clearly indicate all HVAC piping system materials.
 - 2. 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.
 - 3. 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.
 - 4. Pipe fabrication drawings and cutsheets for all refrigerant piping showing all specified 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.
 - 5. Additional items as required in Section 23 01 00.

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: ASTM A53 or ASTM A106, ANSI B36.10 black as specified. **[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", Type "L", or Type "M" copper water tube as defined by the Copper and Brass Research Association.
 - 3. Preinsulated Steel Pipe: ASTM A53, ASTM A106, and ANSI B31.1. [Piping shall be domestically manufactured by one of the manufacturers listed in the latest edition of the American Petroleum Institute (API) approved manufacturers listing.]

2.2 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.
 - 1. Cast Iron Flanged Fittings: ANSI B16.1, Class 125 or Class 250, black including bolting and gasketing.
 - 2. Malleable Iron Threaded Fittings: ANSI B16.3, Class 150 or Class 300, black as specified.
 - 3. Malleable Iron Threaded Unions: ANSI B16.39, 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.
 - 4. Threaded Pipe Plugs: ANSI B16.14.

5. Steel Flanges/Fittings: ANSI B16.5 and B16.9, including bolting, gasketing, and butt weld end connections.
6. Forged Steel Socket-welding and Threaded Fittings: ANSI B16.11, rated to match schedule of connected pipe.
7. Wrought Steel Butt-welding Fittings: ANSI B16.9, except ANSI B16.28 for short radius elbows and returns; rated to match connected pipe.
8. Pipe Nipples: 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).
9. Wrought Copper/Bronze Solder-joint Fittings: ANSI B16.22 suitable for working pressure up to 250 psig.
10. Grooved End Fittings: ASTM A47 or ASTM A536 joined with Victaulic Style 77 or Style 07 couplings and Grade "E" gaskets on steel systems. **[On copper systems, ASTM B-75 Alloy 12200 or sand casting B-S84-87 Alloy CDA844 (81-3-7-9) with Style 606 coupling.]**
11. Flanged Fittings: Comply with ANSI B16.15 for bolt-hole dimensioning, materials, and flange-thickness.
12. 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.
13. Flange Bolt Thread Lubricant: Lubricant shall be an antiseize compound designed for temperatures up to 1000°F and shall be Crane Anti-Seize Thread Compound or approved equal.

B. Miscellaneous Piping Materials/Products:

1. Welding Materials: Comply with ASME Boiler and Pressure Vessels Code, Section II, Part C, for welding materials.
2. Brazing Materials: American Welding Society, AWS A5.B, Classification BCup-5.
3. Gaskets for Flanged Joints: 1/16" thick for all pipe size 10" and smaller and 1/8" thick for all pipe size 12" and larger. Ring-type shall be used between raised face flanges and full face-type between flat face flanges with punched bolt holes and pipe opening. Gaskets shall be Garlock Style 3400 compressed nonasbestos or equal.
4. Insulating (Dielectric) Unions: Provide dielectric unions at all pipe connections between ferrous and nonferrous piping. Unions shall be "Delvin" as made by Pipeline Seal and Insulator Company or "EPCO" as made by Epco Sales, Inc. and shall have nylon insulation, or "Clearflow" waterway by Victaulic.
5. Solder: All solder used for sweating of joints shall be 95/5 tin-antimony or tin-silver.
6. Threadsealing Tape: Threadsealing tape used for chilled and hot water applications up to 150 psi shall be stretched or nonstretched teflon tape. Threadsealing tape used for chilled and hot water applications over 150 psi and all steam applications shall be nonstretched 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 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.
- B. Steel Pipe: Ream steel pipe after cutting and before threading. 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 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. Trench: Excavate the trench to the depth required. Properly brace and dewater the trench and keep it free of water during installation, testing pipe, and backfilling. No water shall be discharged onto the street or freeway without approval by the Architect. Refer to Section 220000 for additional requirements.
 4. Excavation: The trench shall be at least 18" wider than the maximum diameter of the pipe and the pipe shall be laid in the center of the trench. The trench shall be excavated to a depth sufficient to provide for pipe cushions or supports as specified. Trench width may be increased as required and piling left in place until sufficient compacted backfill is in place. Properly sheet and brace all open trenches to render them secure and remove all such sheeting and bracing before completing the backfill. Comply with local regulations or, in the absence thereof, with the "Manual of Accident Prevention in Construction" of the Associated General Contractors of America, Inc. The quantity of excavation required to install sheeting and the installation and removal of sheetings and bracings will not be regarded as Extra Work. All costs incurred for this excavation and the installation of sheeting shall be included in the Contract Price. Refer to Section 23 03 00 for additional requirements.
 5. Grading: Upon completion of excavation and prior to the laying of the pipe, the trench bottom shall be brought up to the required elevation with a pipe cushion, except where the cushion has

been eliminated by the Engineer. Pipe cushions shall be select material deposited in the trench and shall be compacted, leveled off, and shaped to obtain a smooth compacted bed along the laying length of the pipe. Pipe cushion material shall comply with local codes. In absence of local code requirements, the cushion shall be bank sand or select backfill material approved by the Architect. Any material used shall pass a one inch (1") screen.

- a. Stable, Firm Semi-dry Trench: Piping shall be laid on undisturbed earth, in a constant uniformly sloped trench. Laying space for mechanical joints shall be hand cut to 6" either side of the joint and stabilized sand poured and wet in to even with the natural earth trench bottom. The pressure test of the piping system shall be inspected by the Owner's Representative prior to covering the piping. Failure to notify the Owner's Representative for inspection prior to covering the piping will result in the piping being uncovered and the test being performed again. Where the slope of the trench is found to belly down along the line of piping, before joining, the pipe shall be removed from the trench and the belly converted to uniform slope by adding stabilized bank sand, wet down and slightly mounded to the center of the trench. The section of piping will then be "rolled" into place so with support uniform along its entire length. Where the slope of the trench is found to arch up along the line of piping, before joining, the pipe shall be removed from the trench and the arch converted to uniform slope by cutting the arch out. The section of piping will then be reset into place with support uniform along its entire length.
 - b. Wet Clay - Black Gumbo: Piping shall be laid in a constant, uniformly sloped trench. After shaping, the trench shall receive 3" minimum clean bedding sand, which shall be uniformly distributed on the trench bottom. Laying space for the mechanical joints shall then be hand removed and the piping placed on the setting bed with the weight of the piping distributed evenly on the setting bed over its entire length. The pressure test of the piping system shall be inspected by the Owner's Representative prior to covering the piping. Failure to notify the Owner's Representative for inspection prior to covering the piping will result in the piping being uncovered and the test performed again.
 - c. Rock: Where rock is encountered, the trench shall be excavated to a minimum of 6" below the pipe elevation and then backfilled with bedding sand to provide a uniform layer for pipe support. Backfill shall be as indicated for Wet Clay - Black Gumbo.
 - d. Special Considerations: Where the expansive soil conditions on the site, special precautions shall be taken to prevent pushing and breakage of underground piping. Precautions shall be in accordance with local installation techniques and may include carton forms or special pipe bedding. Installation methods shall comply with preinsulated piping system manufacturer's requirements where applicable.
6. 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.
 7. 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 the backfill. The

upper 24" of backfill may be water jetted, if desired. Bring backfill up to finish grade identified on the Architectural 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.

8. Existing Surfaces: Restore existing streets, driveways, and sidewalks damaged during the excavation work to acceptable condition, subject to approval by the Architect.
9. Safety: Provide street and sidewalk excavations with approved barricades, warning lights, d cover plates as required by the City. Refer to Section 23 03 00 and Division 1 for additional requirements.

F. Pipe Fabrication Drawings:

1. Pipe fabrication 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.
2. Pipe fabrication 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 pipings.
3. Pipe fabrication drawings shall be coordinated with other trades and building construction prior to submittal for approval. Refer to Section 23 01 00 for additional shop drawing requirements.

G. 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, 10" and below, and Standard Weight, 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.
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 isolation 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. Grooved couplings shall be Victaulic Style 75, Style 77 with Grade "E" gaskets. Rigid couplings shall be used at valves and in other areas where piping system rigidity is required and shall be Victaulic Style 07 Zero-Flex couplings with Grade "E" gaskets. Taps to mains shall be made using Victaulic Style 72 or Style 920 hot dip galvanized outlet couplings or fittings. Mechanical "T" couplings with U-bolts shall not be permitted. Flange connections shall be made using Victaulic Style 741 flanges with Grade "E" gaskets. Fittings for elbows, tees, reducers, etc. shall be Victaulic hot dip galvanized full flow fittings. All grooved piping connection materials shall be utilized with the manufacturer's recommended groove cutting tool. All grooved piping couplings and fittings used in association

with an individual coupling or fitting shall be by the same manufacturer. The use of boltless couplings, reducing couplings and Mechanical "T" fittings with U-bolts is prohibited. All wetted surfaces in the piping system shall be hot dip galvanized and all proposed grooved piping connection materials shall be suitable for domestic water use at the temperatures and pressures at the point of application. Painted couplings may be used where they meet the above requirements. Grooved reducing couplings shall not be installed.

- C. All piping shall be a butt welded system in accordance with ANSI B31.1.0 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 ANSI B16.9 with wall thickness and material identical to pipe being fitted. Flanges shall be ANSI B16.5 forged steel with beveled edge weld type neck. Branch piping taps more than one size smaller than the main shall be made with weld-o-lets and/or thread-o-lets (integrally reinforced branch weld-on fittings) manufactured in accordance with ANSI B16.9. All butt weld fittings shall have wall thickness as specified by ANSI B31.1.0 and ANSI 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 40'.
- G. Basic Piping Installation: Refer to Section 23 03 00.

3.3 **[CHILLED AND CONDENSER WATER PIPING SYSTEMS UNDERGROUND:]**

- A. **[Piping: Underground chilled water piping shall be Ric-Wil Chil-Gard or an approved equal preinsulated piping composed of integral sealed units of PVC plastic outer jacket, 150 psig PVC plastic carrier pipe, 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. Underground condenser water piping shall be Manville DR-25 "Blue Brute" or approved equal PVC bell and spigot type and shall be designed for 100 psig and shall be Class 100 in accordance with AWWA C900 requirements for Polyvinyl Chloride (PVC) pressure pipe.]**
- 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 manufacturers 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 preinsulated 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.]**

- 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 [CHILLED AND HEATING HOT WATER PIPING SYSTEMS UNDERGROUND:]

- A. [Piping: Underground chilled and heating hot water piping shall be Ric-Wil Terra-Gard System or an approved equal composed of integral sealed units of PVC plastic outer jacket, black steel standard weight class carrier pipe in accordance with ANSI B36.10. Preinsulated black steel pipe with insulation and "FRP" outer jacket as manufactured by Perma-Pipe shall be considered an equal. Piping 4" and smaller shall be ASTM A120 black steel. Piping 5" and larger shall be black steel ASTM A53 seamless or electric resistance welded (fully normalized after welding). All piping shall be a butt welded system in accordance with ANSI B31.1.0. 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.]
- 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 preinsulated 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 AND HEATING HOT WATER PIPING SYSTEMS UNDERGROUND:]

- A. [General: Underground chilled and heating hot water piping shall be Perma-Pipe Poly-Therm preinsulated pipe installed in a factory conduit system, or an approved equal and shall be fully compatible with the existing piping system which is being connected to. All straight sections, fittings, anchors and other accessories shall be factory-fabricated 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 stress on the carrier pipe and anticipated thermal movement of the service pipe. The system design shall be in strict conformance with ANSI B31.1, latest edition. Factory-trained field-supervision shall be provided for critical periods of installation, i.e. unloading, field joint instruction, and testing.]
- B. [Internal Piping: Internal piping shall be Schedule 40 black steel per ASTM A53. 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. **[Protective Jacket: All straight sections of the insulated piping system shall be jacketed in a 180 mil filament-wound, polyester resin/fiberglass reinforcement composite directly applied on the insulating foam to the nominal Thickness specified below. Thermoplastic casing material, e.g. PVC or PE shall not be allowed. All fittings of the insulated piping system shall be prefabricated to minimize field joints and jacketed in a chipped spray-up, polyester resin/fiberglass reinforcement composite, directly applied onto the insulating foam to a thickness related to the filament wound jacket thickness.]**
- E. **[Field Joints: After the internal pipe has been hydrostatically hammer-tested to 150 psig or 1-1/2 times the operating pressure, whichever is greater. Insulation shall then be poured in place into the field weld area. All field-applied insulations shall be placed only in straight sections. Field-insulation of fittings shall be made of clear adhesive backed polyester film. The installer shall seal the field-joint with wrappings of glass reinforcement fully saturated with a catalyzed resin identical in properties to the factory-applied resin. 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.]**
- F. **[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.]**
- G. **[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.]**
- H. **[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.]**

3.6 STEAM PIPING SYSTEMS:

- A. Pipe: Black steel, ASTM A53, Schedule 40.
- B. Fittings: Service pressure up to 300 psig:
 - 1. Fittings, 2" in diameter and smaller, threaded, Class 250 rated, 300 psig, black, banded, malleable iron.
 - 2. Fittings, 2-1/2" in diameter and larger, factory-fabricated, Class 250, full flow weld-type.
 - 3. Flanges, Class 250, forged steel weld neck.
- C. All piping shall be a butt welded system in accordance with ANSI B31.1.0 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 through 2" IPS at pressure up to 100 psig. At pressures above 100 psig, socket welded fitting shall be used for pipe sizes up to 2". All taps shall be made using factory-manufactured fittings.
- D. Welded fittings shall be factory made wrought steel in accordance with ANSI B16.9 with wall thickness and material identical to pipe being fitted. Flanges shall be ANSI B16.5 forged steel with beveled edge weld type neck. Branch piping taps one half the main size or smaller on piping at pressures up to 100 psig may be made with weld-o-lets and/or thread-o-lets (integrally reinforced branch weld-on fittings) manufactured in accordance with ANSI B16.9. All taps for branches at pressures above 100 psig shall be made using fittings welded in-line in the main being tapped. All butt weld fittings shall have wall thickness as specified by ANSI B31.1.0 and ANSI 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. Piping shall be installed in such a manner as to not obstruct the removal of filters, lubrication or general servicing of connected equipment. The routing of piping shall be placed so as to conserve as much space as possible in equipment rooms. Flat bushings, bull head tee connections and other piping connections which cause excessive pressure drop are not permitted. Reductions in line size for control valves shall not be made more than two pipe diameters away from the connections to the valve.

- E. All steam apparatus and risers shall have steam traps sized for flow of piping. All steam piping take-offs shall be made off the top of the steam supply main or header. All steam condensate trap connections shall be made off the bottom of the steam main or header. All steam equipment shall have a minimum 3/4" diameter by 12" long "dirt" leg and a properly sized steam trap in the steam trap in the steam line serving the equipment.
 - F. Cold-springing: Cold-springing of piping will not be permitted, unless scheduled or shown otherwise on the Drawings.
 - G. Pitch: Install steam piping with a downward pitch of not less than one inch (1") in 40' in the direction of flow, toward traps and as shown on the Drawings.
 - H. Traps: Refer to Section 23 20 10.
 - I. Basic Piping Installation: Refer to Section 23 03 00.
- 3.7 PUMPED CONDENSATE RETURN PIPING SYSTEMS:
- A. Pipe: Black steel, ASTM A53 or A120, Schedule 80.
 - B. Fittings: Service pressure up to 150 psig:
 - 1. Fittings, 2" in diameter and smaller, threaded, Class 150 rated, black, banded, malleable iron.
 - 2. Fittings, 2-1/2" in diameter and larger, factory-fabricated, Class 150, full flow weld-type.
 - 3. Flanges, Class 150, forged steel weld neck.
 - C. All piping shall be a butt welded system in accordance with ANSI B31.1.0 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 through 2" IPS at pressure up to 100 psig. At pressures above 100 psig, socket welded fitting shall be used for pipe sizes up to 2". All taps shall be made using factory-manufactured fittings.
 - D. Welded fittings shall be factory made wrought steel in accordance with ANSI B16.9 with wall thickness and material identical to pipe being fitted. Flanges shall be ANSI B16.5 forged steel with beveled edge weld type neck. Branch piping taps one half the main size or smaller on piping at pressures up to 100 psig may be made with weld-o-lets and/or thread-o-lets (integrally reinforced branch weld-on fittings) manufactured in accordance with ANSI B16.9. All taps for branches at pressures above 100 psig shall be made using fittings welded in-line in the main being tapped. All butt weld fittings shall have wall thickness as specified by ANSI B31.1.0 and ANSI 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. All steam apparatus and risers shall have steam traps sized for flow of piping. All steam piping take-offs shall be made off the top of the steam supply main or header. All steam condensate trap connections shall be made off the bottom of the steam main or header. All steam equipment shall have a minimum 3/4" diameter by 12" long "dirt" leg and a properly sized steam trap in the steam trap in the steam line serving the equipment.
 - F. Cold-springing: Cold-springing of piping will not be permitted, unless scheduled or shown otherwise on the Drawings.
 - G. Pitch: Install condensate return piping with an upward pitch in direction of flow of not less than one inch (1") in 40'.
 - H. Basic Piping Installation: Refer to Section 23 03 00.

[SELECT ONE OF THE FOLLOWING]

3.8 **[UNDERGROUND STEAM AND STEAM CONDENSATE PIPING SYSTEMS:]**

- A. **[Piping:** Underground steam and steam condensate piping shall be Ric-Wil Imperial Smoothwall Epoxy Coated Conduit System or equal system consisting of an epoxy-coated black steel outer conduit, Ric-Wil fiberglass insulation, internal pipe support guides and steam or steam condensate piping as specified hereinabove.]
- B. **[Fittings:** Premanufactured matching fittings shall be provided as required. All pipe joints shall be butt welded. Joint insulation and conduit cover shall be as recommended by the manufacturer. Provide leakplates and end and gland seals at conduit entry to building. Prefabricated plate anchors shall be provided if shown on the Drawings.]
- 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 preinsulated 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. **[Provide thrust block pipe anchors and pipe expansion loops as shown on the Drawings.]**
- F. **[The completed piping system shall be pressure tested as specified hereinbelow before joint insulation and trench cover-up. After pressure testing, backfill trench as specified.]**

[OR]

3.9 **[UNDERGROUND STEAM AND CONDENSATE PIPING SYSTEMS:]**

- A. **[General:** Underground steam and condensate piping shall be the drainable and dryable Perma-Pipe RezCon-A type or an approved equal and shall be fully compatible with the existing piping system which is being connected to. The system supplier shall have fabricated systems of the composition defined herein for at least 3 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 ANSI 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.]
- B. **[External Piping:** Piping shall be Schedule 60 carbon steel for steam piping and Schedule 80 carbon steel for condensate 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:** Carrier pipe insulation shall be calcium silicate. Split insulation shall be held in place by stainless steel bands installed on not less than 18" centers. 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 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 preinsulated 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.]

3.10 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 galvanized 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 painted to match the roof color.]

3.11 COMPRESSED AIR PIPING SYSTEM (TEMPERATURE CONTROL REQUIREMENTS):

- A. Compressed Air Piping: Compressed air piping, 2-1/2" trade size and smaller, for operation at pressures of 150 psig and less shall be **[ASTM A53, Schedule 40, black steel joined by Class 150 pound, banded, black, malleable iron threaded fittings] [ASTM B88 copper tubing Type "L" with cast bronze solder joint fittings, ANSI B16.18, or wrought copper bronze solder joint fittings, ANSI B16.22, except brass compression-type fittings at connections to equipment.]**

3.12 REFRIGERANT PIPING:

- A. General: Refrigerant piping shall be fabricated of Type L hard drawn "ACR" tubing that has been cleaned and capped for refrigeration service. Fittings shall be wrought copper and shall be installed with silver solder joints. 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 shown. Submit Shop Drawings of piping system showing all traps, pipe sizes, and accessories. Drawings to be marked "Approved", and signed by a representative of the Application Engineering Department of the condensing unit manufacturer. Pipe sizes to be as recommended by unit manufacturer. Submit line sizing calculations for review by Engineer.
- 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.
- D. Install and insulate all refrigerant piping per unit manufacturers latest published 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 modification shall be made as recommended by the compressor 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.

3.13 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 diesel engine, muffler, and flexible connection supplied with the emergency generator by Division 16.
- D. Mechanical 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 emergency generators by the Division 16 Contractor **[and with the fire pump(s) by the Fire Protection Contractor]**.
- E. Size of the diesel exhaust piping shall be coordinated with the engine furnished and the actual field routing and installation shall be in accordance with the detail shown on the mechanical drawings. This coordination shall be performed prior to any fabrication or installation.

3.14 CLEANING, FLUSHING, TESTING AND INSPECTING:

- A. Cleaning: Clean exterior surfaces of installed piping systems and prepare surface for application of any required coatings.
- B. Piping Tests:
 - 1. General: Blank off equipment during tests. Perform tests before piping is enclosed in walls, floors, partitions or in any other way concealed from view. Tests may be performed in sections. Tests shall be witnessed by the Engineer and local inspectors and results presented to the Engineer for acceptance and approval prior to concealing piping from view. Provide all necessary equipment for testing, including pumps and gauges. Refer to Section 220000 for additional requirements.
 - 2. Steam and Water Systems: Test all pressurized HVAC steam and water piping systems hydrostatically to a pressure of 150 psig or 1-1/2 times working pressure, whichever is greater, for a period of 24 hours. Repair all leaks, replacing materials as necessary, and repeat tests until systems are proven tight. Flush water piping systems with clean water and steam and condensate systems with steam following successful testing. Refer to Section 230300 for additional pipe flushing and cleaning requirements.
 - 3. Condensate Drainage System: Test condensate drainage piping by plugging all openings and filling system to height of 10' above the level of the pipe being tested, for a minimum of 4 hours. Inspect all joints for leaks, repair all leaks found, and retest until piping is demonstrated to be free from leaks as evidenced by no perceptible lowering of the water level after 4 hours.
 - 4. Compressed Air Piping Systems: Test compressed air piping with compressed air or nitrogen to a pressure at 150% of the expected maximum service pressure, but not less than 150 psig, for a period of 24 hours. Repair all leaks, replacing materials as necessary, and repeat test until systems are proven tight.
 - 5. Refrigerant Piping System: After completion of the refrigerant piping system and before charging, test the system with dry carbon dioxide at 250 psig for 24 hours. Test joints under pressure with soap solution. During the test, isolate expansion valves and other auxiliary devices to prevent damage due to high pressure.
 - a. 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.
 - b. 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.
- C. Inspecting: Visually inspect each run of each system for completion of joints, adequate hangers, supports, and inclusion of accessories and appurtenances.
- D. Chemical Treating: Refer to Section 23 50 00, "Water Treatment Systems", for flushing and cleaning systems.

3.15 IDENTIFICATION:

- A. Refer to Section 23 03 00 for applicable painting, nameplates, and labeling requirements.

END OF SECTION 23 20 00