SECTION 23 21 13

HVAC PIPING

PART 1 GENERAL

1.1 SUMMARY

A. Work included:
   1. Heating Water Piping, Buried
   2. Heating Water Piping, Above Ground
   3. Chilled Water Piping, Buried
   4. Chilled Water Piping, Above Grade
   5. Refrigerant Piping

1.2 RELATED SECTIONS

A. Contents of Division 23, HVAC and Division 01, General Requirements apply to this Section.

1.3 REFERENCES AND STANDARDS

A. References and Standards per Section 23 00 00, HVAC Basic Requirements and Division 01, General Requirements.

1.4 SUBMITTALS

A. Submittals as required by Section 23 00 00, HVAC Basic Requirements and Division 01, General Requirements.

B. In addition, provide:
   1. Welding Certificates: Copies of certificates for welding procedures and personnel.
   2. Field Test Reports: Written reports of tests specified in Part 3 of this Section. Include the following:
      a. Test procedures used.
      b. Test results that comply with requirements.
      c. Failed test results and corrective action taken to achieve requirements.
   3. Water Analysis: Submit a copy of the water analysis to illustrate water quality available at project site.
   4. Buried piping manufacturer to submit thrust block (chilled water) and anchor plate (heating hot water) layout and details including anchorage and seismic calculations.

1.5 QUALITY ASSURANCE

A. Quality assurance as required by Section 23 00 00, HVAC Basic Requirements and Division 01, General Requirements.

B. In addition, meet the following:
   1. Installer Qualifications: Company specializing in performing work of the type specified in this Section, with documented experience.
   2. Welder Qualifications: Certify in accordance with ASME (BPV IX).
   3. ASME Compliance: Comply with ASME B31.9 "Building Services Piping" for materials, products, and installation. Provide safety valves and pressure vessels with the appropriate ASME label. Fabricate and stamp air separators and expansion tanks to comply with the ASME Boiler and Pressure Vessel Code, Section VIII, Division 01.
   4. Refrigerant Piping:
      a. Welding: Qualify procedures and personnel according to ASME Boiler and Pressure Vessel Code: Section IX "Welding and Brazing Qualifications."

c. ASME Standard: comply with ASME B31.5, "Refrigeration Piping."

d. UL Standard: Provide products complying with UL 207, "Refrigerant-Containing Components and Accessories, Nonelectrical" or UL 429 "Electrically Operated Valves."

1.6 WARRANTY

A. Warranty of materials and workmanship as required by Section 23 00 00, HVAC Basic Requirements and Division 01, General Requirements.

PART 2 PRODUCTS

2.1 HEATING WATER PIPING, BURIED

A. Acceptable Manufacturers:

   1. Underground Heating Water Piping Systems:
      a. Ricwil
      b. Uponor
      c. Thermacor
      d. Rovanco
      e. Perma-Pipe
      f. Rehau
      g. Or approved equivalent.

B. Steel Pipe: ASTM A 53/A 53M, Schedule 40, black, Grade B, ERW (Type E) or seamless (Type S).

      a. Make changes in direction with weld fittings.
      b. Where tee branches are smaller than the mains they join, weld-o-lets may be used.
      c. Provide weld fittings that are long radius and the same wall thickness as adjacent piping.

   2. Joints: Welded in accordance with AWS D1.1.

   3. Insulation: Polyurethane foam either spray applied or high pressure injected with one shot into the annular space between carrier pipe and jacket. Provide insulation rigid, 90-95 percent closed cell polyurethane with a 2.0 to 3.0 pounds per cubic foot density and coefficient of thermal conductivity (K-Factor) of 0.14 and conforming to ASTM C-591. Maximum operating temperature not-to-exceed 250 Degrees F.

   4. Jacketing Material: Provide either extruded white polyvinyl chloride, consisting of clean, virgin NSF approved Class 12454-B PVC compound, conforming to ASTM D-1784, Type 1, Grade 1 or high density polyethylene (HDPE). Provide PVC jacket with a wall thickness in mils equal to ten times the nominal jacket diameter and not less than 60 mils. HDPE to have a minimum wall thickness of 125 mils for jacket sizes equal to or less than 12-inches or 150 mils for jacket sizes greater than 12-inch to 24-inch and be used for all jacketing larger than 16-inch. No FRP, HDUP, or tape jacket allowed.

   5. Provide jacketing for fittings, valves, etc. of the same material as for piping.

   6. Expansion Loop and Ells:
      a. Expansion loops or expansion elbows furnished and enclosed in the same type of casing as those furnished for the standard section of the piping system.
      b. Size to permit the inner pipe or pipes to move without damage to the insulation material.
      c. Provide expansion loops or expansion elbows prefabricated and shipped to the job site in as few pieces as possible (manufacturer's recommendations to govern).
      d. Provide inner pipe loops and expansion bends cold sprung in the field as required.
      e. Provide calculations as part of submittals.

   7. Moisture Barrier End Seals: Factory applied, sealed to the jacket and carrier pipe. Provide end seals certified as having passed a 20-foot head pressure test. Provide end seals with high temperature mastic completely sealing the exposed end of the insulation. Field applied end seals installed at any field cut to the piping before continuing with the installation.
C. Copper Tube: ASTM B 88 (ASTM B 88M), Type K (A). Copper piping to have ends cut square for socket brazing. Provide straight sections of factory insulated pipe 20-feet in length and having 6-inch of exposed pipe at each end for field joint fabrication. Field joining of piping to utilize approved methods of silver soldering or brazing with alloys melting at or above 1100 degrees F; 50-50 tin-lead solder is not acceptable.

2. Joints: Solder, lead free, ASTM B 32, HB alloy (95-5 tin-antimony), or tin and silver.
3. Insulation: Polyurethane foam either spray applied or injected with one shot into the annular space between carrier pipe and jacket, and bonded to both. Provide insulation rigid, 90-95 percent closed cell polyurethane with a 2.0 to 3.0 pounds per cubic foot density and coefficient of thermal conductivity (K-Factor) of 0.14 and conforming to ASTM C-591. Maximum operating temperature of urethane not-to-exceed 250 degrees F.
4. Jacketing Material: Provide either extruded white polyvinyl chloride, consisting of clean, virgin NSF approved Class 12454-B PVC compound, conforming to ASTM D-1784, Type 1, Grade 1 or high density polyethylene (HDPE). Provide PVC jacket with a wall thickness in mils equal to ten times the nominal jacket diameter and not less than 60 mils. HDPE to have a minimum wall thickness of 125 mils for jacket sizes equal to or less than 12-inch or 150 mils for jacket sizes greater than 12-inch to 24-inch and used for all jacketing larger than 16-inch. No FRP, HDUP or tape jacket allowed.
   a. Provide jacketing for fittings, valves, etc. of same material as for piping.
5. Expansion Loops and Ells:
   a. Expansion loops or expansion elbows furnished and enclosed in the same type of casing as those furnished for the standard section of the piping system.
   b. Size to permit the inner pipe or pipes to move without damage to the insulation material.
   c. Provide expansion loops or expansion elbows prefabricated and shipped to the job site in as few pieces as possible (manufacturer's recommendations govern).
   d. Inner pipe loops and expansion bends cold sprung in the field as required.
6. Moisture Barrier End Seals: Factory applied, sealed to the jacket and carrier pipe. End seals certified as having passed a 20-foot head pressure test. Provide end seals with high temperature mastic completely sealing the exposed end of the insulation. Field applied end seals installed at any field cut to the piping before continuing with the installation.

2.2 HEATING WATER PIPING, ABOVE GROUND

A. Steel Pipe: ASTM A53/A 53M, Schedule 40, black, Type E (electric resistance welded), Grade B.
   2. Wrought Cast and Forged Steel Flanges and Flanged Fittings: ASME B16.5 including bolts, nuts, and gaskets of the following material group, end connections, and facings:
      b. End Connections: Butt welding.
      c. Facings: Raised face.
   3. Joints: Threaded or AWS D1.1 welded.
B. Copper Tube: ASTM B 88 (ASTM B 88M), Type L (B), drawn.
   2. Joints: Solder, lead free ASTM B32, HB alloy (95-5 tin antimony), or tin and silver.
   3. Joints: Brazed, AWS A5.8, Classification BAg-1 (silver). Pipes 2-1/2-inches or larger or piping routed over food preparation centers, food serving facilities, food storage areas, computer rooms, telecommunications rooms, and electrical rooms.

2.3 CHILLED WATER PIPING, BURIED

A. Underground Chilled Water Piping Systems:
   1. Ricwil
   2. Thermacor
   3. Rovanco.
   4. Perma-Pipe
5. Or approved equivalent.

B. Steel Pipe: ASTM A 53/A 53M, Schedule 40, black, Grade B, ERW (Type E) or seamless (Type S).
   1. Fittings: ASTM A 234/A 234M, wrought steel welding type with double layer, half-lapped polyethylene tape.
   2. Weld Fittings:
      a. Changes in direction made with weld fittings.
      b. Where tee branches are smaller than the mains they join, weld-o-lets may be used.
      c. Provide weld fittings long radius and the same wall thickness as adjacent piping.
   4. Insulation: Polyurethane foam either spray applied or high pressure injected with one shot into the annular space between carrier pipe and jacket. Insulation rigid, 90-95 percent closed cell polyurethane with a 2.0 to 3.0 pounds per cubic foot density and coefficient of thermal conductivity (K-Factor) of 0.14 and conforming to ASTM C-591. Maximum operating temperature not-to-exceed 250 Degrees F.
   5. Jacketing Material: Provide either extruded white polyvinyl chloride, consisting of clean, virgin NSF approved Class 12454-B PVC compound, conforming to ASTM D-1784, Type 1, Grade 1 or high density polyethylene (HDPE). Provide PVC jacket with a wall thickness in mils equal to ten times the nominal jacket diameter and not less than 60 mils. HDPE to have a minimum wall thickness of 125 mils for jacket sizes equal to or less than 12-inch or 150 mils for jacket sizes greater than 12-inch to 24-inch and used for all jacketing larger than 16-inch. No FRP, HDUP, or tape jacket allowed.
   6. Provide jacketing for fittings, valves, etc. of the same material as for piping.
   7. Expansion Loop and Ells:
      a. Expansion loops or expansion elbows furnished and enclosed in the same type of casing as those furnished for the standard section of the piping system.
      b. Size to permit the inner pipe or pipes to move without damage to the insulation material.
      c. Expansion loops or expansion elbows prefabricated and shipped to the job site in as few pieces as possible (manufacturer's recommendations to govern).
      d. Inner pipe loops and expansion bends cold sprung in the field as required.
      e. Provide calculations as part of submittals.
   8. Moisture Barrier End Seals: Factory applied, sealed to the jacket and carrier pipe. End seals certified as having passed a 20-foot head pressure test. Provide end seals with high temperature mastic completely sealing the exposed end of the insulation. Field applied end seals installed at any field cut to the piping before continuing with the installation.

C. Copper Tube: ASTM B 88 (ASTM B 88M), Type K (A) annealed. Copper piping to have ends cut square for socket brazing. Provide straight sections of factory insulated pipe of 20-feet in length and having 6-inches of exposed pipe at each end for field joint fabrication. Field joining of piping to utilize approved methods of silver soldering or brazing with alloys melting at or above 1100 degrees F; 50-50 tin-lead solder is not acceptable.
   2. Joints: Solder, lead free, ASTM B32, HB alloy (95-5 tin-antimony), or tin and silver.
   3. Insulation: Polyurethane foam either spray applied or injected with one shot into the annular space between carrier pipe and jacket, and bonded to both. Insulation rigid, 90-95 percent closed cell polyurethane with a 2.0 to 3.0 pounds per cubic foot density and coefficient of thermal conductivity (K-factor) of 0.14 and conforming to ASTM C-591. Maximum operating temperature of urethane not-to-exceed 250 degrees F.
   4. Jacketing Material: Provide either extruded white polyvinyl chloride, consisting of clean, virgin NSF approved Class 12454-B PVC compound, conforming to ASTM D-1784, Type 1, Grade 1 or high density polyethylene (HDPE). Provide PVC jacket with a wall thickness in mils equal to ten times the nominal jacket diameter and not less than 60 mils. HDPE to have a minimum wall thickness of 125 mils for jacket sizes equal to or less than 12-inch or 150 mils for jacket sizes greater than 12-inch to 24-inch and used for all jacketing larger than 16-inch. No FRP, HDUP or tape jacket allowed.
a. Provide jacketing for fittings, valves, etc. of same material as for piping.

5. Expansion Loops and Ells:
   a. Expansion loops or expansion elbows furnished and enclosed in the same type of casing as those furnished for the standard section of the piping system.
   b. Size to permit the inner pipe or pipes to move without damage to the insulation material.
   c. All expansion loops or expansion elbows prefabricated and shipped to the job site in as few pieces as possible (manufacturer's recommendations govern).

6. Provide inner pipe loops and expansion bends cold sprung in the field as required.

7. Moisture Barrier End Seals: Factory applied, sealed to the jacket and carrier pipe. End seals certified as having passed a 20-foot head pressure test. Provide end seals with high temperature mastic completely sealing the exposed end of the insulation. Field applied end seals installed at any field cut to the piping before continuing with the installation.

   1. Fittings: ASTM D 2466, or ASTM D 2467, PVC.
   2. Joints: Solvent welded.
   3. Insulation: Polyurethane foam either spray applied or injected with one shot into the annular space between carrier pipe and jacket, and bonded to both. Insulation rigid, 90-95 percent closed cell polyurethane with a 2.0 to 3.0 pounds per cubic foot density and coefficient of thermal conductivity (K-Factor) of 0.14 and conform to ASTM C-591. Maximum operating temperature of urethane not-to-exceed 250 degrees F.
   4. Jacketing Material: Provide either extruded white polyvinyl chloride, consisting of clean, virgin NSF approved Class 12454-B PVC compound, conforming to ASTM D-1784, Type 1, Grade 1 or high density polyethylene (HDPE). PVC jacket to have a wall thickness in mils equal to ten times the nominal jacket diameter and not less than 60 mils. HDPE to have a minimum wall thickness of 125 mils for jacket sizes equal to or less than 12-inch or 150 mils for jacket sizes greater than 12-inch to 24-inch and used for all jacketing larger than 16-inch. No FRP, HDUP, or tape jacket allowed.
      a. Jacketing for fittings, valves, etc. of same material as for piping.

5. Expansion Loops and Ells:
   a. Expansion loops or expansion elbows furnished and enclosed in the same type of casing as those furnished for the standard section of the piping system.
   b. Size to permit the inner pipe or pipes to move without damage to the insulation material.
   c. All expansion loops or expansion elbows prefabricated and shipped to the job site in as few pieces as possible (manufacturer's recommendations govern).  
   d. All inner pipe loops and expansion bends cold sprung in the field as required.

6. Moisture Barrier End Seals: Factory applied, sealed to the jacket and carrier pipe. End seals certified as having passed a 20-foot head pressure test. Provide end seals with high temperature mastic completely sealing the exposed end of the insulation. Field applied end seals installed at any field cut to the piping before continuing with the installation.

E. Preinsulated Underground PEX Pipe
   1. Factory preinsulated piping system, consisting of an inner media carrier pipe, insulation around the carrier pipe, and a water/vapor seal jacket over the insulation. Rated for minimum 180F heating water at 85 PSI.
   2. Carrier Pipe Material: PEX piping. NSF, Combined supply and return.
   3. Insulation: Rigid closed cell polyurethane.
   4. Outer Casing:
   5. Flexible HPDE.
   6. Each factory prefabricated section provides complete sealing of insulation at each end of conduit/casing. Provide permanent water and vapor seal.
   7. Carry over outer casing and extend to carrier pipe or use prefabricated caps specifically designed for end seal of prefabricated insulation systems. Fabricate caps of the same material as the outer casing.

2.4 CHILLED WATER PIPING, ABOVE GRADE

A. Steel Pipe: ASTM A 53/A 53M, Schedule 40, black, Type E (electric resistance welded), Grade B.
   2. Wrought Cast and Forged Steel Flanges and Flanged Fittings: ASME B16.5 including bolts, nuts, and gaskets of the following material group, end connections, and facings:
      b. End Connections: Butt welding.
      c. Facings: Raised face.
   3. Joints: Threaded or AWS D1.1 welded.

B. Copper Tube: ASTM B 88 (ASTM B 88M), Type K (A), hard drawn.
   2. Joints: Solder, lead free ASTM B32, HB alloy (95-5 tin antimony), or tin and silver.
   3. Joints: Brazed, AWS A5.8, Classification BAg-1 (silver). (Pipes 2-1/2-inches or larger or piping routed over food preparation centers, food serving facilities, food storage areas, computer rooms, telecommunications rooms, or electrical rooms

2.5 REFRIGERANT PIPING

A. Piping:
   1. Copper Tube: ASTM B 280, Type ACR, drawn-temper tube, clean, dry and capped.

B. Moisture and Liquid Indicators:
   1. Manufacturers:
      b. Parker Hannifin/Refrigeration and Air Conditioning.
      c. Sporlan Valve Company.
      d. Substitutions: See Section 23 00 00, HVAC Basic Requirements, Division 00, Procurement and Contracting Requirements and Division 01, General Requirements requirements.
   2. Indicators: Single port type, UL listed, with copper or brass body, flared or solder ends, sight glass, color coded paper moisture indicator and plastic cap; for maximum temperature of 200 degrees F and maximum working pressure of 300 PSI.

C. Valves:
   1. Manufacturers:
      b. Henry Technologies.
      c. Danfoss Flomatic.
      d. Substitutions: See Section 23 00 00, HVAC Basic Requirements, Division 00, Procurement and Contracting Requirements and Division 01, General Requirements.
   2. Packaged Ball Valves:
      a. Two piece bolted forged brass body with Teflon ball seals and copper tube extensions, brass seal cap, chrome plated ball, stem with neoprene ring stem seals; for maximum working pressure of and maximum temperature of 300 degrees F.

D. Filter-Driers:
   1. Manufacturers:
      a. Flow Controls Division of Emerson Electric.
      b. Parker Hannifin/Refrigeration and Air Conditioning.
3. Performance:
   a. Flow Capacity - Liquid Line: As required by equipment manufacturer, rated in accordance with ARI 710.
   b. Flow Capacity - Suction Line: As required by equipment manufacturer, rated in accordance with ARI 730.
   c. Water Capacity: As recommended by equipment manufacturer, rated in accordance with ARI 710.
   d. Pressure Drop: No greater than maximum recommended by equipment manufacturer, when operating at full connected evaporator capacity.
   e. Design Working Pressure: 350 PSI, maximum.

4. Cores: Molded or loose-fill molecular sieve desiccant compatible with refrigerant, activated alumina, and filtration to 40 microns; of construction that will not pass into refrigerant lines.

   a. Replaceable Core Type: Steel shell with removable cap.
   b. Sealed Type: Copper shell.
   c. Connections: As specified for applicable pipe type.

PART 3 EXECUTION

3.1 PREPARATION
   A. Ream pipe and tube ends. Remove burrs. Bevel plain end ferrous pipe.
   B. Remove scale and dirt on inside and outside before assembly.
   C. Prepare piping connections to equipment with flanges or unions.
   D. Keep open ends of pipe free from scale and dirt. Protect open ends with temporary plugs or caps.

3.2 BURIED PIPING INSTALLATION
   A. Install in accordance with Drawings, specifications, and manufacturer's installation instructions. Provide a field service instructor on site to train the Contractor in all phases of installation.
   B. Underground Systems: Buried in a trench of not less than 2-feet deeper than the top of the pipe and not less than 18-inches wider than the combined O.D. of all piping systems. A minimum thickness of 24-inches of compacted backfill over the top of the pipe is required. System installation must meet H-20 highway loading.
   C. Trench bottom to have a minimum of 6-inch of sand, pea gravel, or specified backfill material, as approved by the engineer, as a cushion for the piping. Field cutting of the pipe performed in accordance with the manufacturer's installation instructions.
   D. Cast a concrete block over anchor plates as recommended by manufacturer. Block to sit on undisturbed trench sidewalls and/or the bottom of the trench. Concrete block to be at least the length as recommended by manufacturer and extend a minimum distance as recommended by manufacturer beyond the top and bottom of anchor plate.
   E. Pressure test buried piping per Field Quality Control article below.
   F. Field Service: Provided by a certified manufacturer's representative or company field service technician. The technician will be available at the job to check unloading, storing, and handling of pipe, joint installation, pressure testing and backfilling techniques.
   G. Provide identification and tracer wire. Section 23 05 53, Identification for HVAC Piping, Ductwork and Equipment.

3.3 INSTALLATION
   A. Install in accordance with manufacturer's instructions.
B. Install heating water, piping to ASME B31.9 requirements. Install chilled water piping to ASME B31.5 requirements.

C. PVC Pipe: Make solvent-welded joints in accordance with ASTM D 2855.

D. Route piping in orderly manner, parallel to building structure, and maintain gradient.

E. Install piping to conserve building space and to avoid interference with use of space.

F. Install groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves.

G. Sleeve pipe passing through partitions, walls and floors allowing adequate space for pipe insulation.

H. Slope piping at 0.2 percent upward in direction of flow and arrange to drain at low points.

I. Install piping to allow for expansion and contraction without stressing pipe, joints, or connected equipment.

J. Install drains, consisting of a tee fitting, NPS 3/4 ball valve, and short NPS 3/4 threaded nipple with cap, at low points in piping system mains and elsewhere as required for system drainage.

K. Unless otherwise indicated, install branch connections to mains using tee fittings in main pipe, with the takeoff coming out the bottom of the main pipe. For up-feed risers, install the takeoff coming out the top of the main pipe.

L. Anchor piping for proper direction of expansion and contraction.

M. Inserts:
   1. Provide inserts for placement in concrete formwork.
   2. Provide inserts for suspending hangers from reinforced concrete slabs and sides of reinforced concrete beams.
   3. Provide hooked rod to concrete reinforcement section for inserts carrying pipe over 4 inches.
   4. Where concrete slabs form finished ceiling, locate inserts flush with slab surface.
   5. Where inserts are omitted, drill through concrete slab from below and provide through-bolt with recessed square steel plate and nut flush with top of slab.

N. Pipe Hangers and Supports:
   1. Install in accordance with Division 23, HVAC, Hangers and Supports.
   2. Install hangers to provide minimum 1/2-inch space between finished covering and adjacent work.
   3. Place hangers within 12-inches of each horizontal elbow.
   4. Use hangers with 1-1/2-inch minimum vertical adjustment. Design hangers for pipe movement without disengagement of supported pipe.
   6. Where several pipes can be installed in parallel and at same elevation, provide multiple or trapeze hangers.
   7. Prepare unfinished pipe, fittings, supports, and accessories, ready for finish painting.
   8. Provide copper plated hangers and supports for copper piping.
   9. Prime coat exposed steel hangers and supports. Hangers and supports located in crawl spaces, pipe shafts, and suspended ceiling spaces are not considered exposed.

O. Provide clearance in hangers and from structure and other equipment for installation of insulation and access to valves and fittings.

P. Provide access where valves and fittings are not exposed.

Q. Use eccentric reducers to maintain top of pipe level.

R. Where pipe support members are welded to structural building framing, scrape, brush clean, and apply one coat of zinc rich primer to welds.

S. Prepare unfinished pipe, fittings, supports, and accessories, ready for finish painting.

T. Refrigerant Piping:
   1. Install systems in accordance with ASHRAE Standard 15.
2. Group piping whenever practical at common elevations and locations. Slope piping one percent in direction of oil return.
3. Arrange piping to return oil to compressor. Provide traps and loops in piping, and provide double risers as required. Slope horizontal piping 0.40 percent in direction of flow.
4. Flood piping system with nitrogen when brazing.
5. Follow ASHRAE Std 15 procedures for charging and purging of systems and for disposal of refrigerant.
6. Provide replaceable cartridge filter-driers, with isolation valves and valved bypass.
7. Locate expansion valve sensing bulb immediately downstream of evaporator on suction line.
8. Fully charge completed system with refrigerant after testing.

3.4 FIELD QUALITY CONTROL
A. Leave joints, including welds, uninsulated and exposed for examination during test.
B. Provide temporary restraints for expansion joints that cannot sustain reactions due to test pressure. If temporary restraints are impractical, isolate expansion joints from testing.
C. Flush system with clean water. Clean strainers.
D. Isolate equipment from piping. If a valve is used to isolate equipment, provide closure capable of sealing against test pressure without damage to valve. Install blinds in flanged joints to isolate equipment.
E. Install safety valve, set at a pressure no more than one-third higher than test pressure, to protect against damage by expanding liquid or other source of overpressure during test.
F. Perform the following tests on hydronic piping:
   1. Use ambient temperature water as a testing medium unless there is risk of damage due to freezing. Another liquid that is safe for workers and compatible with piping may be used.
   2. While filling system, use vents installed at high points of system to release trapped air. Use drains installed at low points for complete draining of liquid.
   3. Check expansion tanks to determine that they are not air bound and that system is full of water.
   4. Subject piping system to hydrostatic test pressure that is not less than 1.5 times the design pressure. Test pressure not-to-exceed maximum pressure for any vessel, pump, valve, or other component in system under test. Verify that stress due to pressure at bottom of vertical runs does not exceed either 90 percent of specified minimum yield strength or 1.7 times "SE" value in Appendix A of ASME B31.9, "Building Services Piping."
   5. After hydrostatic test pressure has been applied for at least four hours, examine piping, joints and connections for leakage. Eliminate leaks by tightening, repairing, or replacing components, and repeat hydrostatic test until there are no leaks.
   6. Prepare written report of testing.
G. Refrigerant Piping:
   1. Test refrigeration system in accordance with ASME B31.5.
   2. Pressure test system with dry nitrogen to 200 PSI. Perform final tests at 27-inches vacuum and 200 PSI using electronic leak detector. Test to no leakage.

3.5 FLUSHING AND CLEANING OF PIPING SYSTEMS
A. Clean piping systems thoroughly. Purge pipe of construction debris and contamination before placing the piping systems in service. Provide temporary connections for cleaning, purging, and circulating fluids through the piping system.
B. Use temporary strainers and temporary pumps that can create fluid velocities up to 10 feet per second to flush and clean the piping systems. Do not use Owner's permanent strainers to trap debris during pipe flushing operations. Fit the temporary construction strainers with a line size blowoff valve.
C. When constructing minor piping modifications or additions, verify with Owner if the Owner's pumps and strainers can be used for flushing and chemical cleaning operations. When the flushing and cleaning operations are complete, insure the strainer baskets and screens installed in the piping systems permanent strainers are replaced with clean elements. Keep temporary strainers in service.
until the equipment has been tested, then replace straining element with a new strainer and deliver the old straining elements to Owner. Fit the Owner's strainers with a line size blowoff valve.

D. Install bypass piping or hoses at the supply and return piping connections at heat exchangers, chillers, pumps, and cooling coils, etc., to prevent debris from being caught or causing damage to equipment which will be connected to the piping system.

E. Circulate a chemical cleaner in chilled and heating water piping systems to remove mill scale, grease, oil, and silt. Cleaner to be selected by chemical treatment vendor on project. Circulate for 48 hours, flush system and replace with clean water. Dispose of chemical solution in accordance with local codes. The chilled and heating water system should then be treated with chemicals and inhibitors to be selected by chemical treatment vendor on project. When the chemical cleaning is complete, remove, clean, and reinstall all permanent screens. Notify Owner so that the reinstallation of clean strainer screens may be witnessed.

3.6 FIELD CONDITIONS

A. Do not install underground piping when bedding is wet or frozen.

END OF SECTION