

SECTION 23 21 13

HYDRONIC PIPING

PART 1 - GENERAL

1.1 DESCRIPTION

A. Water piping to connect HVAC equipment, including the following:

1. Condenser water, and drain piping.
2. Extension of domestic water make-up piping.
3. Glycol-water piping.

1.2 RELATED WORK

- A. Section 01 00 00, GENERAL REQUIREMENTS.
- B. Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, and SAMPLES.
- C. Section 31 20 11, EARTH MOVING:
- D. Section 03 30 00, CAST-IN-PLACE CONCRETE.
- E. Section 23 05 11, COMMON WORK RESULTS FOR HVAC: General mechanical requirements and items, which are common to more than one section of Division 23.
- F. Section 23 21 23, HYDRONIC PUMPS: Pumps.
- G. Section 23 07 11, HVAC, PLUMBING, and BOILER PLANT INSULATION: Piping insulation.
- H. Section 23 09 23, DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC: Temperature and pressure sensors and valve operators.

1.3 QUALITY ASSURANCE

- A. Section 23 05 11, COMMON WORK RESULTS FOR HVAC, which includes welding qualifications.
- B. Submit prior to welding of steel piping a certificate of Welder's certification. The certificate shall be current and not more than one year old.
- C. For mechanical pressed sealed fittings, only tools of fitting manufacturer shall be used.
- D. Mechanical pressed fittings shall be installed by factory trained workers.
- E. All grooved joint couplings, fittings, valves, and specialties shall be the products of a single manufacturer. Grooving tools shall be the same manufacturer as the grooved components.
  1. All castings used for coupling housings, fittings, valve bodies, etc., shall be date stamped for quality assurance and traceability.

F. Qualifications of piping fabricators: The only acceptable method for joining pipe systems is by a heat fusion process. Submit documentation substantiating the following qualifications:

1. Fabricators shall have completed a heat fusion school in which each participant has performed a heat fusion procedure under direct supervision of an approved manufacturing certification program or a DOT certified heat fusion technician.

#### 1.4 SUBMITTALS

A. Submit in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, and SAMPLES.

B. Manufacturer's Literature and Data:

1. Pipe and equipment supports.
2. Pipe and tubing, with specification, class or type, and schedule.
3. Pipe fittings, including miscellaneous adapters and special fittings.
4. Flanges, gaskets and bolting.
5. Grooved joint couplings and fittings.
6. Valves of all types.
7. Strainers.
8. Flexible connectors for water service.
9. All specified hydronic system components.
10. Water flow measuring devices.
11. Gages.
12. Thermometers and test wells.

C. Manufacturer's certified data report, Form No. U-1, for ASME pressure vessels:

1. Air separators.
2. Expansion tanks.

D. Submit the welder's qualifications in the form of a current (less than one year old) and formal certificate.

E. Coordination Drawings: Refer to Article, SUBMITTALS of Section 23 05 11, COMMON WORK RESULTS FOR HVAC and STEAM GENERATION.

F. As-Built Piping Diagrams: Provide drawing as follows for condenser water, and other piping systems and equipment.

1. One wall-mounted stick file with complete set of prints. Mount stick file in the chiller plant or control room along with control diagram stick file.
2. One complete set of reproducible drawings.



A53/A53M-07.....Standard Specification for Pipe, Steel, Black  
and Hot-Dipped, Zinc-Coated, Welded and  
Seamless

A106/A106M-08.....Standard Specification for Seamless Carbon  
Steel Pipe for High-Temperature Service

A126-04.....Standard Specification for Gray Iron Castings  
for Valves, Flanges, and Pipe Fittings

A183-03 ..... Standard Specification for Carbon Steel Track  
Bolts and Nuts

A216/A216M-08 ..... Standard Specification for Steel Castings,  
Carbon, Suitable for Fusion Welding, for High  
Temperature Service

A234/A234M-07 ..... Piping Fittings of Wrought Carbon Steel and  
Alloy Steel for Moderate and High Temperature  
Service

A307-07 ..... Standard Specification for Carbon Steel Bolts  
and Studs, 60,000 PSI Tensile Strength

A536-84 (2004) ..... Standard Specification for Ductile Iron Castings

A615/A615M-08 ..... Deformed and Plain Carbon Steel Bars for  
Concrete Reinforcement

A653/A 653M-08 ..... Steel Sheet, Zinc-Coated (Galvanized) or Zinc-  
Iron Alloy Coated (Galvannealed) By the Hot-Dip  
Process

B32-08 ..... Standard Specification for Solder Metal

B62-02 ..... Standard Specification for Composition Bronze or  
Ounce Metal Castings

B88-03 ..... Standard Specification for Seamless Copper Water  
Tube

B209-07 ..... Aluminum and Aluminum Alloy Sheet and Plate

C177-04 ..... Standard Test Method for Steady State Heat Flux  
Measurements and Thermal Transmission Properties  
by Means of the Guarded Hot Plate Apparatus

C478-09 ..... Precast Reinforced Concrete Manhole Sections

C533-07 ..... Calcium Silicate Block and Pipe Thermal  
Insulation

C552-07 ..... Cellular Glass Thermal Insulation

D3350-08 ..... Polyethylene Plastics Pipe and Fittings  
Materials

- C591-08 ..... Unfaced Preformed Rigid Cellular Polyisocyanurate Thermal Insulation
- D1784-08 ..... Rigid Poly (Vinyl Chloride) (PVC) Compounds and Chlorinated Poly (Vinyl Chloride) (CPVC) Compound
- D1785-06 ..... Poly (Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80 and 120
- D2241-05 ..... Poly (Vinyl Chloride) (PVC) Pressure Rated Pipe (SDR Series)
- F439-06 ..... Standard Specification for Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 80
- F441/F441M-02 ..... Standard Specification for Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe, Schedules 40 and 80
- F477-08 ..... Elastomeric Seals Gaskets) for Joining Plastic Pipe
- F. American Water Works Association (AWWA):
  - C110-08.....Ductile Iron and Grey Iron Fittings for Water
  - C203-02.....Coal Tar Protective Coatings and Linings for Steel Water Pipe Lines Enamel and Tape Hot Applied
- G. American Welding Society (AWS):
  - B2.1-02.....Standard Welding Procedure Specification
- H. Copper Development Association, Inc. (CDA):
  - CDA A4015-06.....Copper Tube Handbook
- I. Expansion Joint Manufacturer's Association, Inc. (EJMA):
  - EMJA-2003.....Expansion Joint Manufacturer's Association Standards, Ninth Edition
- J. Manufacturers Standardization Society (MSS) of the Valve and Fitting Industry, Inc.:
  - SP-67-02a.....Butterfly Valves
  - SP-70-06.....Gray Iron Gate Valves, Flanged and Threaded Ends
  - SP-71-05.....Gray Iron Swing Check Valves, Flanged and Threaded Ends
  - SP-80-08.....Bronze Gate, Globe, Angle and Check Valves

SP-85-02.....Cast Iron Globe and Angle Valves, Flanged and  
Threaded Ends

SP-110-96.....Ball Valves Threaded, Socket-Welding, Solder  
Joint, Grooved and Flared Ends

SP-125-00.....Gray Iron and Ductile Iron In-line, Spring  
Loaded, Center-Guided Check Valves

K. National Sanitation Foundation/American National Standards Institute,  
Inc. (NSF/ANSI):

14-06.....Plastic Piping System Components and Related  
Materials

50-2009a.....Equipment for Swimming Pools, Spas, Hot Tubs  
and other Recreational Water Facilities -  
Evaluation criteria for materials, components,  
products, equipment and systems for use at  
recreational water facilities

61-2008.....Drinking Water System Components - Health  
Effects

L. Tubular Exchanger Manufacturers Association: TEMA 9th Edition, 2007

#### 1.6 SPARE PARTS

A. For mechanical pressed sealed fittings provide tools required for each  
pipe size used at the facility.

### PART 2 - PRODUCTS

#### 2.1 PIPE AND EQUIPMENT SUPPORTS, PIPE SLEEVES, AND WALL AND CEILING PLATES

A. Provide in accordance with Section 23 05 11, COMMON WORK RESULTS FOR  
HVAC.

#### 2.2 PIPE AND TUBING

A. Condenser Water, Ground-Coupled Closed-Loop Piping System:

1. Above Ground Piping:

a. Copper water tube: ASTM B88, Type K, hard drawn.

2. Ground Heat Exchanger Piping System: Provide high density  
polyethylene pipe, fittings and piping components for the  
underground portions of the ground heat exchanger, Use of polyvinyl  
chloride (PVC) or polybutylene pipe and fittings is not permitted.  
Provide high density polyethylene pipe coiled on reel, with U-bend  
factory installed, pipe pre-marked for depth and U-bend connections

factory tested. Because of their size and weight, coiled PE piping requires appropriate equipment and procedures for safe handling, installation and use. Reels and coiled pipe shall allow easy and thorough inspection of the pipe exterior for any shipping and handling damage. The reel shall be capable of securing the pipe coil while the pipe is being pressure tested. The reel and pipe coil shall allow easy access and handling while spooling the pipe coil off the reel for inspection into the bore hole. Pipe coil on reel shall be factory marked to show depth graduations.

a. High Density Polyethylene Pipe: Pipe shall be manufactured from virgin high density polyethylene extrusion material in accordance with ASTM D 2513 with PE345434C or PE355434C cell classification and UV stabilizer of C, D or E as specified in ASTM D 3350. Provide ASTM D 3035 pipe with a standard dimension ratio (SDR) of 11.0 for pipe less than 1.25 inches diameter. Provide ASTM D 2447, Schedule 40 or ASTM D 3035 pipe with a minimum SDR of 13.5 for pipe 1.25 inches diameter or greater. Provide ASTM D 3035 pipe in vertical bores greater than 200 feet deep with a SDR of 11.0.

B. Extension of Domestic Water Make-up Piping: ASTM B88, Type K, hard drawn copper tubing.

C. Cooling Coil Condensate Drain Piping:

1. From air handling units: Copper water tube, ASTM B88, Type K, or schedule 40 PVC plastic piping.
2. From fan coil or other terminal units: Copper water tube, ASTM B88, Type K.

D. Pipe supports, including insulation shields, for above ground piping: Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

### 2.3 FITTINGS FOR COPPER TUBING

A. Joints:

1. Solder Joints: Joints shall be made up in accordance with recommended practices of the materials applied. Apply 95/5 tin and antimony on all copper piping.
2. Contractor's Option: Mechanical press sealed fittings, double pressed type, NSF 50/61 approved, with EPDM (ethylene propylene diene monomer) non-toxic synthetic rubber sealing elements for up 65 mm (2-1/2 inch) and below are optional for above ground water piping only.

3. Mechanically formed tee connection in water and drain piping: Form mechanically extracted collars in a continuous operation by drilling pilot hole and drawing out tube surface to form collar, having a height of not less than three times the thickness of tube wall. Adjustable collaring device shall insure proper tolerance and complete uniformity of the joint. Notch and dimple joining branch tube in a single process to provide free flow where the branch tube penetrates the fitting.

B. Bronze Flanges and Flanged Fittings: ASME B16.24.

C. Fittings: ANSI/ASME B16.18 cast copper or ANSI/ASME B16.22 solder wrought copper.

#### 2.4 FITTINGS FOR PLASTIC PIPING

A. Schedule 40, socket type for solvent welding.

B. Schedule 40 PVC drain piping: Drainage pattern.

C. Chemical feed piping for condenser water treatment: Chlorinated polyvinyl chloride (CPVC), Schedule 80, ASTM F439.

#### 2.5 DIELECTRIC FITTINGS

A. Provide where copper tubing and ferrous metal pipe are joined.

B. 50 mm (2 inches) and Smaller: Threaded dielectric union, ASME B16.39.

C. 65 mm (2 1/2 inches) and Larger: Flange union with dielectric gasket and bolt sleeves, ASME B16.42.

D. Temperature Rating, 99 degrees C (210 degrees F).

E. Contractor's option: On pipe sizes 2" and smaller, screwed end brass ball valves or dielectric nipples may be used in lieu of dielectric unions.

#### 2.6 SCREWED JOINTS

A. Pipe Thread: ANSI B1.20.

B. Lubricant or Sealant: Oil and graphite or other compound approved for the intended service.

#### 2.7 VALVES

A. Asbestos packing is not acceptable.

B. All valves of the same type shall be products of a single manufacturer.

C. Shut-Off Valves

1. Ball Valves (Pipe sizes 2" and smaller): MSS-SP 110, screwed or solder connections, brass or bronze body with chrome-plated ball with full port and Teflon seat at 2760 kPa (400 psig) working

pressure rating. Provide stem extension to allow operation without interfering with pipe insulation.

D. Globe and Angle Valves

1. Globe Valves

- a. 50 mm (2 inches) and smaller: MSS-SP 80, bronze, 1034 kPa (150 lb.) Globe valves shall be union bonnet with metal plug type disc.
- b. 65 mm (2 1/2 inches) and larger: 861 kPa (125 psig), flanged, iron body, bronze trim, MSS-SP-85 for globe valves.

2. Angle Valves:

- a. 50 mm (2 inches) and smaller: MSS-SP 80, bronze, 1034 kPa (150 lb.) Angle valves shall be union bonnet with metal plug type disc.
- b. 65 mm (2 1/2 inches) and larger: 861 kPa (125 psig), flanged, iron body, bronze trim, MSS-SP-85 for angle.

E. Check Valves

1. Swing Check Valves:

- a. 50 mm (2 inches) and smaller: MSS-SP 80, bronze, 1034 kPa (150 lb.), 45 degree swing disc.
- b. 65 mm (2 1/2 inches) and larger: 861 kPa (125 psig), flanged, iron body, bronze trim, MSS-SP-71 for check valves.

2. Non-Slam or Silent Check Valve: Spring loaded double disc swing check or internally guided flat disc lift type check for bubble tight shut-off. Provide where check valves are shown in chilled water and hot water piping. Check valves incorporating a balancing feature may be used.

- a. Body: MSS-SP 125 cast iron, ASTM A126, Class B, or steel, ASTM A216, Class WCB, or ductile iron, ASTM 536, flanged, grooved, or wafer type.
- b. Seat, disc and spring: 18-8 stainless steel, or bronze, ASTM B62. Seats may be elastomer material.

F. Water Flow Balancing Valves: For flow regulation and shut-off. Valves shall be line size rather than reduced to control valve size.

1. Ball style valve.

2. A dual purpose flow balancing valve and adjustable flow meter, with bronze or cast iron body, calibrated position pointer, valved pressure taps or quick disconnects with integral check valves and preformed polyurethane insulating enclosure.

3. Provide a readout kit including flow meter, readout probes, hoses, flow charts or calculator, and carrying case.
- G. Automatic Balancing Control Valves: Factory calibrated to maintain constant flow (plus or minus five percent) over system pressure fluctuations of at least 10 times the minimum required for control. Provide standard pressure taps and four sets of capacity charts. Valves shall be line size and be one of the following designs:
1. Gray iron (ASTM A126) or brass body rated 1205 kPa (175 psig) at 93 degrees C (200 degrees F), with stainless steel piston and spring.
  2. Brass or ferrous body designed for 2067 kPa (300 psig) service at 121 degrees C (250 degrees F), with corrosion resistant, tamper proof, self-cleaning piston/spring assembly that is easily removable for inspection or replacement.
  3. Combination assemblies containing ball type shut-off valves, unions, flow regulators, strainers with blowdown valves and pressure temperature ports shall be acceptable.
- H. Manual Radiator/Convactor Valves: Brass, packless, with position indicator.

## 2.8 WATER FLOW MEASURING DEVICES

- A. Minimum overall accuracy plus or minus three percent over a range of 70 to 110 percent of design flow. Select devices for not less than 110 percent of design flow rate.
- B. Venturi Type: Bronze, steel, or cast iron with bronze throat, with valved pressure sensing taps upstream and at the throat.
- C. Wafer Type Circuit Sensor: Cast iron wafer-type flow meter equipped with readout valves to facilitate the connecting of a differential pressure meter. Each readout valve shall be fitted with an integral check valve designed to minimize system fluid loss during the monitoring process.
- D. Self-Averaging Annular Sensor Type: Brass or stainless steel metering tube, shutoff valves and quick-coupling pressure connections. Metering tube shall be rotatable so all sensing ports may be pointed down-stream when unit is not in use.
- E. Insertion Turbine Type Sensor: Section 23 09 23, DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC.
- F. Flow Measuring Device Identification:
  1. Metal tag attached by chain to the device.

2. Include meter or equipment number, manufacturer's name, meter model, flow rate factor and design flow rate in l/m (gpm).

## 2.9 STRAINERS

### A. Y Type.

1. Screens: Bronze, monel metal or 18-8 stainless steel, free area not less than 2-1/2 times pipe area, with perforations as follows: 1.1 mm (0.045 inch) diameter perforations for 100 mm (4 inches) and larger: 3.2 mm (0.125 inch) diameter perforations.

### B. Suction Diffusers: Specified in Section 23 21 23, HYDRONIC PUMPS.

## 2.10 FLEXIBLE CONNECTORS FOR WATER SERVICE

### A. Flanged Spool Connector:

1. Single arch or multiple arch type. Tube and cover shall be constructed of chlorobutyl elastomer with full faced integral flanges to provide a tight seal without gaskets. Connectors shall be internally reinforced with high strength synthetic fibers impregnated with rubber or synthetic compounds as recommended by connector manufacturer, and steel reinforcing rings.
2. Working pressures and temperatures shall be as follows:
  - a. Connector sizes 50 mm to 100 mm (2 inches to 4 inches), 1137 kPa (165psig) at 121 degrees C (250 degrees F).
  - b. Connector sizes 125 mm to 300 mm (5 inches to 12 inches), 965 kPa (140 psig) at 121 degrees C (250 degrees F).
3. Provide ductile iron retaining rings and control units.

### B. Mechanical Pipe Couplings:

See other fittings specified under Part 2, PRODUCTS.

## 2.11 HYDRONIC SYSTEM COMPONENTS

- A. Tangential Air Separator: ASME Pressure Vessel Code construction for 861 kPa (125 psig) working pressure, flanged tangential inlet and outlet connection, internal perforated stainless steel air collector tube designed to direct released air into expansion tank, bottom blowdown connection. Provide Form No. U-1. If scheduled on the drawings, provide a removable stainless steel strainer element having 5 mm (3/16 inch) perforations and free area of not less than five times the cross-sectional area of connecting piping.
- B. Diaphragm Type Pre-Pressurized Expansion Tank: ASME Pressure Vessel Code construction for 861 kPa (125 psig) working pressure, welded steel shell, rust-proof coated, with a flexible elastomeric diaphragm

suitable for a maximum operating temperature of 116 degrees C (240 degrees F). Provide Form No. U-1. Tank shall be equipped with system connection, drain connection, standard air fill valve and be factory pre-charged to a minimum of 83 kPa (12 psig).

- C. Pressure Reducing Valve (Water): Diaphragm or bellows operated, spring loaded type, with minimum adjustable range of 28 kPa (4 psig) above and below set point. Bronze, brass or iron body and bronze, brass or stainless steel trim, rated 861 kPa (125 psig) working pressure at 107 degrees C (225 degrees F).
- D. Pressure Relief Valve: Bronze or iron body and bronze or stainless steel trim, with testing lever. Comply with ASME Code for Pressure Vessels, Section 8, and bear ASME stamp.
- E. Automatic Air Vent Valves (where shown): Cast iron or semi-steel body, 1034 kPa (150 psig) working pressure, stainless steel float, valve, valve seat and mechanism, minimum 15 mm (1/2 inch) water connection and 6 mm (1/4 inch) air outlet. Air outlet shall be piped to the nearest floor drain.

#### 2.12 GAGES, PRESSURE AND COMPOUND

- A. ASME B40.100, Accuracy Grade 1A, (pressure, vacuum, or compound for air, oil or water), initial mid-scale accuracy 1 percent of scale (Qualify grade), metal or phenolic case, 115 mm (4-1/2 inches) in diameter, 6 mm (1/4 inch) NPT bottom connection, white dial with black graduations and pointer, clear glass or acrylic plastic window, suitable for board mounting. Provide red "set hand" to indicate normal working pressure.
- B. Provide brass lever handle union cock. Provide brass/bronze pressure snubber for gages in water service.
- C. Range of Gages: Provide range equal to at least 130 percent of normal operating range.
  - 1. For condenser water suction (compound): Minus 100 kPa (30 inches Hg) to plus 700 kPa (100 psig).

#### 2.13 PRESSURE/TEMPERATURE TEST PROVISIONS

- A. Pete's Plug: 6 mm (1/4 inch) MPT by 75 mm (3 inches) long, brass body and cap, with retained safety cap, nordel self-closing valve cores, permanently installed in piping where shown, or in lieu of pressure gage test connections shown on the drawings.

- B. Provide one each of the following test items to the Resident Engineer:
1. 6 mm (1/4 inch) FPT by 3 mm (1/8 inch) diameter stainless steel pressure gage adapter probe for extra long test plug. PETE'S 500 XL is an example.
  2. 90 mm (3-1/2 inch) diameter, one percent accuracy, compound gage, -- 100 kPa (30 inches) Hg to 700 kPa (100 psig) range.
  3. 0 - 104 degrees C (220 degrees F) pocket thermometer one-half degree accuracy, 25 mm (one inch) dial, 125 mm (5 inch) long stainless steel stem, plastic case.

#### 2.14 THERMOMETERS

- A. Mercury or organic liquid filled type, red or blue column, clear plastic window, with 150 mm (6 inch) brass stem, straight, fixed or adjustable angle as required for each in reading.
- B. Case: Chrome plated brass or aluminum with enamel finish.
- C. Scale: Not less than 225 mm (9 inches), range as described below, two degree graduations.
- D. Separable Socket (Well): Brass, extension neck type to clear pipe insulation.
- E. Scale ranges:
1. Chilled Water and Glycol-Water: 0-38 degrees C (32-100 degrees F).
  2. Hot Water and Glycol-Water: -1 - 116 degrees C (30-240 degrees F).

#### 2.15 FIRESTOPPING MATERIAL

Refer to Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

#### 2.16 AUXILIARY DRAIN PAN, DRAIN CONNECTIONS, AND DRAIN LINES

Provide galvanized steel auxiliary drain pans under units where indicated. Provide separate drain lines for the unit drain and auxiliary drain pans. Trap drain pans from the bottom to ensure complete pan drainage. Provide drain lines full size of drain opening. Traps and piping to drainage disposal points shall conform to Section 22 00 00 PLUMBING SYSTEMS.

#### 2.17 ANTIFREEZE PROTECTION

Provide propylene glycol antifreeze solution which meets local and State requirements and is acceptable to heat pump component manufacturers. The antifreeze shall be used in closed-loop ground source heat pump systems for the transfer of energy to provide heating and cooling. The fluid shall contain the necessary corrosion inhibitors to protect pipe and equipment from attack by the antifreeze solution utilized.

- A. Biodegradability

The fluid shall not be less than 90 percent biodegradable.

B. Properties

The fluid shall conform to the following requirements, and tests shall be performed in accordance with specified test methods on the fluid.

1. Flash Point

The flash point shall not be lower than 194 degrees F, determined in accordance with ASTM D 92.

2. Biological Oxygen Demand (BOD)

For 5 days the BOD, at 50 degrees F, shall not exceed 0.007 ounce oxygen per gram nor be less than 0.0035 ounce oxygen per gram.

3. Freezing Point

The freezing point shall not exceed 15 degrees F, determined in accordance with ASTM D 1177.

4. Toxicity

The toxicity shall not be less than LD 50 (oral-rats) of 0.175 ounce per kilogram. The NFPA hazardous material rating for health shall not be more than 1 (slight).

5. Storage Stability

The fluid, tested in accordance with ASTM F 1105, shall neither show separation from exposure to heat or cold nor show an increase in turbidity.

C. Quality

The fluid, shall be homogeneous, uniform in color, and free from skins, lumps, and foreign materials detrimental to usage of the fluid.

2.18 CHEMICAL FEED TANK

Construct of steel for minimum working pressure of 125 psi. Provide chemical pipe, fittings, and valves as specified for water piping.

A. Condenser Water Piping System

Add borate-nitrite corrosion inhibitors, acceptable to heat pump component manufacturers, to initial fill water for heating and cooling water systems in concentrations of 0.5 ounce/gal of system water if corrosion inhibitors are not contained in freeze protection solution in the ground heat exchanger loop.

2.19 Tracer Wire for Nonmetallic Piping

Provide bare copper or aluminum wire not less than 0.10 inch in diameter in sufficient length to be continuous over each separate run of nonmetallic pipe.

2.20 U-Bend Assemblies

Provide factory-assembled and fused injection-molded 180 degree U-bend assemblies equipped with anti-buoyancy devices. U-bend assemblies shall be used for the vertical well field vertical loop heat exchangers. U-bend assemblies shall be prefabricated assemblies with u-bends and continuous pipe. The assemblies shall be pre-marked with depth graduations. Each assembly shall be the indicated length of the vertical loop heat exchanger as indicated. Each assembly shall be factory pressure tested to 100 psig<sup>50</sup>. Each assembly shall be provided with a factory pressure test report. Each U-bend assembly shall be temporarily capped to prevent the entry of dirt during storage and installation.

2.21 Bentonite Grout

Provide bentonite grout mixture for pressure grouting and sealing the bore hole of the vertical well. Provide grouting of wells in accordance with IGSHPA 21015. The grout selected shall meet ANSI/NSF Standard 60. The grout shall meet all local and state rules and regulations. The bentonite will be a slurry that will be tremie grouted from the bottom of the boring to the surface in accordance with the IGSHPA installation manual. The contractor will work quickly to assure that there are no air voids forming as a result of the bentonite placing.

2.22 High Grade Bentonite Grout

Provide high grade bentonite grout mixture. The grout shall be mixed with potable water. The grout shall be mixed per manufacturer instructions. The thermoconductivity of the grout shall be 0.43 Btu/hr-ft-F or greater. The minimum solids content shall be 23%. The target grout weight shall be 9.5 lb/gallons to 9.8 lb/gallon.

PART 3 - EXECUTION

3.1 GENERAL

- A. The drawings show the general arrangement of pipe and equipment but do not show all required fittings and offsets that may be necessary to connect pipes to equipment, fan-coils, coils, radiators, etc., and to coordinate with other trades. Provide all necessary fittings, offsets and pipe runs based on field measurements and at no additional cost to the government. Coordinate with other trades for space available and relative location of HVAC equipment and accessories to be connected on ceiling grid. Pipe location on the drawings shall be altered by

contractor where necessary to avoid interferences and clearance difficulties.

- B. Store materials to avoid excessive exposure to weather or foreign materials. Keep inside of piping relatively clean during installation and protect open ends when work is not in progress.
- C. Support piping securely. Refer to PART 3, Section 23 05 11, COMMON WORK RESULTS FOR HVAC. Install heat exchangers at height sufficient to provide gravity flow of condensate to the flash tank and condensate pump.
- D. Install piping generally parallel to walls and column center lines, unless shown otherwise on the drawings. Space piping, including insulation, to provide 25 mm (one inch) minimum clearance between adjacent piping or other surface. Unless shown otherwise, slope drain piping down in the direction of flow not less than 25 mm (one inch) in 12 m (40 feet). Provide eccentric reducers to keep bottom of sloped piping flat.
- E. Locate and orient valves to permit proper operation and access for maintenance of packing, seat and disc. Generally locate valve stems in overhead piping in horizontal position. Provide a union adjacent to one end of all threaded end valves. Control valves usually require reducers to connect to pipe sizes shown on the drawing. Install butterfly valves with the valve open as recommended by the manufacturer to prevent binding of the disc in the seat.
- F. Offset equipment connections to allow valving off for maintenance and repair with minimal removal of piping. Provide flexibility in equipment connections and branch line take-offs with 3-elbow swing joints where noted on the drawings.
- G. Tee water piping runouts or branches into the side of mains or other branches. Avoid bull-head tees, which are two return lines entering opposite ends of a tee and exiting out the common side.
- H. Provide manual or automatic air vent at all piping system high points and drain valves at all low points. Install piping to floor drains from all automatic air vents.
- I. Connect piping to equipment as shown on the drawings. Install components furnished by others such as:
  - 1. Water treatment pot feeders and condenser water treatment systems.
  - 2. Flow elements (orifice unions), control valve bodies, flow switches, pressure taps with valve, and wells for sensors.

- J. Thermometer Wells: In pipes 65 mm (2-1/2 inches) and smaller increase the pipe size to provide free area equal to the upstream pipe area.
- K. Firestopping: Fill openings around uninsulated piping penetrating floors or fire walls, with firestop material. For firestopping insulated piping refer to Section 23 07 11, HVAC, PLUMBING, and BOILER PLANT INSULATION.
- L. Where copper piping is connected to steel piping, provide dielectric connections.

### 3.2 INSTALLATION

#### A. Heat Pump System

Maintenance access to each piece of equipment shall not be compromised by any type of piping, electrical conduit, or any other utility. Further, install equipment in accordance with the manufacturer's written installation instructions, including the following:

1. Water-source water-to-air heat pumps -installation instructions

### 3.3 ABOVEGROUND PIPING

- A. Provide unions in piping to facilitate removal of heat pump for maintenance or replacement. Test, inspect, and approve piping before covering or concealing. Provide fittings for changes in direction of piping and for connections. Make changes in piping sizes through tapered reducing fittings; bushings will not be permitted. Install valves with stems horizontal or above. Provide flanges or unions at valves, traps, strainers, and connections to equipment; unions are not required in copper tubing piping systems.
  1. Threaded Connections: Threaded joints shall be sealed with a sealant compatible with the circulating fluid; use of Teflon tape is not permitted. Do not thread metal pipe into plastic piping.
  2. Pipe Hangers and Supports: Install in accordance with MSS SP-69. Provide additional pipe hangers and supports at in-line water pumps and flanged valves.
  3. Piping to Receive Insulation: Provide temporary wood spacers between the pipe hangers and supports, and the pipe to properly slope the piping and establish final elevations. Provide temporary wood spacers of same thickness as insulation to be provided under Section 23 07 11 HVAC and Boiler Plant Insulation.
  4. Cleaning of Piping: Keep interior and ends of new piping and existing piping, affected by Contractor's operations, cleaned of water and foreign matter during installation by using plugs or

other approved methods. When work is not in progress, securely close open ends of pipe and fittings to prevent entry of water and foreign matter. Inspect piping before placing into position.

B. Flushing the Aboveground Piping

Before connection of the header to the polyethylene ground heat exchanger loops, flush the entire aboveground piping system thoroughly in accordance with IGSHPA 21020 recommendations and leave filled with clean water. If the header is not immediately joined to the ground heat exchanger loop, the open ends shall be taped or capped. Purge and vent the above ground system piping of all air.

3.4 EARTHWORK

Earthwork shall be performed in accordance with applicable provisions of Section 31 20 11 EARTH MOVING, except that bentonite and thermally enhanced grouts shall be used where indicated or specified.

3.5 GROUND HEAT EXCHANGER PIPING

- A. Examine areas and conditions under which ground heat exchanger systems will be installed. Prior to excavation, trenching, or drilling, locate and mark buried utilities. Do not proceed with work until approved by the Contracting Officer. Sharp bends and mitered joints shall not be used in piping.. Provide fittings for changes in direction when minimum bend radius, as recommended by the pipe manufacturer, is exceeded. All pipe bends shall be radius type elbows. Make changes in piping sizes through tapered concentric fittings. Leaks shall be "cut-out" and repaired in accordance with the pipe manufacturer's recommendations. Direct buried threaded or flanged connections are not permitted. Prior to installation of the ground heat exchanger systems, verify that the installers are certified Ground Heat Exchanger Installers. Inspect all piping for damage prior to installation. Installation shall follow IGSHPA guidelines as well as local, state, and Federal guidelines and regulations. Upon delivery of piping, inspect the pipe for damage and verify that the pipe meets the project specifications. Prior to installation of pipe, carefully inspect pipe for damage. Do not use the pipe if it has a cut or a gouge that is more than 10 per cent of the minimum wall thickness of the pipe. Provide reels and pipe coil. Reels shall be used to securely hold the pipe coil while being pressure tested. When inserting the pipe into the bore hole, spool off pipe from the reel into the hole.

B. Vertical Well Fields

Each vertical well and ground heat exchanger loop shall have a Well Construction Permit as required by local and state regulations. In addition, each well and ground heat exchanger loop shall have a local and /or state Approved Well Permit as required by local and state regulations. The contractor shall maintain these permits during the construction contract period. A copy of the permits shall be submitted with the As-built documentation. Construction and installation of each well shall be in accordance to these permits. Each well shall be performed by a state S.C. certified well driller. Certifications shall be in the state where the work occurs. Prior to installation of wells, verify the well drillers and pump installers are certified. For any well that is abandon, abandonment shall be performed in accordance to local and state regulations. Provide abandonment records with certification to the contracting officer for review and submittal to the state. For any well that is closed, closing shall be performed in accordance to local and state regulations. Provide closing records with certification to the contracting officer for review and submittal to the state. All well submittals and records shall have the names of the well drillers and pump installers, copies of their certifications.

Each U-bend loop shall be factory assembled, laid out straight, taped to reduce springback, and water pressure tested at 100 psi for leaks and flow by IGSHPA 21020 recommended procedures before the hole is bored. Comply with all local and state codes, regulations, and requirements during the construction of the vertical wells or bore holes. Submit for each vertical well a Well Construction Log Record.

1. The borehole shall be constructed as indicated. Where any discrepancy exists between local and state codes, regulations, and requirements and this specification, the more stringent requirement applies. The U-bend shall be factory assembled and pressure tested to 100 psig prior to insertion into the vertical bore. All connections shall be by heat fusion. When inserting the U-bend assembly into the bore hole, use the depth graduations as another means of verification of depth of the bore hole. There shall be no joint in either leg of each vertical loop except for the factory assembled connection at the U-bend.

2. Vertical bores shall be 5 feet deeper than the length of the U-bend assembly loop and shall be clean (no casing) and of sufficient diameter to facilitate the installation of the U-bend assembly and a third pipe for pressure grouting. Fill the loop with water and pressurize to 40 psi to prevent the pipe from being crushed by backfill material. Temporarily cap the ends of the U-bend assemblies until the actual testing begins. The cap shall be fused to the pipe end in order to hold the pressure. Pressure testing can be performed while the bore hole is being drilled.
3. Backfill the bores from the bottom up with a bentonite grout material and grouting process in conformance with IGSHPA 21010 to ensure pipe contact and compliance with local and State requirements for sealing. Bentonite grout shall be prepared and mix in accordance with manufacturer's recommendations for water-to-mix ratio. Grouting materials shall be placed using a pressure pump with a tremie pipe system. Install the grouting material from the bottom to the top of the vertical borehole. If ant settling occurs during the initial 24-hour period after installation, additional material shall be added to insure the grouting material remains at the desired surface level. The bores shall not contain large, sharp, or jagged rocks or debris. Take reasonable and prudent care during installation and backfilling to not crush, cut, or kink the pipe.
4. In the event that a geological formation is encountered, that prevents the grouting material from forming a solid seal, either a 3/8 inch or 3/4 inch cementitious bentonite grout material may be used to seal the specific formation zone. Notify the contracting officer of any problems encountered. Upon completion of the specific zone, resume grouting until the desired surface of the vertical well or bore hole is reached.
5. During installation of the vertical well, maintain a water and soils log. The log shall indicate depth of water encountered, materials encountered, depth intervals of materials and physical description. If water is encountered, indicate in the log the depths at which it was encountered, and the static water level. Include in the log the type of drill rig used, the actual drilling time to complete the bore hole.

6. In absence of other requirements or as indicated, provide u-bend assemblies having the following pipe diameters for the u-bend assembly length as follows:
  - a. 1 inch diameter for 150 to 300 feet loop length
7. Each well location shall be shown and identified on as built drawings. Provide a tracer wire system. The tracer wire system shall include a locator device to identify the well field. The locator device shall be located in the mechanical room.
8. Minimum vertical well distance: In absence of other requirements or as indicated, provide a minimum well separation distance between wells of 20 feet. Provide a minimum separation distance between wells and building foundation walls of 10 feet.

C. Polyethylene Piping

Install piping in accordance with manufacturer's written instructions. Polybutylene piping shall not be used. Piping components shall be joined by a heat fusion method that conforms the piping manufacturer's recommendation for this application. During installation, keep trash, soil, and foreign objects out of the pipe. Tape or cap ends of the pipe until the pipe is joined to the circuit. The vertical loop take-off tee fittings may be made using tee fittings or the saddle fusion process on header piping 1.25 inches diameter and above. Completely remove the cutout on the saddle tees. Use bell reductions at pipe reductions. Use reducing socket tees when fabricating socket type reducing headers. Avoid sharp bends and mitered elbows and bends in piping. Consult pipe manufacturer for minimum bend radius. Install elbow fittings at changes in pipe direction that are tighter than the minimum recommended bend radius. Use only continuous pipe in vertical U-bend loops.

D. Heat Fusion Process

Joining shall be either by butt, socket, or saddle (for sidewall applications only) fusion in accordance with the manufacturer's Heat Fusion Qualification Guide. Use socket fusion joints for pipe 3/4 inches diameter and less. Use butt fusion joints for pipe greater than 3/4 inches diameter. Different plastics or grades of plastic shall not be fused together. When fusing pipe, perform heat fusion tests to verify the quality of the joints. Notify the Contracting Officer, the results of the heat fusion tests.

E. Pressurizing

After assembly of the entire ground loop system, fill the system with water and pressure test to 100 psi. Visually inspect welds prior to backfill of the trenches.

F. Pipe Identification

Install metalized (detectable) warning and identification tape above each horizontal pipe run. Install tape a minimum of 6 inches below finish grade. Install mechanical identification of vertical bore holes and connecting headers.

G. Tracer Wire

Install a continuous length of tracer wire for the full length of each run of nonmetallic pipe. Attach wire to top of pipe in such manner that it will not be displaced during construction operations.

3.6 FIELD QUALITY CONTROL

Upon completion and before final acceptance of work, test each system in service to demonstrate compliance with the contract requirements. Adjust controls and balance systems prior to final acceptance of completed systems. Test controls through every cycle of operation. Test safety controls to demonstrate performance of required function. Correct defects in work provided by Contractor and repeat tests.

Furnish fuel, water, electricity, instruments, connecting devices, and personnel for tests. Flush and clean piping before placing in operation. Clean equipment, piping, strainers, ducts, and filters.

A. Piping Systems Except for Ground Heat Exchanger and Refrigerant

For above ground piping systems, and steel or copper piping systems: Before insulating, hydrostatically test each new piping system at not less than 1296 kPa gage 188 psi based on 1.5 times a system pressure of 862 kPa gage 125 psig. Maintain pressure for 2 hours with no leakage or reduction in gage pressure. Obtain approval before applying insulation.

B. Flow Test of Ground Heat Exchanger Piping

Before backfilling the trenches, flush, purge, and vent systems of air and flow test to ensure all portions of the heat exchanger are properly flowing using the procedures recommended by IGSHPA 21020. Utilize a portable temporary purging unit consisting of the following:

1. High volume, high head purge pump
2. Open reservoir
3. Filter assembly with bypass

4. Flow meter
5. Pressure gage
6. Connecting piping
7. Connecting hoses

Using a purge pump and the procedures recommended by IGSHPA 21020, flush and purge each ground heat exchanger system until free of air, dirt, and debris. A velocity of 0.6 m/sec 2 feet/sec is required in pipe sections to remove the air. Purge and vent all air from the piping.

Perform the flushing and purging operation with the water source heat pumps isolated by shutoff valves from the ground heat exchanger system. Allow purge pump to run 15 minutes after the last air bubbles have been removed. After the ground heat exchanger is completely flushed of air and debris, open the isolation valves and permit circulation through the heat pumps until the entire system is flushed and purged.

Utilizing the purging unit and the procedures recommended by IGSHPA 21020, conduct a pressure and flow test on the ground heat exchanger to ensure the system is free of blockage. If the flow test indicates blockage, locate the blockage using the manufacturer's recommendation, remove the blockage, then repeat the purge procedure and conduct the pressure and flow test again until all portions of the system are free flowing. The flow test shall be observed and approved by the Contracting Officer.

After purging has been completed, add the required amount of antifreeze to the system to achieve the required solution concentration. Fill the open reservoir with the quantity of antifreeze required for -9 degree C 15 degree F freeze protection and run the purge pump 15 minutes to deliver the antifreeze to the system. Test the solution with a hydrometer to determine the actual freezing point.

Form 1, "Ground Heat Exchanger Inspection and Test Report" located below,  
shall be completed for each system by the Contractor after completion  
of the flow and injection of required antifreeze to the system and  
before the systems can be backfilled.

FORM 1

GROUND HEAT EXCHANGER (GHX) INSPECTION AND TEST REPORT

NOTE: Use separate form for each GHX loop system.

Building:\_\_\_\_\_ Inspection Date:\_\_\_\_\_

Ground Heat Exchanger No. or Description:\_\_\_\_\_

Does the ground heat exchanger have a Well Construction Permit? Permit No.?

Does the ground heat exchanger have an approved well permit? Permit No.

List the WSHP Unit No.'s served by this GHX: \_\_\_\_\_

Ground Heat Exchanger Design Water Flow - \_\_\_\_\_ liters/sec gpm

Calculated purging flow and press to achieve 0.61 m 2 feet/sec

Purging: Flow \_\_\_\_\_ liters/sec gpm Head \_\_\_\_\_ kPa psi, Duration of test  
\_\_\_\_\_ min.

Hydrostatic test pressure \_\_\_\_\_ kPa psi; Duration \_\_\_\_\_ min.

Did the system pass the pressure test? \_\_\_\_\_

Is antifreeze required in system?\_\_\_\_ If yes, was antifreeze measured?\_\_\_\_

Has a dimensioned drawing been prepared, completely and accurately showing  
the layout of the ground heat exchanger?  
\_\_\_\_\_

Does the layout differ substantially from the contract documents? \_\_\_\_\_

If so is the deviation approved? \_\_\_\_\_

Depth of installed vertical loops is \_\_\_\_\_m feet. (Design is \_\_\_\_\_ m feet.)

Depth of horizontal piping is \_\_\_\_\_ m feet. (Design is \_\_\_\_\_m feet.)

Are the trenches clear of sharp bends, rocks, or other sharp objects that  
could restrict flow?\_\_\_\_\_

Are all joints heat fused (butt-, socket-, or saddle-fusion)?\_\_\_\_\_

Do the joints have the proper amount of roll-out?\_\_\_\_\_

Has the piping material been cut-out and properly removed from saddle-fusion  
tees?\_\_\_\_\_

Grout Manufacturer? \_\_\_\_\_; Percent of solids used in  
grout?\_\_\_\_\_Grout Type?\_\_\_\_\_Grout Thermal conductivity, k? (give  
units)\_\_\_\_\_

Was the system backfilled properly with good clean backfill material?\_\_\_\_\_

Attach the soil boring and water well log sheet for the bore hole?\_\_For each  
well submit a Well Construction Log Record

Comments:\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

Inspected and approved this \_\_\_\_\_ date by \_\_\_\_\_

Title: \_\_\_\_\_

C. Pressure Test of Ground Heat Exchanger Piping

Prior to any cover or backfill of bore holes or trenches and after flow testing, flushing, and purging, the ground heat exchanger piping and headers shall be pressure tested by hydrostatic test. The system shall be isolated from all connections to piping. Ensure that the piping system has been flushed of all dirt and debris. The piping shall then be plugged or capped as necessary in preparation for the hydrostatic test(s).

1. Hydrostatic Test

The piping shall be hydrostatically pressurized to 150 percent of system pressure 150psi and monitor piping. If there is any pressure loss or visible leakage during the testing, the leak shall be identified and repaired in accordance with the piping components manufacturer's recommendations. Test shall be repeated until there is no loss in pressure during the test period. Provide results of test in test report. During testing, do not exceed the pipe/pipe fitting manufacturer test pressure rating or 150 percent of the pipe pressure rating. Do not pneumatic test the pipe. Prior to testing, remove all air from the system. Provide test in accordance to IGSHPA standards.

D. Field Tests

E. Soil Thermal Conductivity Testing

Perform soil thermal conductivity testing of the well system project location. The test will establish the thermal properties for verification of the design of the well field and the subsurface conditions at the site. The test will be performed by performed under the supervision of and certified by the ground source heat pump (GSHP) specialist. The test will be performed at locations as indicated. Each test will contain a minimum of 48 hours of recorded data.

1. Ground Source Heat Pump Specialist (GSHP)

shall be conducted by an individual who is a Certified GeoExchange Designer and is regularly engaged in the design of the type and capacity of system(s) specified in this project for the immediate three years prior to the submittal of the System Designer's Statement of Qualifications. Certification as a certified GeoExchange Designer shall be kept up to date and maintained with the Association of Energy Engineers. The GSHP's Statement of Qualifications shall include design experience in ground-loop heat

pump systems, geothermal heat pump design, data identifying the location, ground-loop heat pump system type, and capacity of at least three systems designed by the proposed System Designer during that period. The Contractor shall furnish documentation from the owner of each of these three systems verifying that each system has performed in the manner intended for the 6 months prior to submission of the Statement of Qualifications.

2. Soil Thermal Conductivity Testing Set-up

Conduct and perform tests in accordance with the procedures outlined in ASHRAE Item 90376.

3. Data Recording and sensor accuracy

Record data by means of automatic data logging equipment intended for such purposes and suitable for service of local ambient outside conditions. Protect compensated thermocouple reference junctions, if used, either from separate from the data logging equipment or integral to it, from rapid changes in environmental conditions. Record data at uniform 5 minute time intervals during the 48 hour test period. Data recorded will include a minimum time, inlet and outlet temperatures, heater power input, circulating pump power input, and ambient temperatures.

Temperature Measurements: Measure inlet and outlet temperatures with immersion temperature sensors. The temperatures sensors shall be calibrated every six months and have a valid calibrated stamp. Include the date and results from the most recent calibration in the test report. Any change-out of the temperature sensor in the system or data logger will require re-calibration.

Temperature Sensor calibration and accuracy: The combined rated sensor and data logger accuracy will be +- 0.5 degrees C 1 degree F or better. Verify temperature sensor and data logger accuracy and calibration at first use of the testing device during the test. The testing equipment shall have been calibrated semi-annually by immersion in ice and water bath. A calibration certificate stamp with date shall be on the test device. The result from the verification test using ice water bath shall not differ from 0 degrees C 32 degrees F by more than the required data accuracy. Additional readings will not differ from one another by more than

+/- 0.2 degrees C 0.5 degrees F when simultaneously immersed in the ice bath.

Power Measurements: Measure heater and circulating pump power input. Power measurements shall be independently determined by using power transducers with the manufacturer stated accuracy of +/- two percent or better at the level of power consumption for the test.

Flow Rate Measurements: Measure the flow rate. Flow rate shall be measured using a variable flow meter calibrated by the flow meter manufacturer having a rated accuracy of +/- two percent of full scale. Full scale or maximum rated flow for the flow meter shall not exceed actual flow rate by more than 70 percent.

4. Test Borehole Construction

Prepare the bore hole in a manner in which the heat exchangers will be ultimately installed to the extent possible with respect to the bore hole size, pipe diameter , grouting method, and grout types as indicated. The installation of the test bore hole shall be as indicated for the vertical well field. The bore hole depth shall not vary more than 5 percent from the indicated design depth. Materials of the test borehole and heat exchanger shall be as indicated.

- a. At least 2 m 6 feet of excess pipe shall be left protruding above grade upon completion of the test borehole construction. Temporarily cap the ends of the protruding pipes until the actual testing begins. All local and state codes and regulations will be adhered to during the construction of the test bore hole. Where any discrepancy exists between local codes and regulations and this specification, the more stringent requirement applies. The U-tube assembly shall be factory assembled and pressure tested to 100 psig prior to insertion into the vertical bore. All connections shall be by heat fusion.
- b. During the completion of the test borehole, maintain a water well and soils property log. For each well submit a Well Construction Log Record

5. Flow Test of Ground Heat Exchanger Piping

Before backfilling the trenches, flush, purge, and vent systems of air and flow test to ensure all portions of the heat exchanger are properly flowing using the procedures recommended by IGSHPA 21020. Utilize a portable temporary purging unit consisting of the following:

- a. High volume, high head purge pump
- b. Open reservoir
- c. Filter assembly with bypass
- d. Flow meter
- e. Pressure gage
- f. Connecting piping
- g. Connecting hoses

Using a purge pump and the procedures recommended by IGSHPA 21020, flush and purge each ground heat exchanger system until free of air, dirt, and debris. A velocity of 2 feet/sec is required in pipe sections to remove the air. Purge and vent all air from the piping.

Perform the flushing and purging operation with the water source heat pumps isolated by shutoff valves from the ground heat exchanger system. Allow purge pump to run 15 minutes after the last air bubbles have been removed. After the ground heat exchanger is completely flushed of air and debris, open the isolation valves and permit circulation through the heat pumps until the entire system is flushed and purged.

Utilizing the purging unit and the procedures recommended by IGSHPA 21020, conduct a pressure and flow test on the ground heat exchanger to ensure the system is free of blockage. If the flow test indicates blockage, locate the blockage using the

manufacturer's recommendation, remove the blockage, then repeat the purge procedure and conduct the pressure and flow test again until all portions of the system are free flowing. The flow test shall be observed and approved by the Contracting Officer.

After purging has been completed, add the required amount of antifreeze to the system to achieve the required solution concentration.

Form 1, "Ground Heat Exchanger Inspection and Test Report" located below, shall be completed for each system by the Contractor after completion of the flow and injection of required antifreeze to the system and before the systems can be backfilled.

FORM 1

GROUND HEAT EXCHANGER (GHX) INSPECTION AND TEST REPORT

NOTE: Use separate form for each GHX loop system.

Building:\_\_\_\_\_ Inspection Date:\_\_\_\_\_

Ground Heat Exchanger No. or Description:\_\_\_\_\_

Does the ground heat exchanger have a Well Construction Permit? Permit No.?

Does the ground heat exchanger have an approved well permit? Permit No.

List the WSHP Unit No.'s served by this GHX: \_\_\_\_\_

Ground Heat Exchanger Design Water Flow - \_\_\_\_\_ gpm

Calculated purging flow and press to achieve 2 feet/sec

Purging: Flow \_\_\_\_\_ gpm Head \_\_\_\_\_ psi, Duration of test \_\_\_\_\_ min.

Hydrostatic test pressure \_\_\_\_\_ psi; Duration \_\_\_\_\_ min.

Did the system pass the pressure test? \_\_\_\_\_

Is antifreeze required in system?\_\_\_\_ If yes, was antifreeze measured?\_\_\_\_

Has a dimensioned drawing been prepared, completely and accurately showing  
the layout of the ground heat exchanger?  
\_\_\_\_\_

Does the layout differ substantially from the contract documents? \_\_\_\_\_

If so is the deviation approved? \_\_\_\_\_

Depth of installed vertical loops is \_\_\_\_\_ feet. (Design is \_\_\_\_\_ feet.)

Depth of horizontal piping is \_\_\_\_\_ feet. (Design is \_\_\_\_\_ feet.)

Are the trenches clear of sharp bends, rocks, or other sharp objects that  
could restrict flow?\_\_\_\_\_

Are all joints heat fused (butt-, socket-, or saddle-fusion)?\_\_\_\_\_

Do the joints have the proper amount of roll-out?\_\_\_\_\_

Has the piping material been cut-out and properly removed from saddle-fusion  
tees?\_\_\_\_\_

Grout Manufacturer? \_\_\_\_\_; Percent of solids used in  
grout?\_\_\_\_\_Grout Type?\_\_\_\_\_Grout Thermal conductivity, k? (give  
units)\_\_\_\_\_

Was the system backfilled properly with good clean backfill material?\_\_\_\_\_

Attach the soil boring and water well log sheet for the bore hole?\_\_For each  
well submit a Well Construction Log Record

Comments:\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

Inspected and approved this \_\_\_\_\_ date by \_\_\_\_\_

Title: \_\_\_\_\_

6. Additional Field Testing

Requirements for testing, adjusting, and balancing (TAB) of ducts, piping, and equipment are specified in Section 23 05 93 TESTING, ADJUSTING, AND BALANCING.

Submit written certificate to report the following:

- a. Water source heat pump unit nameplate data, and actual voltage and ampere consumption.
- b. Supply and return terminal airflow, and equipment used to measure airflow.
- c. Water source heat pump cfm and entering and leaving air temperatures.
- d. Water source heat pump unit condenser water gpm and entering and leaving temperatures.
- e. Ambient outside air temperature, date, and person testing, balancing, and reporting.

3.7 ADJUSTMENTS

Adjust controls and equipment so as to give satisfactory operation. Adjust entire water temperature control system and place in operation so that water quantities circulated are as indicated.

3.8 OPERATING AND PERFORMANCE TEST AND INSTRUCTION

- A. Refer to PART 3, Section 23 05 11, COMMON WORK RESULTS FOR HVAC and STEAM GENERATION.
- B. Adjust red set hand on pressure gages to normal working pressure.

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