
USACE / NAVFAC / AFCEA UFGS-15741N (February 2003)

Preparing Activity: NAVFAC Superseding
UFGS-15741N (August 2000)

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMLR dated 22 December 2004

Latest change indicated by CHG tags

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SECTION 15741N

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02/03

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SECTION 15741N

WATER SOURCE HEAT PUMP SYSTEMS 02/03

NOTE: This guide specification covers the requirements for water source heat pump systems and ground source closed-loop heat pump systems.

Comments and suggestions on this guide specification are welcome and should be directed to the technical proponent of the specification. A listing of technical proponents, including their organization designation and telephone number, is on the Internet.

Recommended changes to a UFGS should be submitted as a Criteria Change Request (CCR).

Use of electronic communication is encouraged.

Brackets are used in the text to indicate designer choices or locations where text must be supplied by the designer.

NOTE: System design requirements must conform to MIL-HDBK-1003/3, "Heating, Ventilating, Air Conditioning, and Dehumidifying Systems," ASHRAE CIGSHP (ISBN1-883413-21-4), and IGSHPA Design Manuals.

NOTE: The following information shall be shown on the project design drawings:

1. Design parameters for each item of equipment including capacity, efficiency, sound ratings, motor speeds, electrical characteristics, and special features.

2. Design heat pump systems for energy efficiency in compliance with FEMP/Energy Star requirements

specified at www.eren.doe.gov/femp/procurement.
Select the most efficient equipment for which there
are at least two products available for the designed
capacity. Indicate the equipment operating
requirements, including efficiency, on the drawings.

3. The locations of access doors for valves.

PART 1 GENERAL

1.1 REFERENCES

NOTE: Issue (date) of references included in
project specifications need not be more current than
provided by the latest guide specification. Use of
SpecsIntact automated reference checking is
recommended for projects based on older guide
specifications.

The publications listed below form a part of this specification to the
extent referenced. The publications are referred to within the text by the
basic designation only.

AIR-CONDITIONING AND REFRIGERATION INSTITUTE (ARI)

ARI 320 (1998) Water-Source Heat Pumps

ARI 330 (1998) Ground Source Closed-Loop Heat Pumps

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI B16.18 (1984; R 1994) Cast Copper Alloy Solder
Joint Pressure Fittings

ANSI B16.23 (1992; Errata 1994) Cast Copper Alloy
Solder Joint Drainage Fittings - DWV

ANSI Z21.22 (1999; A 2001) Relief Valves for Hot Water
Supply Systems

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS (ASHRAE)

ASHRAE 52.1 (1992) Gravimetric and Dust-Spot
Procedures for Testing Air-Cleaning
Devices Used in General Ventilation for
Removing Particulate Matter

ASHRAE Hdbk-IP (2001) Fundamentals Handbook, I-P Edition

AMERICAN SOCIETY OF SANITARY ENGINEERING (ASSE)

ASSE 1003 (2001) Water Pressure Reducing Valves

ASME INTERNATIONAL (ASME)

ASME B16.11	(2002) Forged Fittings, Socket-Welding and Threaded
ASME B16.22	(2002) Wrought Copper and Copper Alloy Solder Joint Pressure Fittings
ASME B16.26	(1988) Cast Copper Alloy Fittings for Flared Copper Tubes
ASME B16.3	(1998) Malleable Iron Threaded Fittings
ASME B16.39	(1998) Malleable Iron Threaded Pipe Unions
ASME B16.5	(2003) Pipe Flanges and Flanged Fittings
ASME B16.9	(2003) Factory-Made Wrought Steel Buttwelding Fittings
ASME B31.5	(2001) Refrigeration Piping and Heat Transfer Components
ASME B31.9	(1996) Building Services Piping
ASME BPVC	(2004) Boiler and Pressure Vessel Codes

ASTM INTERNATIONAL (ASTM)

ASTM A 106	(2002a) Seamless Carbon Steel Pipe for High-Temperature Service
ASTM A 126	(2004) Gray Iron Castings for Valves, Flanges, and Pipe Fittings
ASTM A 193/A 193M	(2004c) Alloy-Steel and Stainless Steel Bolting Materials for High-Temperature Service
ASTM A 194/A 194M	(2004a) Carbon and Alloy Steel Nuts for Bolts for High Pressure or High Temperature Service or Both
ASTM A 53	(1999b) Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM B 265	(2003) Titanium and Titanium Alloy Strip, Sheet, and Plate
ASTM B 280	(2003) Seamless Copper Tube for Air Conditioning and Refrigeration Field Service
ASTM B 306	(2002) Copper Drainage Tube (DWV)
ASTM B 32	(2004) Solder Metal
ASTM B 333	(2003) Nickel-Molybdenum Alloy Plate, Sheet, and Strip

ASTM B 42	(2002e1) Seamless Copper Pipe, Standard Sizes
ASTM B 424	(1998a) Ni-Fe-Cr-Mo-Cu Alloy (UNS N08825 and UNS N08221)* Plate, Sheet, and Strip
ASTM B 62	(2002) Composition Bronze or Ounce Metal Castings
ASTM B 88	(2003) Seamless Copper Water Tube
ASTM B 88M	(2003) Seamless Copper Water Tube (Metric)
ASTM D 1177	(1994; R 1998e1) Freezing Point of Aqueous Engine Coolants
ASTM D 2447	(2003) Polyethylene (PE) Plastic Pipe, Schedules 40 and 80, Based on Outside Diameter
ASTM D 2513	(2004a) Thermoplastic Gas Pressure Pipe, Tubing, and Fittings
ASTM D 2581	(2002) Polybutylene (PB) Plastics Molding and Extrusion Materials
ASTM D 2666	(1996a) Polybutylene (PB) Plastic Tubing
ASTM D 2683	(2004) Socket-Type Polyethylene Fittings for Outside Diameter-Controlled Polyethylene Pipe and Tubing
ASTM D 3000	(1995ae1) Polybutylene (PB) Plastic Pipe (SDR-PR) Based on Outside Diameter
ASTM D 3035	(2003a) Polyethylene (PE) Plastic Pipe (DR-PR) Based on Controlled Outside Diameter
ASTM D 3261	(2003) Butt Heat Fusion Polyethylene (PE) Plastic Fittings for Polyethylene (PE) Plastic Pipe and Tubing
ASTM D 3350	(2002a) Polyethylene Plastics Pipe and Fittings Materials
ASTM D 92	(2002b) Flash and Fire Points by Cleveland Open Cup Tester
ASTM F 1105	(2003) Preparing Aircraft Cleaning Compounds, Liquid-Type, Temperature-Sensitive, or Solvent-Based, for Storage Stability Testing

FOUNDATION FOR CROSS-CONNECTION CONTROL AND HYDRAULIC RESEARCH
(FCCCHR)

FCCCHR List (continuously updated) List of Approved

Backflow Prevention Assemblies

INTERNATIONAL GROUND SOURCE HEAT PUMP ASSOCIATION (IGSHPA)

- IGSHPA 21010 (1991) Grouting Procedures for
Ground-Source Heat Pump Systems
- IGSHPA 21020 (1988) Closed-Loop/Ground-Source Heat Pump
System/Installation Guide

MANUFACTURERS STANDARDIZATION SOCIETY OF THE VALVE AND FITTINGS
INDUSTRY (MSS)

- MSS SP-58 (2002) Pipe Hangers and Supports -
Materials, Design and Manufacture
- MSS SP-67 (2002) Butterfly Valves
- MSS SP-69 (2002) Pipe Hangers and Supports -
Selection and Application
- MSS SP-70 (1998) Cast Iron Gate Valves, Flanged and
Threaded Ends
- MSS SP-71 (1997) Gray Iron Swing Check Valves,
Flanged and Threaded Ends
- MSS SP-80 (2003) Bronze Gate, Globe, Angle and Check
Valves
- MSS SP-85 (2002) Cast Iron Globe & Angle Valves,
Flanged and Threaded Ends

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

- NFPA 70 (2005) National Electrical Code

SHEET METAL AND AIR CONDITIONING CONTRACTORS' NATIONAL ASSOCIATION
(SMACNA)

- SMACNA HVAC Duct Const Stds (1995, 2nd Ed) HVAC Duct Construction
Standards - Metal and Flexible

UNDERWRITERS LABORATORIES (UL)

- UL 94 (1996; Rev thru Dec 2003) Tests for
Flammability of Plastic Materials for
Parts in Devices and Appliances

1.2 SYSTEM DESCRIPTION

**NOTE: Select fourth sentence for water source heat
pump systems and fifth sentence for ground source
closed loop heat pump systems.**

Provide [new] [and modify existing] heat pump systems complete and ready
for operation. Systems include heat pumps, system equipment and condenser.

Installation of HVAC system including equipment, materials, installation, workmanship, fabrication, assembly, erection, examination, inspection, and testing shall be in accordance with ASME B31.9, ASME B31.5, ASHRAE Hdbk-IP, IGSHPA 21010, IGSHPA 21020, NFPA 70, as supplemented and modified by this section. [Provide water source heat pump condenser piping under Section 15181N CHILLED CONDENSER OR DUAL SERVICE WATER PIPING.] [Provide ground coupled condenser loop piping by the requirements of this section.]

1.3 RELATED REQUIREMENTS

[Requirements for cooling towers are specified in Section 15601N CENTRAL REFRIGERATION EQUIPMENT FOR AIR CONDITIONING.]

[Requirements for water heating boilers are specified in Section 15515N LOW PRESSURE WATER HEATING BOILERS.]

Requirements for metal duct systems are specified in Section 15720N AIR HANDLING UNITS.

1.4 SUBMITTALS

NOTE: Submittals must be limited to those necessary for adequate quality control. The importance of an item in the project should be one of the primary factors in determining if a submittal for the item should be required.

A "G" following a submittal item indicates that the submittal requires Government approval. Some submittals are already marked with a "G". Only delete an existing "G" if the submittal item is not complex and can be reviewed through the Contractor's Quality Control system. Only add a "G" if the submittal is sufficiently important or complex in context of the project.

For submittals requiring Government approval on Army projects, a code of up to three characters within the submittal tags may be used following the "G" designation to indicate the approving authority. Codes for Army projects using the Resident Management System (RMS) are: "AE" for Architect-Engineer; "DO" for District Office (Engineering Division or other organization in the District Office); "AO" for Area Office; "RO" for Resident Office; and "PO" for Project Office. Codes following the "G" typically are not used for Navy projects.

Submittal items not designated with a "G" are considered as being for information only for Army projects and for Contractor Quality Control approval for Navy projects.

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are [for Contractor Quality Control approval.] [for information only. When used, a designation following the

"G" designation identifies the office that will review the submittal for the Government.] The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Ground heat exchanger piping system as-Built drawings; G

SD-03 Product Data

NOTE: Include the integral or appurtenant space temperature controls (STC) following when Section 15901, "Space Temperature Control Systems" or Section 15910, "Direct Digital Control Systems" is not included in the project design specifications.

Product data for integral or appurtenant space temperature controls (STC) supplied with the listed equipment shall include shall include point-to-point electrical wiring diagrams for each STC.

Water-source water-to-air heat pumps; G
[including STC data]

Water-source water-to-water heat pumps; G
[including STC data]

[Ground heat exchanger piping system; G]

[Closed circuit coolers; G]

[Plate heat exchangers; G]

Valves

Specialty valves; G

Expansion tanks

Air separators

[Heat tape]

[Antifreeze; G]

SD-06 Test Reports

Piping welds NDE report

[Water-source water-to-air heat pumps - field acceptance test plan; G]

[Water-source water-to-water heat pumps - field acceptance test plan; G]

[Closed Circuit Coolers - field acceptance test plan; G]

- [Plate Heat Exchangers - field acceptance test plan; G]
- [Water-source water-to-air heat pumps - field acceptance test report; G]
- [Water-source water-to-water heat pumps - field acceptance test report; G]
- [Closed Circuit Coolers - field acceptance test report; G]
- [Plate Heat Exchangers - field acceptance test report; G]

SD-07 Certificates

- Employer's record documents
- Welding procedures and qualifications
- Qualifications of ground heat exchanger fabricators; G
- Qualifications of ground heat exchanger installers; G

SD-08 Manufacturer's Instructions

- [Water-source water-to-air heat pumps - installation instructions]
- [Water-source water-to-water heat pumps - installation instructions]
- [Closed Circuit Coolers - installation instructions]
- [Plate Heat Exchangers - installation instructions]
- [Heat Tape - installation instructions]

SD-10 Operation and Maintenance Data

- [Water-source water-to-air heat pumps, Data Package 2; G]
- [Water-source water-to-water heat pumps, Data Package 2; G]
- [Closed Circuit Coolers, Data Package 2; G]
- [Plate Heat Exchangers, Data Package 2; G]
- [Heat Tape, Data Package 2; G]

Submit in accordance with Section 01781 OPERATION AND MAINTENANCE DATA.

1.5 QUALITY ASSURANCE

1.5.1 Ground heat exchanger piping system As-Built Drawings

Provide dimensioned as-built drawings of each complete ground heat exchanger piping system, depicting its relationship to other utilities and buildings in its proximity before burying, covering, or concealing. Drawings shall be of a quality equivalent to the contract design drawings. The as-built drawings of the installed ground heat exchanger piping system shall be laminated or stored in a clear plastic envelope and affixed

visibly to the heat pump unit or on the wall in the mechanical room if serving a system of multiple heat pumps. A permanent label shall be affixed to each heat pump unit indicating basic information for that unit. The information shall include: nominal flow rate l/s gpm, pressure drop kPa feet, temperature drop/rise degree C degree F, and capacity W Btu/hr.

1.5.2 Piping Welding Requirements

Provide welding work specified this section for piping systems in conformance with ASME B31.9, as modified and supplemented by this specification section and the accompanying drawings. The welding work includes: qualification of welding procedures, welders, welding operators, brazers, brazing operators, and nondestructive examination personnel; maintenance of welding records, and examination methods for welds.

1.5.3 Employer's Record Documents

Submit to the Contracting Officer for their review and approval the following documentation. This documentation and the subject qualifications shall be in compliance with ASME B31.9.

- a. List of qualified welding procedures that is proposed to be used to provide the work specified in this specification section.
- b. List of qualified welders, brazers, welding operators, and brazing operators that are proposed to be used to provide the work specified in this specification section.
- c. List of qualified weld examination personnel that are proposed to be used to provide the work specified in this specification section.

1.5.4 Welding Procedures and Qualifications

- a. Specifications and Test Results: Submit copies of the welding procedures specifications and procedure qualification test results for each type of welding required. Approval of any procedure does not relieve the Contractor of the responsibility for producing acceptable welds. Submit this information on the forms printed in ASME BPVC SEC IX or their equivalent.
- b. Certification: Before assigning welders or welding operators to the work, submit a list of qualified welders, together with data and certification that each individual is performance qualified as specified. Do not start welding work prior to submitting welder, and welding operator qualifications. The certification shall state the type of welding and positions for which each is qualified, the code and procedure under which each is qualified, date qualified, and the firm and individual certifying the qualification tests.

1.5.5 Welding Examinations

Conduct non-destructive examinations (NDE) on piping welds and verify welds meet the acceptance criteria specified in ASME B31.9. NDE on piping welds covered by ASME B31.9 is visual inspection only. Submit a piping welds NDE report meeting the requirements specified in ASME B31.9.

1.5.6 Qualifications of Ground Heat Exchanger Fabricators

NOTE: The experience clause in this section has been approved by a Level 1 Contracting Officer, and may be used without further approval or request for waiver.

The only acceptable method for joining buried pipe systems is by a heat fusion process. Submit documentation substantiating the following qualifications: ground heat exchanger 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.

NOTE: The experience clause in this section has been approved by a Level 1 Contracting Officer, and may be used without further approval or request for waiver.

1.5.7 Qualifications of Ground Heat Exchanger Installers

Submit documentation substantiating the following qualifications: installers shall have completed an approved manufacturer's certification program and shall have successfully completed at least two projects with ground heat exchanger work similar in size and complexity to that required for this project within the last 4 years.

PART 2 PRODUCTS

2.1 EQUIPMENT

Equipment using refrigerants R-11, R-12, R-113, R-114, R-115, R-500, or refrigerants with ozone depletion factor (ODF) greater than 0.05 will not be permitted.

2.1.1 Water-Source Water-to-Air Heat Pumps (WAHP)

NOTE: In compliance with FEMP/Energy Star requirements, units shall have minimum SEER of 14.1 and minimum heating performance COP of 3.3. Indicate the equipment operating requirements, including efficiency, on the drawings.

[Provide water-source water-to-air heat pump units factory assembled, designed, tested, and rated in accordance with ARI 320.] [Provide ground-coupled closed-loop water-to-air heat pump (extended range) units factory assembled, designed, tested, and rated in accordance with ARI 330.] Units shall be ARI certified, or listed in ARI directory. Units shall include fans, refrigerant-to-air heat exchangers, filters, dampers, compressor, reversing valve, expansion valve, refrigerant-to-water heat exchangers, [desuperheater], hose kits, and controls. A permanent label shall be affixed to each heat pump unit indicating basic information for that unit. The information shall include: nominal flow rate l/s gpm,

pressure drop kPa feet, temperature drop/rise degree C degree F, and capacity W Btu/hr.

- a. Cabinet: Provide manufacturer's standard galvanized steel cabinet finished with corrosion resistant epoxy coating or lacquer acrylic. Provide access panels for inspection and access to internal parts. Insulate cabinet with minimum 12 mm 1/2 inch multi-density, fiberglass insulation with exposed edges sealed or tucked under flanges to prevent introduction of fibers into the airstream. Female threaded pipe condensate drain connections, supply water connections, and return water connections shall be copper threaded fittings mechanically fastened to the cabinet. Water piping shall be insulated. Construct cabinet with compartments and locate the compressor, reversing valve, and water coil out of the airstream. Insulate the divider between the compressor and fan sections. The control box shall be located within the unit.
- b. Fans: Provide centrifugal type, direct drive fans with permanently lubricated motors. Motors shall be permanent split capacitor (PSC) type with thermal overload protection.
- c. Refrigerant-to-Air Heat Exchanger: Provide coil constructed of rifled copper tubes with plate aluminum fins designed for refrigerant working pressure of 3102 kPa 450 psi. The condensate drain pan shall be epoxy coated and insulated. Provide internal traps on vertical units. Provide drain pan with overflow protection.
- d. Filter Section: Provide [replaceable (throwaway) [25 mm one inch] [50 mm 2 inch] thick UL listed fiberglass] [permanent washable] type filters with [standard dust-holding capacity] [a mean efficiency of [35] [65] percent when tested in accordance with ASHRAE 52.1]. Mount filters in filter frames and provide access panels or doors for removal and replacement of filters.
- e. Compressor: Provide hermetically sealed type compressor, installed on vibration isolators enclosed in an acoustically treated enclosure. Provide high and low pressure switches, low suction temperature cut-out, motor thermal overload protection, 5 minute anti-recycle timer, and start capacitor kit. Provide capability to reset compressor lockout circuit at the remote thermostat and at the disconnect. [Provide units with factory installed sound attenuation package.]
- f. Reversing Valve: Provide solenoid activated refrigerant reversing valves energized only during the cooling mode and designed to fail in the heating position.
- g. Refrigerant-to-Water Heat Exchangers: [Provide refrigerant-to-water heat exchangers of coaxial type, with inner cupronickel water tube and outer steel refrigerant tube.] Heat exchanger shall be tested and rated for 3102 kPa 450 psi refrigerant working pressure. A parallel capillary tube/thermal expansion valve assembly shall provide superheat over [one to 43 degree C 30 to 110 degree F] [7 to 32 degree C 45 to 90 degree F] liquid temperature range.
- [h. Factory-Installed Domestic Hot Water Desuperheater: Provide

desuperheater of vented double-wall construction and factory installed within indoor heat pump cabinet.]

- [i. Field-Installed Domestic Hot Water Desuperheater: Provide units factory assembled, designed, tested, and rated. Units shall include double-wall vented refrigerant-to-water heat exchanger, water pump powered by a sealed magnetic drive motor, water line thermostat, secondary safety thermostat to prevent scalding, internal fuse, internally mounted disconnect switch, air bleed port, and refrigerant ports. Units shall be UL listed. Units shall be provided by the ground source closed loop heat pump manufacturer.]
- j. Emergency Heater: Provide UL or ETL listed, electric resistance heater with internal fusing integral with heat pump unit; fan shall run until heater cools. Locate downstream of indoor coil.
- k. Hose Kits: Kits shall include two 0.6 m 2 foot long metal braided hoses with swivel connectors on one end, an manual flow control valve with test ports, two shutoff ball valves with memory stops (one with test port), blow down ball valve, and Y-strainer. Hoses shall be fire rated to meet UL 94. Hoses shall have a maximum working pressure of 2067 kPa 300 psi.
- l. Hanger Kits: Provide horizontal units with hanger kits consisting of galvanized steel brackets, bolts, washers, and vibration isolators. The hanger kit shall be designed to support the unit from below and suspend from threaded rods.

Note: Microprocessor based controls should normally be utilized on large projects. Electromechanical controls should be used on small installations, housing, and remote location projects.

- m. Controls: Controls and safety devices shall be factory wired and mounted within the control box of the unit cabinet.
 - (1) Provide a microprocessor based controller that communicates with an electronic multi-stage space thermostat. The microprocessor shall control sequencing, high and low pressure switch monitoring, freeze protection, lockout control, night setback, emergency shutdown, short cycle protection, random start, LED mode and fault indicators, fault memory, input and output diagnostics, and a communications port. Provide a factory-installed low voltage terminal block for field control wiring and a low voltage transformer. [Provide communications capability for remote direct digital control (DDC).] [Provide a hand held, remote service terminal from the heat pump manufacturer capable of interfacing with heat pump unit microprocessor controller to perform diagnostics, data retrieval, and calibration functions.]
 - [(2) Provide 24 volt electromechanical controls supplied with a low voltage transformer, controls for compressor, reversing valve, and fan motor operation. Controls shall include a random start relay, a night setback relay, a compressor cycling relay for demand load shedding, and a condensate overflow switch. Provide a

low voltage terminal block for field control wiring.]

- n. Space Temperature Controls: Provide electronic multi-stage, auto-changeover, adjustable thermostats with OFF-HEAT-AUTO-COOL-EMERGENCY system switch and AUTO-ON fan switch. Thermostats shall be furnished by the unit manufacturer. Provide relays, transformers, contractors, and control wiring between thermostats and unit. Thermostats shall read out in degrees C and degrees F.

NOTE: Plate heat exchangers are required in systems using closed circuit coolers or cooling towers to isolate the ground heat exchanger loops from the building terminal loops.

2.1.2 Water-Source Water-to-Water Heat Pumps (WWHP)

NOTE: In compliance with FEMP/Energy Star requirements, units 19040 Wshall have minimum SEER of 14.1 and minimum heating performance COP of 3.3. Indicate the equipment operating requirements, including efficiency, on the drawings.

[Provide water-source water-to-water heat pump units factory assembled.]
[Provide ground-coupled closed-loop water-to-water heat pump (extended range) units factory assembled.] Units shall be listed by ETL, or listed in ARI directory. Units shall include compressor, reversing valve, expansion valve, refrigerant-to-water condensing coil, refrigerant-to-water evaporator coil, [desuperheater], hose kits, and controls.

- a. Cabinet: Provide manufacturer's standard galvanized steel cabinet finished with corrosion resistant epoxy coating or lacquer acrylic. Provide access panels for inspection and access to internal parts. Insulate cabinet with minimum 12 mm 1/2 inch multi-density, fiberglass insulation. Provide copper or stainless steel female threaded pipe connections for supply water and return water connections; these connections shall be mechanically fastened to the cabinet. Water piping shall be insulated.
- b. Compressor: Provide hermetically sealed type compressor, installed on vibration isolators enclosed in an acoustically treated enclosure. Provide high and low pressure switches, low suction temperature cut-out, motor thermal overload protection, 5 minute anti-recycle timer, and start capacitor kit. Provide capability to reset compressor lockout circuit at the remote thermostat and at the disconnect. [Provide units with factory installed sound attenuation package.]
- c. Reversing Valve: Provide solenoid activated refrigerant reversing valves energized only during the cooling mode and designed to fail in the heating position.
- d. Refrigerant-to-Water Heat Exchangers: Provide refrigerant-to-water heat exchangers of coaxial type, with inner cupronickel water tube and outer steel refrigerant tube. Heat

exchanger shall be tested and rated for 3102 kPa 450 psi refrigerant working pressure. A parallel capillary tube/thermal expansion valve assembly shall provide superheat over [one to 43 degree C30 to 110 degree F] [7 to 32 degree C45 to 90 degree F] liquid temperature range. Refrigerant-to-water heat exchangers and refrigerant piping shall be insulated to prevent condensation on the piping containing low temperature water.

- e. Factory-Installed Domestic Hot Water Desuperheater: Provide desuperheater of vented double-wall construction and factory installed within indoor heat pump cabinet.]
- f. Hose Kits: Kits shall include two 0.6 m 2 foot long metal braided hoses with swivel connectors on one end, [an flow control valve with test ports,] two shutoff ball valves with memory stops (one with test port), blow down ball valve, and Y-strainer. Hoses shall be fire rated to meet UL 94. Hoses shall have a maximum working pressure of 2067 kPa 300 psi.
- g. Hanger Kits: Provide units with hanger kits consisting of galvanized steel brackets, bolts, washers, and vibration isolators. The hanger kit shall be designed to support the unit from below and suspend from threaded rods.

Note: Microprocessor based controls should normally be utilized on large projects. Electromechanical controls should be used on small installations, housing, and remote location projects.

- h. Controls: Controls and safety devices shall be factory wired and mounted within the control box of the unit cabinet.
 - (1) Provide a microprocessor based controller. The microprocessor shall control sequencing, high and low pressure switch monitoring, freeze protection, lockout control, night setback, emergency shutdown, short cycle protection, random start, LED mode and fault indicators, fault memory, input and output diagnostics, and a communications port. Provide a factory-installed low voltage terminal block for field control wiring and a low voltage transformer. [Provide communications capability for remote direct digital control (DDC).] [Provide a hand held, remote service terminal from the heat pump manufacturer capable of interfacing with heat pump unit microprocessor controller to perform diagnostics, data retrieval, and calibration functions.]
 - [(2) Provide 24 volt electromechanical controls supplied with a low voltage transformer, pump relay, controls for compressor, reversing valve coil, and lock out relay. Controls shall include a random start relay, a night setback relay, and a compressor cycling relay for demand load shedding, and a condensate overflow switch. Provide a low voltage terminal block for field control wiring.]
- i. Space Temperature Controls: Provide electronic multi-stage, auto-changeover, adjustable thermostats with OFF-HEAT-AUTO-COOL-EMERGENCY system switch and AUTO-ON fan switch.

Thermostats shall be furnished by the unit manufacturer. Provide relays, transformers, contractors, and control wiring between thermostats and unit. Thermostats shall read out in degrees C and degrees F.

[2.1.3 Closed Circuit Coolers

- a. Fan and Casing: Construct the fan section (up to top of intake louvers) of heavy gage stainless steel and construct casing of hot-dip galvanized steel. Standard pan accessories shall include louver access, overflow, drain, Type 304 stainless steel strainers, and brass make-up valve with plastic float.
- b. Axial Propeller Fans: Fans shall be heavy duty axial propeller type statically balanced. Construct fans with aluminum alloy blades, and install in a closed fitted cowl with venturi air inlet.
- c. Fan Motors: Motors shall be totally enclosed, ball bearing type, and suitable for outdoor service.
- d. Drive: Fan drive shall be multi-groove, solid V-belt type with taper lock sheaves designed for 150 percent of nameplate kWHP. Fan and motor sheave shall be aluminum alloy construction. Belt adjustment shall be accomplished from exterior of unit.
- e. Heat Transfer Coil: The coil shall be steel, encased in steel framework with the entire assembly hot-dip galvanized after fabrication. Arrange tubes in a self-spacing, staggered pattern in the direction of airflow for maximum heat transfer efficiency and minimum pressure drop, without the use of additional spacers between the coil tubes. Design coil with sloping tubes for free drainage of liquid and test to 2413 kPa 350 psi air pressure under water.
- f. Water Distribution System: The system shall provide a water flow rate of not less than .3846 l/sec 6 gpm over each square foot of unit face area to ensure proper flooding of the coil. Construct spray header of Schedule 40 polyvinyl chloride (PVC) pipe for corrosion resistance. Spray branches shall be removable for cleaning. Distribute water over the entire coil surface by spray nozzles (381 by 8 mm 15 by 5/16 inch orifice) with internal sludge ring to eliminate clogging. Thread nozzles into spray header to provide easy removal for maintenance.
- g. Water Recirculation Pump: The pump shall be close-coupled, centrifugal type with mechanical seal, installed vertically at the factory to allow free drainage at shutdown.
- h. Eliminators: Construct eliminators of inert PVC in easily handled sections. The eliminator design shall incorporate three changes in air direction to ensure complete removal of entrained moisture from the discharge airstream. Maximum drift rate shall be less than 0.001 percent of the circulating water rate.
- i. Construct Louvers From PVC: Mount louvers in removable frames for maintenance access to the pan. Louvers shall have a minimum of two changes in air direction to prevent splash out and block direct sunlight.

- j. Finish: Apply corrosion protection system to the outside of galvanized surfaces. Construct non-stainless metal components of mill hot-dip galvanized steel. Coat component edges and welds with a 95 percent pure zinc-rich compound. Preparation for coating shall include degreasing, cleaning, and a light surface burnishing. The coating shall be suitable for field repair with the same original coating material applied in the same manner.
- k. Electric Pan Heater Package: Electric pan heater package consists of electric immersion heaters, heater thermostat, and low water cutout, all installed in pan. Size heaters to maintain +5 degrees C +40 degrees F pan water temperature with the fans off at design conditions indicated on drawings. Control the heaters with a thermostat, and provide water cutout to prevent heaters from cycling on unless they are completely submerged. Provide heater contactor and wiring under Section 16402 INTERIOR DISTRIBUTION SYSTEM.
- l. Discharge Hood With Positive Closure Dampers: Provide unit with discharge hood, positive closure dampers, and 120-volt actuator for reduction of heat loss during idle periods of winter time operation. Construct the discharge hood and dampers of hot dipped galvanized steel. Equip hoods with access panels to facilitate maintenance on the eliminators and water distribution system. Factory assemble the dampers, damper actuator, and linkage.

]2.1.4 Plate Heat Exchangers

 NOTE: Plate heat exchangers are required in systems using closed circuit coolers or cooling towers to isolate the ground heat exchanger loops from the building terminal loops.

 NOTE: Provide the following flat plate heat exchanger information on the drawing:

1. Maximum water pressure drop through clean plates and headers in kPa psi at the flow rates and temperatures indicated.

2. Minimum rate of turbulent flow in l/sec gpm through any two plate segment.

3. Minimum plate thickness in mm inch.

Plates, frames, and gaskets shall be designed for a working pressure of 2.07 MPa 300 psi and factory tested at 31.0 MPa 450 psi. Medium temperature water, low temperature water, and pressure relief valve connections shall be located in accordance with the manufacturer's standard practice. Connections larger than 80 mm 3 inches shall be ASME 2.07 MPa 300 pound flanged. Plates shall be corrugated [Type 304 stainless steel] [Type 316 stainless steel] [nickel-iron-chromium alloy conforming to ASTM B 424] [nickel-molybdenum alloy conforming to ASTM B 333] [titanium alloy conforming to ASTM B 265].

2.1.5 Pumps

NOTE: Design pumping systems for energy efficiency
in compliance with FEMP/Energy Star requirements
specified at www.eren.doe.gov/femp/procurement.
Indicate the equipment operating requirements,
including efficiency, on the drawings.

2.1.5.1 In-Line Pumps

Provide pumps constructed of manufacturer's standard materials suitable for chilled water and hot water heating systems. Pumps shall have mechanical seals and drip-proof electric motors.

2.1.5.2 End Suction Water Pumps

Pumps shall be single stage centrifugal, with mechanical seals and drip-proof electric motors. Impeller shall be bronze. Other pump parts shall be manufacturer's standard materials provided with bronze impeller pump. Provide threaded suction and discharge pressure gage tapping with square-head plugs. Provide flexible coupling with steel cover guard on base-mounted pumps. Base-mounted pump, coupling guard, and motor shall each be bolted to a fabricated steel base which shall have bolt holes for securing base to supporting surface. Close-coupled pump shall be provided with integrally cast or fabricated steel feet with bolt holes for securing feet to supporting surface.

[Provide pump suction diffuser. Pump casing shall include an angle type body of cast iron. Unit shall have internal straightening vanes, strainer with minimum 6.35 mm 0.25 inch openings, and auxiliary disposable fine mesh strainer which shall be removed 30 days after start-up. Provide warning tag for operator indicating scheduled date for removal. Casing shall have connection sizes to match pump suction and pipe sizes, and be provided with adjustable support foot or support foot boss to relieve piping strains at pump suction. Blowdown port and plug shall be provided on unit casing. Provide a magnetic insert to remove debris from system.]

[2.1.5.3 Pump Modules

Provide pump module units factory designed, assembled, and pressure tested. Units shall include flanged pumps, brass fill and purge valves, quick release fill and purge ports, pressure/temperature (Pete's) plug, wiring, and fuse protection. Pumps shall be the wet rotor and single stage types, with pump casings thermally insulated. Provide manufacturer's standard galvanized steel cabinet, finished with corrosion resistant epoxy paint. Pump module units shall be provided by the ground source, closed loop heat pump manufacturer.

] 2.2 ELECTRICAL

2.2.1 Electrical Motors, Controllers, Contactors, and Disconnects

Furnish with respective pieces of equipment. Motors, controllers, contactors, and disconnects shall conform to Section 16402 INTERIOR DISTRIBUTION SYSTEM. Provide electrical connections under Section 16402 INTERIOR DISTRIBUTION SYSTEM. Provide controllers and contactors with maximum of 120-volt control circuits, and auxiliary contacts for use with

controls furnished. When motors and equipment furnished are larger than sizes indicated, the cost of providing additional electrical service and related work shall be included under this section.

2.2.2 Electrical Work

Provide in accordance with Section 16402 INTERIOR DISTRIBUTION SYSTEM.

[Provide control wiring in accordance with Section 15901N SPACE TEMPERATURE CONTROL SYSTEMS.] [Provide control wiring in accordance with Section 15910N DIRECT DIGITAL CONTROL SYSTEMS.] [Provide control wiring in this section, in accordance with NFPA 70.]

2.3 ABOVEGROUND PIPING SYSTEMS

Provide the following pipe and fittings. Provide dielectric fittings, unions, or flanges between steel piping and copper tubing for all piping sizes; except that copper alloy valves and strainers may be used without dielectric fittings, unions, or flanges. Water piping sizes 100 mm 4 inches and smaller shall be copper tubing. [Water piping sizes larger than 100 mm 4 inches shall be copper tubing or steel piping.]

2.3.1 Copper Tubing Systems

Provide copper tubing for the following systems.

- a. Copper condensate drain piping from drain pans.
- b. Copper refrigerant tubing.
- [c. Condenser water piping aboveground or within mechanical space.]
- [d. Chilled/Hot Water Piping.]

2.3.1.1 Copper Condensate Drain Piping

Provide copper tubing in accordance with ASTM B 88M ASTM B 88, Type L or M for piping sizes 25 mm one inch and smaller. Provide ASTM B 306 copper tubing and ANSI B16.23 solder joint fittings for piping sizes larger than 25 mm one inch. In lieu of copper tubing, 32 mm 1.25 inch Schedule 40 polyvinyl chloride (PVC) plastic pipe, fittings, and solvent cement may be provided.

2.3.1.2 Copper Refrigerant Tubing

Provide ASTM B 280, cleaned, dehydrated, and sealed. Provide ASME B16.22 solder joint refrigerant fittings and adapters. Provide silver brazing alloy solder and silver brazing alloy flux. During brazing operations bleed a small amount of dry oil-free nitrogen continuously through the refrigerant tubing. Provide ASME B16.26 flared fittings.

2.3.1.3 Soldered Joint Copper Tubing Systems

For condenser water piping and chilled/hot water piping, provide ASTM B 88M ASTM B 88, Type L or M for aboveground piping, Type K for buried piping, with ANSI B16.18 or ASME B16.22 solder joint fittings, unions, and flanges; provide adapters as required. Provide ASTM B 42 copper pipe nipples with threaded end connections. Provide ASTM B 32, 95-5 tin-antimony (Sn-Pb) solder.

2.3.2 Steel Piping Systems

Provide steel piping for the following piping systems.

- [a. Condenser water piping aboveground or within mechanical spaces.]
- [b. Ground heat exchanger piping within valve pits.]
- [c. Chilled/Hot Water Piping.]

2.3.2.1 Steel Pipe

Provide ASTM A 53 Type E or Type S, or ASTM A 106 steel pipe; except ASTM A 53, Type F steel pipe may be provided for water pipe sizes larger than 100 mm 4 inches. Provide Weight Class STD or Schedule No. 40 black steel pipe for welding end connections. Provide Weight Class XS or Schedule No. 80 black steel pipe for threaded end connections.

2.3.2.2 Steel Pipe Fittings

Provide ASME B16.3 or ASME B16.11 threaded fittings, and ASME B16.39 threaded unions. Provide ASME B16.9 butt welding fittings of the same material and weight as the piping in which fittings are installed; provide backing rings compatible with piping materials being butt welded. Provide ASME B16.11 socket welding fittings.

2.3.2.3 Steel Pipe Unions

Provide ASME B16.39, Class 1034 150, unions with threaded end connections on one side of threaded valve in steel piping systems.

2.3.2.4 Steel Pipe Flanges

Provide ASME B16.5, Class 1034 150 welding neck flanges. Extend bolts no less than two full threads beyond the nut with the bolts tightened to the required torque.

- a. Gaskets: Provide one piece factory cut gaskets suitable for the intended service. Provide full-face gaskets for flat-face flanged joints, and ring gaskets for raised-face flanged joints.
- b. Bolts: Provide ASTM A 193/A 193M, Grade B7 bolts.
- c. Nuts: ASTM A 194/A 194M, Grade 7.
- d. Washers: Provide steel flat circular washers under bolt heads and nuts.

2.3.3 Valves

NOTE: Boiler type service valves are not to be used.

Valves shall have flanged end connections, except valves smaller than 65 mm 2.5 inches may have threaded end connections with a union on one side of the valve. Solder end connections may be used for connections between copper alloy valves and copper tubing.

2.3.3.1 Gate Valves

MSS SP-80, Class 862 125, except sizes 65 mm 2.5 inches and larger shall conform to MSS SP-70, Class 862 125.

2.3.3.2 Globe and Angle Valves

MSS SP-80, Class 862 125, except sizes 65 mm 2.5 inches and larger shall conform to MSS SP-85, Class 862 125.

2.3.3.3 Check Valves

MSS SP-80, Class 862 125, swing check; except sizes 65 mm 2.5 inches and larger shall conform to MSS SP-71, Class 862 125.

2.3.3.4 Butterfly Valves

MSS SP-67, except sizes 65 mm 2.5 inches and larger shall have lugged or wafer body designed for installation between ASME Class 1034 150 flanges. Valves shall have two-position lever handles.

2.3.3.5 Ball Valves

Full port design, copper alloy body, except sizes 65 mm 2.5 inches and larger shall be cast-iron body. Valves shall have two-position lever handles unless indicated otherwise. Ball valves may be provided in lieu of butterfly valves and gate valves.

2.3.3.6 Vent Valves

Provide manual vent valves designed to be operated manually with screwdriver or thumbscrew, 6 mm 1/8 inch NPS connection. The valve material shall be compatible with the working fluid (antifreeze).

2.3.3.7 Water Relief Valves

Provide water relief valves as indicated, and in accordance with ASME BPVC. Bronze body, test level, ASME rated. Pressure relief at 207 kPa 30 psi.

2.3.4 Specialty Valves

2.3.4.1 Combination Pressure and Temperature Relief Valves

ANSI Z21.22, copper alloy body, automatic reseating, with test lever. Discharge capacity pressure relief setting shall be 862 kPa 125 psi and temperature setting of 85 degrees C 210 degrees F based on AGA temperature steam rating.

2.3.4.2 Water Pressure Reducing Valves

ASSE 1003, copper alloy body, automatic reseating, with test lever.

2.3.4.3 Water Temperature Regulating Valves

Provide copper alloy body, direct acting, pilot operated, for the intended service.

2.3.4.4 Flow Control Balancing Valves

Copper alloy or cast iron body, copper alloy, or stainless internal working parts, and integral pointer that indicates the degree of valve opening. Valves shall be suitable for 862 kPa (gage) 125 psi at 87.8 degrees C 190 degrees F hot water. Valve shall function as a service valve when in fully closed position. Valve body shall have factory-installed tapings for differential pressure meter connections for verification of pressure differential across valve orifice. Meter connections shall have positive check valves or shutoff valves. Each valve shall have metal tag showing the liters per second gallons per minute flow for each differential pressure reading.

2.3.4.5 Backflow Prevention Assemblies

Provide reduced pressure principle type backflow prevention assemblies which are approved by and have a current "Certificate of Approval" from the FCCCHR List. Listing of the particular make, model/design, and size in the current FCCCHR List will be acceptable as the required proof.

2.4 GROUND HEAT EXCHANGER PIPING SYSTEM

Provide polyethylene [or polybutylene] pipe and fittings for the underground portions of the ground heat exchanger. Use of polyvinyl chloride (PVC) pipe and fittings is not permitted.

2.4.1 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 32 mm 1.25 inches diameter. Provide ASTM D 2447, Schedule 40 or ASTM D 3035 pipe with a minimum SDR of 13.5 for pipe 32 mm 1.25 inches diameter or greater, and a minimum SDR of 17.0 for pipe 75 mm 3 inches diameter or greater. Provide ASTM D 3035 pipe in vertical bores greater than 60 m 200 feet deep with a SDR of 11.0.

**NOTE: Polybutylene pipe is not available in the
Continental United States. This product is used in
Europe.**

[2.4.2 Polybutylene Pipe

Pipe shall be manufactured from virgin polybutylene extrusion material in accordance with ASTM D 2581, Type II, Grade 1, Class B or C. Provide ASTM D 2666 pipe with a minimum SDR of 13.5 for pipe 50 mm 2 inches diameter or less. Provide ASTM D 3000 pipe with a SDR of 11.0 for pipe greater than 50 mm 2 inches diameter. Provide ASTM D 3035 pipe in vertical bores greater than 60 m 200 feet deep with a SDR of 11.0.

]2.4.3 Fittings

Provide ASTM D 3261 butt and saddle fusion fittings and ASTM D 2683 socket fusion fittings manufactured in accordance with ASTM D 2513. Barbed fittings and hose clamps are not permitted in polyethylene [or polybutylene] pipe systems.

2.4.3.1 U-bends

Provide factory-fused, injection-molded 180 degree U-bend assemblies equipped with anti-buoyancy devices.

2.4.3.2 Threaded Transition Fittings

Provide ASTM D 2513 reinforced threaded steel-to-polyethylene fittings. Fittings shall have a factory applied external epoxy coating.

2.5 PIPING ACCESSORIES

2.5.1 Pipe Hangers and Supports

Provide MSS SP-58 and MSS SP-69. Type 1 with adjustable type steel support rods, except as specified or indicated otherwise. Attach to steel joists with Type 19 or 23 clamps and retaining straps. Attach to Steel W or S beams with Type 21, 28, 29, or 30 clamps. Attach to steel angles and vertical web steel channels with Type 20 clamp with beam clamp channel adapter. Attach to horizontal web steel channel and wood with drilled hole on centerline and double nut and washer. Attach to concrete with Type 18 insert or drilled expansion anchor. Provide Type 40 insulation protection shields for insulated piping.

2.5.2 Strainers

ASTM A 126, Class B, flanged iron body, for 65 mm 2.5 inches and larger. ASTM B 62, cast iron or bronze for 50 mm 2 inches and smaller. Provide basket or Y type. Tee type is acceptable for water service. Provide screens constructed of bronze, monel metal, or 18-8 stainless steel, free area not less than 2.5 times pipe area, with perforations as follows:

- a. 80 mm 3 inches and smaller: 1.1 mm 0.045 inches diameter perforations for liquids.
- b. 100 mm 4 inches and larger: 3.2 mm 0.125 inches diameter perforations for liquids.

NOTE: To minimize the potential for leaks, install pressure gage taps in ground heat exchanger loop; do not install pressure gages.

2.5.3 Pressure Gages

Provide single style pressure gage with 115 mm 4.5 inch dial, brass or aluminum case, bronze tube, gage cock, pressure snubber, and syphon. Provide scale range for intended service.

2.5.4 Pressure/Temperature Test Provisions

2.5.4.1 Pete's Plug

Provide 15 mm 0.5 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.

2.5.4.2 Testing Accessories

Provide one each of the following test items to the Contracting Officer:

- a. 8 mm 0.25 inch FPT by 3.2 mm 0.125 inch diameter stainless steel pressure gage adapter probe for extra long test plug.
- b. 90 mm 3.5 inch diameter, one percent accuracy, compound pressure gage, 0 to 1378 kPa 0 to 200 psi range.
- c. -29 to 49 degree C -20 to 120 degree F pocket thermometer one-half degree accuracy, 25 mm one inch dial, 127 mm 5 inch long stainless steel stem, plastic case.

2.5.5 Thermometers

Provide bi-metal dial type thermometers with stainless steel case, stem, and fixed thread connection; 75 mm 3 inch diameter dial with glass face gasketed within the case; and accuracy within 2 percent of scale range. Provide scale range for intended service.

2.5.6 Flexible Pipe Connectors

Provide flexible bronze or stainless steel piping connectors with single braid where indicated. Connectors shall be suitable for the intended service.

**NOTE: Residential ground coupled heat pump systems
do not require expansion tanks, vents, or make-up
water systems.**

2.5.7 Expansion Tanks

Construct of steel for minimum working pressure of 862 kPa (gage) 125 psi. Tank shall have polypropylene or butyl lined diaphragm which keeps the air charge separated from the water.

2.5.8 Air Separators

[Provide tangential inlet and outlet connections, blowdown connections, and internal perforated stainless steel air collector tube to direct released air to automatic air vent. Construct of steel for minimum working pressure of 862 kPa (gage) 125 psi.] [Design to separate air from water and to direct released air to automatic air vent. Unit shall be of one piece cast-iron construction with internal baffles and two air chambers at top of unit; one air chamber shall have outlet to expansion tank and other air chamber shall be provided with automatic air release device. Unit shall be for minimum working pressure of 862 kPa (gage) 125 psi.]

2.5.9 Pipe Sleeves

Except as indicated otherwise, provide pipe sleeves as specified in this section. Provide where piping passes entirely through walls, ceilings, roofs, and floors. Secure sleeves in position and location during construction. Provide sleeves of sufficient length to pass through entire thickness of walls, ceilings, roofs, and floors. Provide 25 mm one inch

minimum clearance between exterior of piping or pipe insulation, and interior of sleeve or core-drilled hole. Firmly pack space with mineral wool insulation. Seal space at both ends of sleeve or core-drilled hole with plastic waterproof cement which will dry to a firm but pliable mass, or provide a mechanically adjustable segmented elastomeric seal. In fire walls and fire floors, seal both ends of sleeves or core-drilled holes with UL listed fill, void, or cavity material.

2.5.9.1 Sleeves in Masonry and Concrete

Provide steel pipe sleeves. Sleeves are not required where drain, waste, and vent (DWV) piping passes through concrete floor slabs located on grade.

Core drilling of masonry and concrete may be provided in lieu of pipe sleeves when cavities in the core-drilled hole are completely grouted smooth.

2.5.9.2 Sleeves Not in Masonry and Concrete

Provide 0.55 mm 26 gage thick galvanized steel sheet pipe sleeves.

2.5.10 Escutcheon Plates

Provide one piece or split hinge metal plates for piping entering floors, walls, and ceilings in exposed spaces. Provide polished stainless steel plates or chromium-plated finish on copper alloy plates in finished spaces.

Provide paint finish on metal plates in unfinished spaces.

2.6 HEAT TAPE

Provide UL listed parallel conduction type heat tape, with electrical characteristics indicated, and adjustable thermostat for outdoor aboveground winterized piping. The heat trace system shall meet requirements of the NFPA 70, Section 427. The tape shall not be affected by direct sunlight, ambient temperature, operating temperature, rain, or salt laden atmosphere.

2.6.1 Heat Tape Construction

Provide flexible, parallel circuit construction consisting of a continuous self-limiting resistance, conductive inner core material between two parallel copper bus wires, designed for cut-to-length at the job site and for wrapping around valves and complex fittings. Self-regulation shall prevent overheating and burnouts even where the cable overlaps itself.

- a. Provide end seals for ends of circuits. Wire at the ends of circuits are not to be tied together.
- b. Provide sufficient cable, as recommended by the manufacturer, to keep the pipe surface at 1.1 degrees C 34 degrees F minimum during winter outdoor design temperature as indicated, but not less than the following:
 - (1) 80 mm 3 inch pipe and smaller with 25 mm one inch thick insulation, 4 watts/0.3 m 4 watts/feet.
 - (2) 100 mm 4 inch pipe and larger 38 mm 1.5 inch thick insulation, 8 watts/0.3 m 8 watts/feet of pipe.

2.6.2 Electrical Accessories

- a. Power supply connection fitting and stainless steel mounting brackets. Provide stainless steel worm gear clamp to fasten bracket to pipe.
- b. 13 mm 0.5 inch wide fiberglass reinforced pressure sensitive cloth tape to fasten cable to pipe at 305 mm 12 inch intervals.
- c. Pipe surface temperature control thermostat shall be cast aluminum, NEMA 4 (watertight) enclosure, 15 mm 0.5 inch NPT conduit hub, SPST switch rated 20 amperes at 480 volts ac, with capillary and copper bulb sensor. Set thermostat to maintain pipe surface temperature at not less than 1.1 degrees C 34 degrees F.
- d. Signs shall be manufacturer's standard (NEC), stamped "ELECTRIC TRACED" located on the insulation jacket at 3 mm 10 feet intervals along the pipe on alternating sides.

2.7 ACCESS DOORS FOR VALVES

**NOTE: Indicate on the design drawings the locations
of access doors for valves.**

Provide factory fabricated and primed flush face steel access doors including steel door frame equipped with continuous hinges and turn-screw-operated latch. Provide door frame installation in plaster and masonry walls.

2.8 AUXILIARY DRAIN PAN, DRAIN CONNECTIONS, AND DRAIN LINES

**NOTE: Indicate on the design drawings the locations
of access doors for valves.**

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 15400N PLUMBING SYSTEMS.

2.9 ANTIFREEZE PROTECTION

**NOTE: Antifreeze solutions may be necessary in
colder climates where the temperature of the ground
heat exchanger fluid falls below the freezing point
of water.**

Provide [ethylene glycol] [acetate potassium] [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.

2.9.1 Biodegradability

The fluid shall not be less than 90 percent biodegradable.

2.9.2 Properties

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

2.9.2.1 Flash Point

The flash point shall not be lower than 90 degrees C 194 degrees F, determined in accordance with ASTM D 92.

2.9.2.2 Biological Oxygen Demand (BOD)

For 5 days the BOD, at 10 degrees C 50 degrees F, shall not exceed 0.2 gram 0.007 ounce oxygen per gram nor be less than 0.1 gram 0.0035 ounce oxygen per gram.

2.9.2.3 Freezing Point

The freezing point shall not exceed [-9 degrees C 15 degrees F], determined in accordance with ASTM D 1177.

2.9.2.4 Toxicity

The toxicity shall not be less than LD 50 (oral-rats) of 5 grams 0.175 ounce per kilogram. The NFPA hazardous material rating for health shall not be more than 1 (slight).

2.9.2.5 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.

2.9.3 Quality

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

2.10 CHEMICAL FEED TANK

Construct of steel for minimum working pressure of 862 kPa (gage) 125 psi. Provide chemical pipe, fittings, and valves as specified for water piping.

2.10.1 Aboveground 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 [0.0039 liter/liter0.5 ounce/gal] of system water if corrosion inhibitors are not contained in freeze protection solution in the ground heat exchanger loop.

2.10.2 Chilled/Hot 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 [0.0039 liter/liter0.5 ounce/gal] of system water if

corrosion inhibitors are not contained in freeze protection solution in the ground heat exchanger loop.

2.10.3 Ground Heat Exchanger Piping

Provide corrosion inhibitors acceptable to heat pump manufacturers with concentrations suitable for each system[and appropriate for the antifreeze used].

PART 3 EXECUTION

3.1 INSTALLATION

3.1.1 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:

[Water-source water-to-air heat pumps - installation instructions]

[Water-source water-to-water heat pumps - installation instructions]

[Closed Circuit Coolers - installation instructions]

[Plate Heat Exchangers - installation instructions]

[Heat Tape - installation instructions]

3.1.2 Connections to Existing Systems

Notify the Contracting Officer in writing at least 15 calendar days prior to the date the connections are required. Obtain approval before interrupting service. Furnish materials required to make connections into existing systems and perform excavating, backfilling, compacting, and other incidental labor as required. Furnish labor and tools for making actual connections to existing systems. Flush existing systems in accordance with paragraph entitled "Flushing the Ground Heat Exchanger" prior to making connections.

3.2 ABOVEGROUND PIPING

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.

- a. 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.
- b. 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.

**NOTE: Insulate indoor piping subject to
condensation and aboveground exterior piping subject
to freezing.**

- c. 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 15080N MECHANICAL INSULATION.
- d. 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.

3.2.1 Flushing the Aboveground Piping

Before connection of the header to the polyethylene [or polybutylene] 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.

3.3 GROUND HEAT EXCHANGER PIPING

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. Avoid sharp bends in piping. Provide fittings for changes in direction when minimum bend radius, as recommended by the pipe manufacturer, is exceeded. Use only continuous pipe in sharp bends. 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 connections are not permitted.

3.3.1 Vertical Well Fields

Each U-bend loop shall be assembled, laid out straight, taped to reduce springback, and water pressure tested at 689 kPa 100 psi for leaks and flow by IGSHPA 21020 recommended procedures before the hole is bored. Vertical bores shall be 1.5 m 5 feet deeper than the length of the 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 276 kPa 40 psi to prevent the pipe from being crushed by backfill material. Backfill the bores from the bottom up with a high solid 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 in accordance with manufacturer's recommendations for water-to-mix ratio. 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.

3.3.2 Horizontal Well Fields and Header Piping

Horizontal trenches for ground heat exchanger piping may be dug with a chain type trenching machine or a backhoe. The piping shall be buried a minimum of 1.2 m 48 inches deep or as indicated. Make joints while pipe is laying beside the trench. If the soil contains rocks, dig the trench 152 mm 6 inches deeper than required and install a base of 152 mm 6 inches of fines or sand before placing the pipe. [Buried piping in systems containing antifreeze and installed within 1.5 m 60 inches of any building wall, structure, or pipe shall be insulated with R-2 minimum closed cell insulation.] After the piping is installed, tested, and flushed, purged, inspected, and approved while still under pressure, backfill 152 mm 6 inches above with fines or sand. Complete backfill in accordance with IGSHPA 21020 recommended procedures.

3.3.3 Polyethylene [and Polybutylene] Piping

Install piping in accordance with manufacturer's written instructions. 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 32 mm 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 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.

3.3.4 Heat Fusion Process

Joining shall be either by butt, socket, or saddle (for sidewall applications only) fusion in accordance with the manufacturer's Heat Qualification Guide. Use socket fusion joints for pipe 50 mm 2 inches diameter and less. Use butt fusion joints for pipe greater than 50 mm 2 inches diameter. Different plastics or grades of plastic shall not be fused together.

3.3.5 Pressurizing

After assembly of the entire ground loop system, fill the system with water and pressure test to 689 kPa 100 psi. Visually inspect welds prior to backfill of the trenches.

3.3.6 Pipe Identification

Install metalized (detectable) warning and identification tape above each horizontal pipe run. Install tape a minimum of 152 mm 6 inches below finish grade. Install mechanical identification of vertical bore holes and connecting headers.

3.3.7 Threaded Fittings

Threaded joints shall be sealed with a sealant compatible with the circulating fluid; use of lubricating tape for sealing is not permitted. Do not thread metal pipe into plastic pipe or vice versa. Direct buried threaded joints are not permitted. Use threaded joints above grade, within mechanical spaces, or within valve pits.

3.4 FLUSHING GROUND HEAT EXCHANGER

Before connection of the plastic ground heat exchanger loops to the header, flush each loop thoroughly in accordance with IGSHPA 21020 recommendations and leave filled with clean water. If the loop is not immediately joined to the header, it shall be taped or capped.

3.5 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. Adjust and balance air duct systems so that air quantities at outlets are as indicated and so that distribution from supply outlets is free from drafts and has uniform velocity over the face of each outlet.

3.6 INSTRUCTING OPERATING PERSONNEL

Upon completion of work and at time designated by Contracting Officer, provide services of water source heat pump manufacturer's technical representative for period of not less than one 8-hour working day for instruction of Government operating personnel in proper operation and maintenance of equipment.

3.7 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.

3.7.1 Piping Systems Except for Ground Heat Exchanger and Refrigerant

Before insulating, hydrostatically test each new piping system at not less than 1278 kPa 188 psi. Maintain pressure for 2 hours with no leakage or reduction in gage pressure. Obtain approval before applying insulation.

3.7.2 Flow Test of Ground Heat Exchanger Piping

Before backfilling the trenches, flush and purge 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

NOTE: In larger systems with high horsepower circulating pumps, air ejectors, and valved-off 35.2 kilowatt 10 ton header systems, a portable purge pump may not be necessary if the ground heat exchanger and indoor piping is free of debris and other construction material.

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.

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. [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] [or QC Manager] 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: _____

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? _____

Was the system backfilled properly with good clean backfill material? _____

Comments: _____

Inspected and approved this _____ date by _____

Title: _____

3.7.3 Refrigerant Piping Pressure Test and Evacuation

Perform the following when field piping connections are provided.

- a. Pressure Test: Test refrigerant piping using dry, oil-free nitrogen, and prove tight at 2068 kPa 300 psi on the high side and 1027 kPa 150 psi on the low side. Maintain pressure for 2 hours with no leakage or reduction in gage pressure.
- b. Evacuation: Using high vacuum pump and certified micron gage, reduce absolute pressure on both sides of system simultaneously to 300 microns 300 microns. After reaching this point charge system with proper refrigerant until pressure of 0 kPa 0 psi is obtained. Repeat evacuation-charging procedure for two more cycles, totaling to three evacuation-charging cycles. On final evacuation, secure pump and maintain 300 microns 300 microns for 2 hours before charging with required final refrigerant.

3.7.4 Equipment Tests

3.7.4.1 Field Testing

Test each item of equipment in operation for continuous period of not less than 24 hours under every condition of operation in accordance with each equipment manufacturer's recommendation. Verify that each item of equipment operating parameters are within limits recommended by the manufacturer.

3.7.4.2 Field Test Plans

Furnish water-source heat pump [and closed circuit cooler] field test plans developed by each equipment manufacturer detailing recommended field test procedures for each item of equipment. Field test plans developed by the installing Contractor, or the equipment sales agency furnishing the equipment will not be acceptable. The Contracting Officer will review and approve the field test plan for each item of equipment listed below prior to commencement of field testing of the equipment.

- a. Equipment Items to Test:

[Water-source water-to-air heat pumps - field acceptance test plan]

[Water-source water-to-water heat pumps - field acceptance test plan]

[Closed Circuit Coolers - field acceptance test plan]

[Plate Heat Exchangers - field acceptance test plan]

- b. Coordinated Testing: Indicate in each field test plan when work required by this section requires coordination with test work required by other specification sections. Furnish test procedures for the simultaneous or integrated testing of equipment controls which interlock and interface with controls factory prewired or external controls for the equipment provided under [Section 15901N SPACE TEMPERATURE CONTROL SYSTEMS] [Section 15910N DIRECT DIGITAL CONTROL SYSTEMS].

- c. Prerequisite Testing: Equipment for which performance testing is dependent upon the completion of the work covered by Section 15950N HVAC TESTING/ADJUSTING/BALANCING shall have that work completed as a prerequisite to testing work under this section. Indicate in each field test plan when such prerequisite work is required.
- d. Test Procedure: Indicate in each field test plan each equipment manufacturer's published installation, start-up, and field acceptance test procedures. Include in each test plan a detailed step-by-step procedure for testing automatic controls provided by the manufacturer. Each test plan shall include the required test reporting forms to be completed by the Contractor's testing representatives. Structure procedures to test the controls through all modes of control to confirm that the controls are performing with the intended sequence of control. Controllers shall be verified to be properly calibrated and have the proper set point to provide stable control of their respective equipment.
- e. Performance Variables: Each test plan shall list performance variables that are required to be measured or tested as part of the field test. Include in the listed variables performance requirements indicated on the equipment schedules on the design drawings. Furnish with each test procedure a description of acceptable results that have been verified. Identify the acceptable limits or tolerances within which each tested performance variable shall acceptably operate.
- f. Job Specific: Each test plan shall be job specific and shall address the particular item of equipment and particular conditions which exist with this contract. Generic or general preprinted test procedures are not acceptable.
- g. Specialized Components: Each test plan shall include procedures for field testing and field adjusting specialized components, such as hot gas bypass control valves, or pressure valves.

3.7.4.3 Field Test Reports

- a. Equipment Items to Test:
 - [Water-source water-to-air heat pumps - field acceptance test report]
 - [Water-source water-to-water heat pumps - field acceptance test report]
 - [Closed Circuit Coolers - field acceptance test report]
 - [Plate Heat Exchangers - field acceptance test report]
- b. Manufacturer's Recommended Test: Conduct the manufacturer's recommended field testing in compliance with the approved test plan specified above. Furnish a factory trained field representative authorized by and to represent the equipment manufacturer at the complete execution of the field testing.
- c. Operational Test: Conduct a continuous 24 hour operational test for each item of equipment. Equipment shutdown before the test

period is completed shall result in the test period being started again and run for the required duration. For the duration of the test period, compile an operational log of each item of equipment. Log required entries every 2 hours. Use the test report forms for logging the operational variables.

- d. Notice of Tests: Conduct the manufacturer's recommended tests and the operational tests; record the required data using the approved reporting forms. Notify the Contracting Officer in writing at least 15 calendar days prior to the testing. Within 30 calendar days after acceptable completion of testing, submit each test report for review and approval.
- e. Report Forms: Type data entries and writing on the test report forms. Completed test report forms for each item of equipment shall be reviewed, approved, and signed by the Contractor's test director and the QC Manager. The manufacturer's field test representative shall review, approve, and sign the report of the manufacturer's recommended test. Signatures shall be accompanied by the person's name typed.
- f. Deficiency Resolution: The test requirements acceptably met; deficiencies identified during the tests shall be corrected in compliance with the manufacturer's recommendations and corrections retested to verify compliance.

3.7.5 Additional Field Testing

NOTE: In the following paragraph, use Section 15950, "HVAC Testing/Adjusting/Balancing" for systems larger than 52,700 W 180,000 Btuh.

NOTE: Use LANTNAVFACENGCOM Section 15949, "HVAC Testing/Adjusting/Balancing For Small Systems" for small systems" less than 52,700 W 180,000 Btuh and larger than 28,100 W 96,000 Btuh.

[Requirements for testing, adjusting, and balancing (TAB) of ducts, piping, and equipment are specified in Section 15950N HVAC TESTING/ADJUSTING/BALANCING.]

NOTE: Use this paragraph for each building which has less than 28.1 kW 96,000 Btuh of cooling, less than 372 square meters 4000 square feet of floor space, or less than 15 supply air outlets. Include bracketed option for LANTNAVFACENGCOM projects.

[Balance air flows to that indicated in accordance with SMACNA HVAC Duct Const Stds, as supplemented and modified by this section. 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 liters/sec cfm and entering and leaving air temperatures.
- d. Water source heat pump unit condenser water liters/sec gpm and entering and leaving temperatures.
- e. Ambient outside air temperature, date, and person testing, balancing, and reporting.]

-- End of Section --