UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated January 2025
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DIVISION 23 - HEATING, VENTILATING, AND AIR CONDITIONING (HVAC)

SECTION 23 81 47

WATER-LOOP AND GROUND-LOOP HEAT PUMP SYSTEMS

02/25

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-- End of Section Table of Contents --

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USACE / NAVFAC / AFCEC **UFGS-23 81 47 (February 2025)**

Preparing Activity: NAVFAC **Superseding**
UFGS-23 81 47 (August 2008)

UNIFIED FACILITIES GUIDE SPECIFICATIONS

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****

SECTION 23 81 47

WATER-LOOP AND GROUND-LOOP HEAT PUMP SYSTEMS
02/25

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

This specification is based on two contract approaches for providing these systems: separate design and contractor installed systems (Design-Bid-Build) and contractor design and installed systems (Design-Build or performance based contracting). The designer selects required preference for the contract approach. Contractor design and install is limited to ground source closed-loop heat pump systems.

Adhere to UFC 1-300-02 Unified Facilities Guide Specifications (UFGS) Format Standard when editing this guide specification or preparing new project specification sections. Edit this guide specification for project specific requirements by adding, deleting, or revising text. For bracketed items, choose applicable item(s) or insert appropriate information.

Remove information and requirements not required in respective project, whether or not brackets are present.

Comments, suggestions and recommended changes for this guide specification are welcome and should be submitted as a Criteria Change Request (CCR).
****

****
NOTES:

1. There are two main types of ground source heat pump system: closed loop systems and open systems. Open systems use and dispose of ground water. There

are variations of closed loop systems based on the configuration of pipe orientations. This specification covers only closed-loop systems. This specification also covers water loop systems that are of the not ground-source type.

2. System design requirements must conform to UFC 3-410-01 "Heating, Ventilating, and Air Conditioning Systems", ASHRAE Ground-Source Heat Pumps Manual - ASHRAE Item 90376 (ISBN1-883413-52-4), ASHRAE 90.1 - SI ASHRAE 90.1 - IP including paragraph 6.5.2.2.3, and IGSHPA Design Manuals.

3. The designer must become familiar with the local and state regulations regarding geothermal wells and water wells. Design and specify the heat exchanger systems to meet the specific local and state regulations that may be required, such as:
a. Well driller licensing
b. Pump installer licensing
c. Well construction permit
d. State approved well permit
e. Allowable grout requirements
f. Allowable heat transfer fluids
g. Allowable pipe materials
h. Well construction log record
i. Authorization to Install and Operate
j. Antifreeze fluid
k. Water treatment chemicals
l. Corrosion inhibitors

****

****

NOTE: Show the following information 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.eere.energy.gov/femp/procurement and www.energystar.gov/products. In selection of equipment, consider life cycle cost. 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.

4. Show configuration, slope and location of each piping system such as: above or below floors, above or below ceilings, above or below roofs, above or below ground.

5. Show a piping diagram with valves, flushing

station, fill station, flexible connections, hose kits, Pete's plugs, drains, and other required hydronic accessories. Show location, sizes, and type of each valve.

6. Show water flow rate, entering and leaving water temperatures, air flow rate, and entering and leaving air temperatures for both cooling and heating loads. Show a water-loop and/or ground-loop heat pump schedule. Show a well depth schedule.

7. Show a ground-loop heat pump well and piping plan. Show recommended minimum distance between wells. Show the well pattern arrangement. Show any existing utilities.

8. Scale ranges for pressure gages and thermometers.

9. Show control schemes. Show optional desuperheater for domestic water use where necessary.

10. Design working pressures and temperatures for each system.

11. Only drawings (not specifications) shall indicate capacity, efficiency, dimensions, details, plan views, sections, elevations and location of equipment; and space required for equipment maintenance.

12. Show specific geothermal well requirements as they relate to local and state regulations.

****

PART 1 GENERAL

1.1 REFERENCES

****

NOTE: This paragraph is used to list the publications cited in the text of the guide specification. The publications are referred to in the text by basic designation only and listed in this paragraph by organization, designation, date, and title.

Use the Reference Wizard's Check Reference feature when you add a Reference Identifier (RID) outside of the Section's Reference Article to automatically place the reference in the Reference Article. Also use the Reference Wizard's Check Reference feature to update the issue dates.

References not used in the text will automatically be deleted from this section of the project specification when you choose to reconcile references in the publish print process.

****

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.

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

ASHRAE 52.2	(2017) Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size
ASHRAE 62.1	(2016) Ventilation for Acceptable Indoor Air Quality
ASHRAE 188	(2021) Legionellosis: Risk Management for Building Water Systems
ASHRAE FUN IP	(2021) Fundamentals Handbook, I-P Edition
ASHRAE FUN SI	(2021) Fundamentals Handbook, SI Edition
ASHRAE Item 90376	(1997) Ground-Source Heat Pumps, Design of Geothermal Systems for Commercial and Institutional Buildings

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME B31.5	(2022) Refrigeration Piping and Heat Transfer Components
ASME B31.9	(2020) Building Services Piping

ASTM INTERNATIONAL (ASTM)

ASTM B117	(2019) Standard Practice for Operating Salt Spray (Fog) Apparatus
ASTM B265	(2020a) Standard Specification for Titanium and Titanium Alloy Strip, Sheet, and Plate
ASTM B333	(2003; R 2018) Standard Specification for Nickel-Molybdenum Alloy Plate, Sheet, and Strip
ASTM B424	(2022) Standard Specification for Ni-Fe-Cr-Mo-Cu Alloy (UNS N08825 and UNS N08221, and UNS N06845) Plate, Sheet, and Strip
ASTM D92	(2012a) Standard Test Method for Flash and Fire Points by Cleveland Open Cup Tester
ASTM D1177	(2017) Standard Test Method for Freezing Point of Aqueous Engine Coolants
ASTM D2513	(2018a) Standard Specification for Polyethylene (PE) Gas Pressure Pipe, Tubing, and Fittings

ASTM D2657	(2007; R 2015) Heat Fusion Joining Polyolefin Pipe and Fittings
ASTM D2683	(2020) Standard Specification for Socket-Type Polyethylene Fittings for Outside Diameter-Controlled Polyethylene Pipe and Tubing
ASTM D3035	(2022) Polyethylene (PE) Plastic Pipe (DR-PR) Based on Controlled Outside Diameter
ASTM D3261	(2016) Standard Specification for Butt Heat Fusion Polyethylene (PE) Plastic Fittings for Polyethylene (PE) Plastic Pipe and Tubing
ASTM D3350	(2021) Polyethylene Plastics Pipe and Fittings Materials
ASTM D3892	(2015) Standard Practice for Packaging/Packing of Plastics
ASTM F402	(2018) Standard Practice for Safe Handling of Solvent Cements, Primers, and Cleaners Used for Joining Thermoplastic Pipe and Fittings
ASTM F714	(2024) Standard Specification for Polyethylene (PE) Plastic Pipe (DR-PR) Based on Outside Diameter
ASTM F1105	(2009; R 2014) Preparing Aircraft Cleaning Compounds, Liquid-Type, Temperature-Sensitive, or Solvent-Based, for Storage Stability Testing
ASTM F1290	(2019) Standard Practice for Electrofusion Joining Polyolefin Pipe and Fittings

INTERNATIONAL GROUND SOURCE HEAT PUMP ASSOCIATION (IGSHPA)

CSA/IGSHPA C448	(2016; R 2021) Design and Installation of Ground Source Heat Pump Systems for Commercial and Residential Buildings
IGSHPA 21015	(2000) Grouting for Vertical GHP Systems
IGSHPA 21020	(1988) Closed-Loop/Ground-Source Heat Pump System/Installation Guide
IGSHPA 21035	(2017) Design and Installation Standards
IGSHPA 21060	(1989) Soil and Rock Classification Field Manual

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION (ISO)

ISO 13256-1	(2021) Water-Source Heat Pumps - Testing and Rating for Performance - Part 1: Water-to-Air and Brine-to-Air Heat Pumps
ISO 13256-2	(2021) Water-Source Heat Pumps - Testing and Rating for Performance - Part 2: Water-to-Water and Brine-to-Water Heat Pumps

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA MG 1	(2021) Motors and Generators
NEMA MG 10009	(2022) Energy Management Guide for Selection and Use of Single-Phase Motors

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2023; ERTA 1 2024; TIA 24-1) National Electrical Code
NFPA 704	(2022) Standard System for the Identification of the Hazards of Materials for Emergency Response

NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY (NIST)

NIST HB 135	(1995; Annual Suppl 2010) Life Cycle Costing Manual for the Federal Energy Management Program

NSF INTERNATIONAL (NSF)

NSF/ANSI 600	(2023) Health Effects Evaluation and Criteria for Chemicals in Drinking Water

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

SMACNA 1966	(2020) HVAC Duct Construction Standards Metal and Flexible, 4th Edition

U.S. DEPARTMENT OF ENERGY (DOE)

Energy Star	(1992; R 2006) Energy Star Energy Efficiency Labeling System (FEMP)

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

29 CFR 1910	Occupational Safety and Health Standards
40 CFR 82	Protection of Stratospheric Ozone

UL SOLUTIONS (UL)

UL 94	(2023; Reprint Jan 2024) UL Standard for Safety Tests for Flammability of Plastic

Materials for Parts in Devices and Appliances

1.2 SYSTEM DESCRIPTION

****
NOTES:

1. Select fourth sentence for water-loop heat pump systems and fifth sentence for ground-loop heat pump systems.

2. For contractor design and installed systems (performance based contracting), select bracketed "Design and". Tailoring is added for design-build optional brackets. For projects that have separate design and contractor installed work, do not select "Design and" brackets. Select the appropriate brackets.

3. For water to air applications that have ductwork to distribute hot or cold air and to provide humidity control, use ARI/ISO 13256-1 as the standard for water source heat pumps.

4. For water to water applications such as in hydronic or circulating fluid systems, domestic water heating systems, and radiant heating systems, use ISO 13256-2 as the standard for water source heat pumps.
****

[Design and]Provide[new][and modify existing][ground-loop][water-loop] heat pump systems complete and ready for operation. Systems include heat pumps, system equipment, piping, pumps, electrical equipment, controls,[wells,] and[ground heat exchanger][condenser]. [Design and] Installation of[ground-loop][water-loop] heat pump systems including equipment, materials, installation, workmanship, fabrication, assembly, erection, examination, inspection, and testing must be in accordance with ASME B31.9, ASME B31.5, ASHRAE FUN SI ASHRAE FUN IP, IGSHPA 21015, IGSHPA 21020, IGSHPA 21035, CSA/IGSHPA C448, IGSHPA 21060, NFPA 70, ASHRAE Item 90376,[ISO 13256-2][ISO 13256-1] and[ISO 13256-2] as supplemented and modified by this section.[Provide water-loop heat pump condenser piping under Section 23 64 26 CHILLED, CHILLED-HOT, AND CONDENSER WATER PIPING SYSTEMS.][Provide ground coupled condenser loop piping by the requirements of this section.]

[1.3 GROUND-LOOP HEAT PUMP SYSTEM DESIGN

****
NOTE: Insert the following paragraphs for design and install projects: GROUND-LOOP HEAT PUMP SYSTEM DESIGN, CALCULATIONS, DETAIL DRAWINGS, SOIL THERMAL CONDUCTIVITY TESTING, and SYSTEM DESIGNER. Tailoring is used for Design-Build optional brackets.
****

Design ground-loop heat pump systems in accordance with the required and advisory provisions of NFPA 70, ASHRAE Item 90376, IGSHPA 21020,

IGSHPA 21035 and CSA/IGSHPA C448 except as modified herein. Provide calculations. Each system must include materials, accessories, and equipment inside and outside the building to provide each system complete and ready for use. Design and provide each system to give full consideration to optimum well spacing and location, piping, electrical equipment, pumps, ground heat exchanger, and other construction and equipment in accordance with detailed working drawings to be submitted for approval. Locate ground-loop wells in a consistent pattern that would give the proper spacing between wells and the optimum performance. Provide well and piping system layout drawings.

[1.3.1 Calculations

[1.3.1.1 Methodology

Submit all calculations as part of the design documentation. Provide all calculations used to determine the system design of the ground-loop heat pump system. Provide calculations for the HVAC loads and load profiles. Calculations must include computer aided design programs that include the effects of thermal interaction between adjacent boreholes. Include submission of the software name and version, and design parameters. Design parameters include soil conditions, ground water level, soil heat transfer coefficients and heat transfer coefficient for grout materials. Heat transfer and other calculations are to be prepared by the System Designer using computer software specifically intended for ground-loop heat pump systems. The design is to be based on calculations that will provide the most life cycle cost effective ground-loop heat pump system using an expected life of 25 years and must be sized based upon the loads shown on the drawings. Life cycle cost analysis must be performed as required by the NIST HB 135 using the current discount rates, factors, and energy cost rates.

]1.3.1.2 Design

****

NOTES:

1. For ground-loop heat pump systems in the South where there are limited heating requirements and where heat transfer fluids are not required, use the second option regarding the minimum water temperature or the 5th sentence.

2. In first sentence, the designer should select items required for software output based on anticipated software input.

3. The designer should select the maximum entering water temperature: 90 degrees F is more conservative and allows longer vertical loops as opposed to the industry standard of 35 degrees 95 degrees.

****

[The diameter, length, flow, velocity,[friction loss,][number and type fittings,][total friction loss,] and the[maximum expected expansion and contraction] of the pipe must be indicated in the program output. An accompanying schematic drawing showing reference points used in the calculations is to be included with the calculations. The maximum

entering water temperature to the heat pumps under the peak air conditioning load design condition should not exceed [32][35] degrees C [90][95] degrees F. The minimum entering water temperature to the heat pumps under the peak heating load design condition should be no lower than minus 1 degrees C 30 degrees F.][The entering water temperature to the heat pumps under peak heating load design is to be [7.2][10] degrees C [45][50] degrees F for ground-loop heat pump systems with limited heating requirements.][Adjacent wells/system will not be spaced closer than [4.5][6][_____] meters [15][20][_____] feet.]

][1.3.2 Detail Drawings

Prepare and provide A1 841 by 594 mm 24 by 36 inch detail working drawings showing the ground-loop heat pump system, layout, assembly and installation details, electrical connection diagrams and wiring diagrams, installation and details of pumps, distribution manifolds, heat pumps, piping, and well field layout. Show well grouting details in accordance with IGSHPA 21015. Show data essential for proper installation of each system. Show details, plan view, elevations, and sections of the systems supply and piping. Drawings must be to scale, show the North arrow, show the graphic scales, equipment schedules, legends, abbreviation definitions, notes, symbol lists, and any key plans. Provide equipment schedules indicating the pump motor horsepower and power consumption. Show piping schematic of systems supply, devices, valves, pipe, and fittings. Show the well field arrangement. Show point to point Electrical Wiring Diagrams. The design and drawings must show the piping lay out, piping sizes to transfer the heat required, including any boring, trenching, installation of piping, and connection to the piping in applicable HVAC System. Drawings must include any information required to demonstrate that the system has been coordinated and will properly function within the HVAC system and indicate equipment relationship to other parts of the work, including clearances required for operation and maintenance and the test point locations where the ground-loop heat pump system will be monitored during testing. Submit drawings signed by the System Designer. Concurrent with submittal of the Detail Drawings, submit certification by the System Designer that the design and calculations conform to all contract requirements, including signed approval of the Soil Thermal Conductivity Test Reports..

][1.3.3 Soil Thermal Conductivity Testing

****

NOTES:

1. Also known as In Situ Thermal Properties Testing

2. For Thermal Conductivity Property Testing, this work is to be performed by the designer for systems where the total cooling load is 700 kW 40 tons or greater. This requires the installation of a test well. This requirement is for both design-build and design-bid-build type projects.

3. Due to possible variance in soil properties and ground water, it is advisable to perform multiple soil thermal conductivity testing at various locations on the project site.

****

For projects where the total heating design load for the ground-loop heat pump system exceeds 140.7 kW 480,000 btu/hr or the total cooling design load exceeds 140.7 kW 40 tons, in situ thermal properties testing will be conducted to determine soil thermal properties prior to the design. These tests must be conducted in accordance with the procedures outlined in ASHRAE Item 90376 and Part 3.0 herein.

][1.3.4 System Designer

****
NOTES:

1. This paragraph is intended for design-build projects. The system designer performs the design of the ground-loop heat pump system.

2. The designer must select the option for the requirements of the system designer as a professional engineer, a certified GeoExchange Designer, or both.
****

The ground-loop heat pump system(s) must be designed by an individual who is a[registered professional engineer][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 3 years prior to the submittal of the System Designer's Statement of Qualifications.[Certification as a certified GeoExchange Designer must be kept up to date and maintained with the Association of Energy Engineers.] The System Designer's Statement of Qualifications must 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 must 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. Provide a letter no later than [14][_____] calendar days after the Notice to Proceed providing the name and Statement of Qualifications of the individual who will prepare the Design and Calculations.

]][1.4 GROUND SOURCE HEAT PUMP INSTALLER

****
NOTES:

1. The ground-loop heat pump system is provided by an accredited geoexchange heat pump installer. The work includes material, installation, and commissioning. The design of the ground-loop heat pump system is performed by the system designer.

2. Delete this paragraph for water-loop heat pump systems.
****

Work specified in this section must be performed by accredited ground source heat pump (GSHP) installers. The GSHP installer must be an "Accredited Installer." Accreditation as an Accredited Installer must be

kept up to date and maintained with the International Ground Source Heat Pump Association (IGSHPA). The Accredited Installer must be engaged in the installation of the type and capacity of the system(s) specified in this project for the immediate 3 years prior to the submittal of the GSHP installer's Statement of Qualifications. The GSHP installer's Statement of Qualifications must include a copy of IGSHPA Installer Certification and data identifying the location, GSHP system type, and capacity of at least three systems installed under the guidance of the proposed GSHP Installer during that period. The Contractor must furnish documentation from the owner of these three GSHP systems verifying that each system has performed in the manner intended for the 6 months prior to submission of the Statement of Qualifications. Provide a letter not later than [14][_____] calendar days after the Notice to Proceed, providing the name and Statement of Qualifications of the individual(s) who will serve as Ground Source Heat Pump Installer.

]1.5 RELATED REQUIREMENTS

****
NOTE: These related requirements are for both water-loop as well as ground-loop water source heat pump systems.
****

****
NOTE: Use the following references for ARMY Projects, if required.
****

[Requirements for cooling towers are specified in Section 23 65 00 COOLING TOWERS AND REMOTE EVAPORATIVELY-COOLED CONDENSERS.][Requirements for water heating boilers are specified in Section 23 52 00 HEATING BOILERS.]

****
NOTE: Use the following references for NAVY Projects, if required.
****

[Requirements for cooling towers are specified in Sections 23 64 10 WATER CHILLERS, VAPOR COMPRESSION TYPE and 23 65 00 COOLING TOWERS AND REMOTE EVAPORATIVELY-COOLED CONDENSERS.]

[Requirements for water heating boilers are specified in Section 23 52 46.00 20 LOW PRESSURE WATER HEATING BOILERS (OVER 800,000 BTU/HR OUTPUT).]

****
NOTE: Use the following references for all Projects, if required.
****

[Requirements for metal duct systems are specified in Section 23 30 00 HVAC AIR DISTRIBUTION.][Requirements for above ground piping are specified in Section 23 64 26 CHILLED, CHILLED-HOT, AND CONDENSER WATER PIPING SYSTEMS.][Requirements for pumps are specified in Section 23 21 23 HYDRONIC PUMPS.]

1.6 SUBMITTALS

****

NOTE: Review Submittal Description (SD) definitions in Section 01 33 00 SUBMITTAL PROCEDURES and edit the following list, and corresponding submittal items in the text, to reflect only the submittals required for the project. The Guide Specification technical editors have classified those items that require Government approval, due to their complexity or criticality, with a "G." Generally, other submittal items can be reviewed by the Contractor's Quality Control System. Only add a "G" to an item if the submittal is sufficiently important or complex in context of the project.

For Army projects, fill in the empty brackets following the "G" classification, with a code of up to three characters 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 and Air Force projects.

The "S" classification indicates submittals required as proof of compliance for sustainability Guiding Principles Validation or Third Party Certification and as described in Section 01 33 00 SUBMITTAL PROCEDURES.

****

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submittals not having a "G" or "S" classification are for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

****

NOTE: Insert the following for design and install projects: "Detail Drawings", "Calculations", "Electrical Wiring Diagrams", "Soil Thermal Conductivity Testing", and "Well and Piping System Layout Drawings". These submittal items are tailored for DESIGN-BUILD.

****

[Detail Drawings; G, [_____]

][Calculations; G, [_____]

][Electrical Wiring Diagrams; G, [_____]

][Soil Thermal Conductivity Testing; G, [_____]

][Well and Piping System Layout Drawings; G, [_____]

] System Diagrams; G, [_____]

SD-03 Product Data

[Water-Source Water-to-Air Heat Pumps; G, [_____]

][Energy Star Label for Residential WAHP Product; S

][Water-Source Water-to-Water Heat Pumps; G, [_____]

][Energy Star Label for Residential WWHP Product; S

] Refrigerants

Ground Heat Exchanger Piping System; G, [_____]

[Thermally-Enhanced Bentonite Grout; G, [_____]

][High Grade Bentonite Grout; G, [_____]

][Cementitious Thermally Enhanced Grout; G, [_____]

][Closed Circuit Coolers; G, [_____]

][Plate Heat Exchangers; G, [_____]

] Heat Tape; G, [_____]

Antifreeze; G, [_____]

Pipe; G, [_____]

Fittings; G, [_____]

Piping Components; G, [_____]

U-Bend Assemblies; G, [_____]

SD-06 Test Reports

[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

[ARI/ISO Performance Data For Water Source Heat Pumps; G, [_____]

] Qualifications Of Ground Heat Exchanger Fabricators; G, [_____]

Qualifications Of Ground Heat Exchanger Installers; G, [_____]

[Qualifications of Ground Source Heat Pump Installer; G, [_____]

] Hydrostatic Test; G, [_____]

****
NOTE: Insert the following for design and install projects: "System Designer".
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[System Designer; G, [_____]

] Work Coordination and Performance Certificate; G, [_____]

Ground Source Heat Pump Installation Certificate; G, [_____]

Well Driller License; G, [_____]

Pump Installer License; G, [_____]

Well Construction Permit; G, [_____]

Approved Well Permit; G, [_____]

Well Construction Log Record; G, [_____]

Test Borehole Well Construction Log Record; G, [_____]

Refrigeration Technician Certification

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

] Closed Circuit Coolers - Operating Instructions

[On-Site Training; G, [_____]

] 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, [_____]

SD-11 Closeout Submittals

[As-Built Drawings; G, [_____]

] Ground Heat Exchanger Piping System As-Built Drawings; G, [_____]

Indoor Air Quality During Construction; S

1.7 QUALITY ASSURANCE

1.7.1 Material and Equipment Qualifications

Provide materials and equipment that are standard products of manufacturers regularly engaged in the manufacture of such products, which are of a similar material, design and workmanship. Standard products must have been in satisfactory commercial or industrial use for 2 years prior to bid opening. The 2-year use must include applications of equipment and materials under similar circumstances and of similar size. The product must have been for sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2-year period.

1.7.2 Alternative Qualifications

Products having less than a 2-year field service record will be acceptable if a certified record of satisfactory field operation for not less than 6000 hours, exclusive of the manufacturer's factory or laboratory tests, can be shown.

1.7.3 Service Support

The equipment items must be supported by service organizations. Submit a certified list of qualified permanent service organizations for support of the equipment which includes their addresses and qualifications. These service organizations must be located within a[1][1.5] hour drive of the equipment installation and able to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract.

1.7.4 Manufacturer's Nameplate

Each item of equipment is to have a nameplate bearing the manufacturer's name, address, model number, and serial number securely affixed in a conspicuous place; the nameplate of the distributing agent will not be acceptable. As applicable the Energy Star label also affixed to the equipment.

1.7.5 Modification of References

In each of the publications referred to herein, consider the advisory provisions to be mandatory, as though the word, "must" had been substituted for "should" wherever it appears. Interpret references in these publications to the "authority having jurisdiction", or words of similar meaning, to mean the Contracting Officer.

1.7.5.1 Definitions

For the International Code Council (ICC) Codes referenced in the contract documents, advisory provisions are to be considered mandatory, the word "should" must be interpreted as "must." Reference to the "code official" must be interpreted to mean the "Contracting Officer." For Navy owned property, references to the "owner" must be interpreted to mean the "Contracting Officer." For leased facilities, references to the "owner" must be interpreted to mean the "lessor." References to the "permit holder" must be interpreted to mean the "Contractor."

1.7.5.2 Administrative Interpretations

For ICC Codes referenced in the contract documents, the provisions of Chapter 1, "Administrator," do not apply. These administrative requirements are covered by the applicable Federal Acquisition Regulations (FAR) included in this contract and by the authority granted to the Officer in Charge of Construction to administer the construction of this project. References in the ICC Codes to sections of Chapter 1, are to be applied appropriately by the Contracting Officer as authorized by his administrative cognizance and the FAR.

1.7.6 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 must be of a quality equivalent to the contract design drawings. The as-built drawings of the installed ground heat exchanger piping system are to 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. As-built drawings must be submitted with operation and maintenance data. A permanent label is to be affixed to each heat pump unit indicating basic information for that unit. The information must include: nominal flow rate [_____] l/s gpm, pressure [_____] drop kPa feet, temperature drop/rise [_____] degree C degree F, and capacity [_____] W Btu/hr.

1.7.7 System Diagrams

After completion, but before final acceptance, submit System diagrams that show the layout of equipment, piping, and circulation pumps, and typed condensed operation manuals explaining preventative maintenance procedures, methods of checking the system for normal, safe operation, and procedures for safely starting and stopping the system. Provide diagrams framed under glass or laminated plastic. After approval, these items are to be posted where directed.

1.7.8 Plastic Piping Heat Fusion Requirements

All plastic pipe must be cut, made up, and installed in accordance with

the pipe manufacturer's recommendations. Heat joining must be performed in accordance with ASTM D2657. Electrofusion joining must be performed in accordance with ASTM F1290. Qualifications for plastic pipe fabricators are given in this section under paragraph QUALIFICATIONS OF GROUND HEAT EXCHANGER FABRICATORS. Conduct heat fusion tests to verify the quality of the joints.

1.7.9 Qualifications of Ground Heat Exchanger Fabricators

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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.

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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 are to 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.

1.7.10 Refrigeration Technician Certification

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NOTE: The following paragraph requires a certification for technicians who work on equipment that could release Class I or II refrigerants, such as R-123, into the atmosphere. This is required as of January 1, 2018 to meet the requirements of 40 CFR 82, Subpart F.

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All technicians working on equipment that contain Class I or II refrigerants must be certified as a Section 608 Technician to meet requirements in 40 CFR 82, Subpart F. Provide copies of technician certifications to the Contracting Officer at least 14 calendar days prior to work on any equipment containing these refrigerants.

1.7.11 Qualifications of Ground Heat Exchanger Installers

Submit documentation substantiating the following qualifications: installers must have completed an approved manufacturer's certification program and 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. In documentation submit licensing requirements as regulated by local and state regulations for well drillers and pump installers. Submit for each well driller, the Well Driller License. For each pump installer, submit the Pump Installer License. Certification and licenses for each well driller and pump installer must be in the state where the work occurs. All required certification and licenses must be kept current. Out of date licenses and certification will not be accepted. Submit to contracting officer for approval the licenses and certification.

1.8 DELIVERY, STORAGE, AND HANDLING

Materials delivered and placed in storage are to be stored with protection

from the weather, excessive humidity variation, excessive temperature variation, dirt, dust or other contaminants. Proper protection and care of material before, during and after installation is the Contractor's responsibility. Any material found to be damaged will be replaced at the Contractor's expense. During installation, piping is to be capped to keep out dirt and other foreign matter. A material Safety Data Sheet (SDS) in conformance with 29 CFR 1910 Section 1200(g) must accompany each chemical delivered for use in pipe installation. At a minimum, this includes all solvents, solvent cements, glues and other materials that may contain hazardous compounds. Handling must be in accordance with ASTM F402. Storage facilities are to be classified and marked in accordance with NFPA 704. Materials must be stored with protection from puncture, dirt, grease, moisture, mechanical abrasions, excessive heat, ultraviolet (UV) radiation damage, or other damage. Pipe and fittings must be handled and stored in accordance with the manufacturer's recommendation. Plastic pipe is to be packed, packaged and marked in accordance with ASTM D3892. Upon delivery of piping, fitting, components, and equipment to the site, inspect items for damage and verify items meet project requirements.

1.9 SAFETY REQUIREMENTS

Exposed moving parts, parts that produce high operating temperature, parts which may be electrically energized, and parts that may be a hazard to operating personnel must be insulated, fully enclosed, guarded, or fitted with other types of safety devices. Safety devices are to be installed so that proper operation of equipment is not impaired.

1.10 PROJECT/SITE CONDITIONS

1.10.1 Verification of Dimensions

The Contractor is to become familiar with all details of the work, verify all dimensions indicated in the field, and advise the Contracting Officer of any discrepancy before performing any work.

1.10.2 Drawings

Because of the small scale of the drawings, it is not possible to indicate all offsets, fittings, and accessories that may be required. The Contractor must carefully investigate the plumbing, fire protection, electrical, structural and finish conditions that would affect the work to be performed and arrange such work accordingly, furnishing required offsets, fittings, and accessories to meet such conditions.

1.10.3 Accessibility

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NOTES:

1. The following requirement is intended to solicit the installer's help in the prudent location of equipment when he has some control over locations. However, designers should not rely on it at all since enforcing this requirement in the field would be difficult.

Therefore, the system designer needs to layout and indicate the locations of equipment, control devices, and access doors so that most of the

accessibility questions are resolved inexpensively during design.

2. On Air Force projects, the designer must provide work/service platforms for accessibility around equipment, such as heat pumps connected to condenser loop, which are installed more than two feet above a suspended ceiling or more than 12 feet above the floor. Refer to 29 CFR 1910 for specific requirements.

3. Provide on drawings access requirements for unit replacement, compressor replacement, and equipment repair.

****

Install all work so that parts requiring periodic inspection, operation, maintenance, and repair are readily accessible. Install concealed valves, expansion joints, controls, dampers, and equipment requiring access, in locations freely accessible through access doors.

1.11 COORDINATION OF WORK AND SYSTEM PERFORMANCE

a. Pump supports, piping offsets, fittings, and any other accessories required must be furnished as required to provide a complete installation and to eliminate interference with other construction.

b. Submit a Work Coordination and Performance Certificate. Concurrent with submittal of the Detail Drawings and the Calculations, submit a Certificate by[both] the[System Designer][and the][Ground Source Heat Pump Installer] stating that the drawings and calculations have been coordinated with all related work and the Ground Source Heat Pump System will perform as[specified][and indicated].

c. Submit a Ground Source Heat Pump Installation Certificate. Concurrent with submittal of the Test Reports, submit certification by the Ground Source Heat Pump Installer stating that the Ground Source Heat Pump System and related work is installed in accordance with the contract requirements, including signed approval of the test reports.

PART 2 PRODUCTS

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NOTE: In accordance with P.L. 109-58 (Energy Policy Act of 2005), Executive Order 13423, and FAR 23.203 Energy-Efficient Products, energy consuming products and systems must meet or exceed the performance criteria for ENERGY STAR qualified or FEMP-designated products as long as these requirements are nonproprietary. The FEMP and ENERGY STAR product requirements are available on the web at www.eere.energy.gov/femp/procurement and www.energystar.gov/products. Where ENERGY STAR or FEMP products are not applicable, energy consuming products and systems must meet the requirements of ASHRAE 90.1 - SI ASHRAE 90.1 - IP

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2.1 EQUIPMENT

Refrigerants containing chlorofluorocarbons (CFC) are prohibited. Provide refrigerants, or refrigerants with ozone depleting potential (ODP) of 0.0. Provide SDS Sheets for all refrigerants.Refrigerants must comply with all EPA rulings - refer to Code of Federal Regulations (CFR) Part 84 (https://www.ecfr.gov/current/title-40/chapter-I/subchapter-C/part-84)

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

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

****

NOTES:

1. Indicate the equipment operating requirements, including efficiency, on the drawings. Units must have EER and COP ratings meeting or exceeding FEMP/Energy Star requirements.

2. For housing or residential applications, the designer should consider residential class water source heat pumps as opposed to commercial class heat pump units. Residential class heat pumps can be provided by the manufacturer with factory installed optional selections of:

a. A factory installed energy management relay to allow unit control by an external source.

b. A factory installed internal heat recovery kit for domestic hot water production.

c. A factory installed ground loop pump kit.

****

[Provide water-source water-to-air heat pump units factory assembled, designed, tested, and rated in accordance with ISO 13256-1.][Provide ground-coupled closed-loop water-to-air heat pump (extended range) units factory assembled, designed, tested, and rated in accordance with ISO 13256-1.]Units are to be ISO 13256-1 certified, or listed in ISO 13256-1 directory. Units must include fans, refrigerant-to-air heat exchangers, filters,[dampers,] compressor, reversing valve, expansion valve, refrigerant-to-water heat exchangers,[desuperheater,][hose kits,] bypass for flushing and purging, and controls. A permanent label must be affixed to each heat pump unit indicating basic information for that unit. The information must include: nominal flow rate l/s gpm, pressure drop kPa feet, temperature drop/rise degree C degree F, and capacity W Btu/hr.[For housing or residential applications, provide heat pump units with factory installed[energy management relay,][factory installed internal heat recovery kit,][and a][factory installed ground loop pump kit].] Provide certificates of ARI/ISO Performance Data For Water Source Heat Pumps.[Provide residential ground-coupled closed-loop water-to-air heat pumps that are Energy Star labeled. Provide proof of Energy Star label for residential WAHP product.]

a. Cabinet: Provide manufacturer's standard[galvanized steel][

stainless 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 are to be copper threaded fittings mechanically fastened to the cabinet. Water piping must 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 is to be located within the unit.

b. Fans: Provide centrifugal type, direct drive fans with permanently lubricated motors.[Provide motors of the permanent split capacitor (PSC) type with thermal overload protection.][Provide Electronically Commutated Motor (ECM) microprocessor controlled DC type motor with internal programming factory set for the specific unit and featuring soft start/stop and a delay off feature for maximum efficiency and quiet operation. There will further be provisions for adjusting the air delivery of the motor and blower by plus or minus 15 percent from rated air flow.]

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. Fins must be mechanically bonded to tubes. The condensate drain pan must be epoxy coated and insulated. Provide internal traps on vertical units. Provide drain pan with overflow protection. Provide drain pan constructed of[corrosion-resistant plastic][galvanized steel][stainless steel].

d. Filter Section: Provide[replaceable][(throwaway)][[25][50] mm [1][2] inch] thick UL listed[fiberglass][permanent washable] type filters with a MERV Rating of[8][11][13] in accordance with ASHRAE 52.2. Mount filters in filter frames and provide access panels or doors for removal and replacement of filters. Access panels or doors for filter access must be provided with appropriate seals and closure mechanisms to prevent unit leakage and mitigate bypassing of air around the filter.

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 two-position automatic valve interlocked to shut off water flow when the compressor is off. Provide refrigerant-to-water heat exchangers of coaxial type (tube-in-tube), with inner[cupronickel][copper] water tube and outer steel refrigerant tube. The refrigerant side of the heat exchanger is to be tested and rated for 3102 kPa 450 psig refrigerant working

pressure. The water side of the heat exchanger is to be tested and rated for 2758 kPa 400 psig working pressure. A parallel capillary tube/thermal expansion valve assembly must provide superheat over the entire liquid temperature range. Refrigerant-to-water heat exchangers and refrigerant piping must be insulated to prevent condensation on the piping containing low temperature water.

****

NOTES:

1. For heat pump units serving a water-loop application, the inlet water temperature range to the heat exchanger is to be[1 to 43 degree C 34 to 110 degree F. For heat pump units serving a ground-loop, the inlet water temperature range to the heat exchanger is to be][7 to 32 degree C 45 to 90 degree F] liquid temperature range. Show these ranges on the drawings.

2. Extended range heat pumps usually provide performance in the range of minus 4 to 38 degrees C 25 to 100 degrees F.

3. Low temperature applications such as boiler and closed loop cooling tower or dry cooler usually provide performance in the range of 4 to 43 degrees C 40 to 110 degrees F.

****

****

NOTE: Provide on the drawings a sequence of operation, control schematic, and applicable points on the control points schedule for the heat pump and desuperheater.

Check ASHRAE 90.1 - SI ASHRAE 90.1 - IP Chapter 6 to determine whether heat recovery for service water heating is required.

****

[h. Factory-Installed Domestic Hot Water Desuperheater: Provide desuperheater of vented double-wall construction and factory installed within indoor heat pump cabinet. Provide desuperheater units factory assembled, designed, tested, and rated.

i. Provide with the desuperheater, factory-installed water pump powered by a sealed magnetic drive motor, water line thermostat, secondary safety thermostat to prevent scalding, internal fuse, internally mounted disconnect switch, outside air thermostat, manual on-off switch, low refrigerant gas temperature limit switch, air bleed port, and refrigerant ports. Units must be UL listed. Desuperheater units must be UL listed. Units must be provided by the[ground source][water source] closed loop heat pump manufacturer.

j. Controls: The manual on- off switch is to be a push button type with a cover. Provide an indicating light next to the switch to indicate the desuperheater pump energized mode.[Provide an outside air thermostat with sun shield set for 4 degree C 40 degree F. The outside air thermostat de-energizes the desuperheater pump.] Provide

in the water return to the desuperheater unit, a high water temperature limit with adjustable settings, which de-energizes the desuperheater pump at 60 degree C 140 degree F Also provide low refrigerant gas temperature limit which de-energizes the desuperheater pump and is set to open at 38 degree C 100 degree F.

][k. Emergency Heater: Provide UL or ETL listed, electric resistance heater with internal fusing integral with heat pump unit; fan must run until heater cools. Locate downstream of indoor coil. The emergency heater coil is to be provided as a supplementary electric heater. The heater must be provided with a rack, control box with hinged cover, safety limits, and relay. Control voltage of the heater must be compatible with the heat pump. The electric heater must be provided by the heat pump manufacturer. The control of the electric heater must only be utilized as second stage heating. The first stage heating is to be normal heat pump operations.

] **********

NOTE: For residential or housing projects, discuss with customer's or activity's housing department the need for emergency back-up electric heater. The designer should consider using an emergency heater for situations such as very cold weather and equipment outages.

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NOTE: The functionality of the hose kits are:

a. Allow ease and convenience of maintenance and installation of the heat pump units.

b. The hose kits allow the ease and convenience of purging and flushing of the system piping.

c. The hose kits also minimize vibration transmission from the heat pump units to the system piping.

Designer must review hose kit pressure drop and include in pump head calculations to assure adequate pump head capacity is scheduled to accommodate the use of hose kits.

****

[l. Hose Kits: Provide hose kits with two 0.6 m 2 foot long metal (stainless steel) 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 must be fire rated to meet UL 94. Provide hoses with a maximum working pressure of 2067 kPa 300 psi.[For residential or housing applications, provide flexible hose kits using heavy-duty radiator rubber hose kits. Provide a bypass around the heat pump unit condenser coil.]

] m. Bypass for Purging and Flushing: Provide a bypass around the heat pump unit condenser coil. The bypass is to include isolation valves and piping that allows for purging and flushing of the system piping. Provide the necessary flushing pump, hoses, and isolation valves.

n. Hanger Kits: Provide horizontal units with hanger kits consisting of galvanized steel brackets, bolts, washers, and vibration isolators. The hanger kit must be designed to support the unit from below and suspend from threaded rods.

o. Floor Mounted Units: Floor mounted units must be installed in accordance with manufacturer's installation requirements. Provide concrete housekeeping pads when installing within mechanical equipment rooms .

****

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

****

p. Controls: Controls and safety devices must 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 must 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). Use standard communication protocol such as[LonWorks,][BACnet,] or other [_____] protocol.][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. When in the heating mode, where there is a continued drop in room temperature, the controller is to energize the second stage of heating, which would be the emergency heater. Provide night setback. The controller is to raise the night setback temperature gradually. Provide 7 day schedule capability.]

[(2) Provide 24 volt electromechanical controls supplied with a low voltage transformer, controls for compressor, reversing valve, and fan motor operation. Controls are to 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.

] (3) [The ECM interface board is to include a screw type terminal board for a thermostat connection, LED's to indicate thermostat status and air delivery.][Provide a factory installed energy management relay to allow unit control by an external source.]

q. 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 must be the programmable type and are to be furnished by the unit manufacturer.[Thermostats must have the Energy Star

rating.] Provide 7 day schedule capability. Provide with battery back-up. The thermostat must have night setback and can raise the night setback temperature gradually. When in the heating mode, where there is a continued drop in room temperature, the thermostat must energize the second stage of heating, which would be the emergency heater. Provide relays, transformers, contractors, and control wiring between thermostats and unit. Thermostats must read out in degrees C and degrees F.

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

****

NOTES:

1. In compliance with FEMP/Energy Star requirements, closed loop units shall have minimum EER of 16.1 and minimum heating performance COP of 3.1; open loop units shall have minimum EER of 20.1 and a minimum heating performance COP of 3.5. Indicate the equipment operating requirements, including efficiency, on the drawings.

2. For housing or residential applications, the designer should consider residential class water source heat pumps as opposed to commercial class heat pump units. Residential class heat pumps can be provided by the manufacturer with factory installed optional selections of:

a. A factory installed energy management relay to allow unit control by an external source.

b. A factory installed internal heat recovery kit for domestic hot water production.

c. A factory installed ground loop pump kit.

3. For projects where the water-to-water heat pump unit is used for domestic water heating, the plumbing code shall be followed. Refer to the International Plumbing Code. To prevent cross connection or contamination of the potable water supply from the refrigerant in the heat pump unit, several approaches should be considered:

a. Consider using a desuperheater. Check ASHRAE 90.1 - SI ASHRAE 90.1 - IP Chapter 6 to determine whether heat recovery for service water heating is required.

b. Consider using a double wall heat exchanger that is vented.

c. Consider using a secondary heat exchange in the water circuit such as a plate heat exchanger.

****

[Provide water-source water-to-water heat pump units factory assembled, designed, tested, and rated in accordance with ISO 13256-2.][Provide

ground-coupled closed-loop water-to-water heat pump (extended range) units factory assembled, designed, tested, and rated in accordance with ISO 13256-2.]Units must be listed by ETL, or listed in ISO 13256-2. Units are to include compressor, reversing valve, expansion valve, refrigerant-to-water condensing coil, refrigerant-to-water evaporator coil,[desuperheater,][hose kits,][dampers,] bypass for flushing and purging, and controls. A permanent label must be affixed to each heat pump unit indicating basic information for that unit. The information is to include: nominal flow rate l/s gpm, pressure drop kPa feet, temperature drop/rise degree C degree F, and capacity W Btu/hr.[For housing or residential applications, provide heat pump units with factory installed[energy management relay,][factory installed internal heat recovery kit,][and a][factory installed ground loop pump kit].] Provide certificates of ARI/ISO Performance Data For Water Source Heat Pumps.[Provide residential water-source water-to-water heat pumps that are Energy Star labeled. Provide proof of Energy Star label for residential WWHP product.]

a. Cabinet: Provide manufacturer's standard[galvanized steel][stainless 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 are to be mechanically fastened to the cabinet. Water piping must 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 (tube-in-tube), with inner [cupronickel][copper] water tube and outer steel refrigerant tube. The refrigerant side of the heat exchanger is to be tested and rated for 3102 kPa 450 psig refrigerant working pressure. The water side of the heat exchanger is to be tested and rated for 2758 kPa 400 psig working pressure. A parallel capillary tube/thermal expansion valve assembly must provide superheat over the entire liquid temperature range. Refrigerant-to-water heat exchangers and refrigerant piping must be insulated to prevent condensation on the piping containing low temperature water.

****

NOTES:

1. For heat pump units serving a water-loop application, the inlet water temperature range to the heat exchanger is to be 1 to 43 degree C 34 to 110 degree F . For heat pump units serving a

ground-loop application, the inlet water temperature range to the heat exchanger is to be 7 to 32 degree C 45 to 90 degree F liquid temperature range. Show these ranges on the drawings.

2. Extended range heat pumps usually provide performance in the range of minus 4 to 38 degrees C 25 to 100 degrees F.

3. Low temperature applications such as boiler and closed loop cooling tower or dry cooler usually provide performance in the range of 4 to 43 degrees C 40 to 110 degrees F.

****

[e. Factory-Installed Domestic Hot Water Desuperheater: Provide desuperheater of vented double-wall construction and factory installed within indoor heat pump cabinet. Provide desuperheater units factory assembled, designed, tested, and rated.

f. Provide with the desuperheater, factory-installed water pump powered by a sealed magnetic drive motor, water line thermostat, secondary safety thermostat to prevent scalding, internal fuse, internally mounted disconnect switch, outside air thermostat, manual on-off switch, low refrigerant gas temperature limit switch, air bleed port, and refrigerant ports. Units must be UL listed. Desuperheater units must be UL listed. Units must be provided by the[ground source][water source] closed loop heat pump manufacturer.

g. Controls: The manual on- off switch is to be a push button type with a cover. Provide an indicating light next to the switch to indicate the desuperheater pump energized mode.[Provide an outside air thermostat with sun shield set for 4 degree C 40 degree F. The outside air thermostat de-energizes the desuperheater pump.] Provide in the water return to the desuperheater unit, a high water temperature limit with adjustable settings, which de-energizes the desuperheater pump at 60 degree C 140 degree F. Also provide low refrigerant gas temperature limit which de-energizes the desuperheater pump and is set to open at 38 degree C 100 degree F

] **********

NOTE: Provide on the drawings a sequence of operation and control schematic for the heat pump and desuperheater.

****

h. Hose Kits: Provide hose kits including two 0.6 m 2 foot long metal (stainless steel) braided hoses with swivel connectors on one end,[a 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 must be fire rated to meet UL 94. Provide hoses with a maximum working pressure of 2067 kPa 300 psi.[For residential applications, provide flexible hose kits using heavy-duty radiator rubber hose kits. Provide a bypass around the heat pump unit condenser coil.]

****

NOTE: The functionality of the hose kits are:

-Allow ease and convenience of maintenance and installation of the heat pump units.

-The hose kits allow the ease and convenience of purging and flushing of the system piping.

-The hose kits also minimize vibration transmission from the heat pump units to the system piping.

Designer must review hose kit pressure drop and include in pump head calculations to assure adequate pump head capacity is scheduled to accommodate the use of hose kits.

****

i. Bypass for Purging and Flushing: Provide a bypass around the heat pump unit condenser coil. The bypass includes isolation valves and piping that allows for purging and flushing of the system piping. Provide the necessary flushing pump, hoses, and isolation valves.

j. Hanger Kits: Provide units with hanger kits consisting of galvanized steel brackets, bolts, washers, and vibration isolators. The hanger kit must 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.

****

k. Controls: Controls and safety devices must be factory wired and mounted within the control box of the unit cabinet.

(1) Provide a microprocessor based controller. The microprocessor must 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). Use standard communication protocol such as[LonWorks,][BACnet,] or other [_____] protocol.][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 are to 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.

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

][2.1.3 Closed Circuit Coolers

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NOTE: It has been proposed as a forthcoming action that this specification paragraph for the closed circuit cooler be moved into Section 23 64 10 WATER CHILLERS, VAPOR COMPRESSION TYPE or Section 23 65 00 COOLING TOWERS AND REMOTE EVAPORATIVELY-COOLED CONDENSERS.

****

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 must include louver access, overflow, drain, Type 304 stainless steel strainers, and brass make-up valve with plastic float.

b. Axial Propeller Fans: Fans are to 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 are to be totally enclosed, ball bearing type, and suitable for outdoor service. Motors 1 Hp and greater must be the premium efficiency type in accordance with NEMA MG 1. Fan motor speed control is to be provided for motors 7.5 hp or larger.

d. Drive: Fan drive is to be multi-groove, solid V-belt type with taper lock sheaves designed for 150 percent of nameplate kW HP. Fan and motor sheave must be aluminum alloy construction. Belt adjustment is to be accomplished from exterior of unit.

e. Heat Transfer Coil: The coil must 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 must 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 are to 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 is to 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. Provide with eliminator design that incorporates three changes in air direction to ensure complete removal of entrained moisture from the discharge airstream. Maximum drift rate must 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 are to 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. Include degreasing, cleaning, and a light surface burnishing in preparation for coating. The coating is to be suitable for field repair with the same original coating material applied in the same manner.

k. Electric Pan Heater Package: Provide electric pan heater package consisting of electric immersion heaters, heater thermostat, and low water cutout, all installed in pan. Size heaters to maintain plus 5 degrees C plus 40 degrees F pan water temperature with the fans off at outdoor 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 26 20 00 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

****

NOTES:

1. Plate heat exchangers provide flexibility for the designer. Plate heat exchangers are recommended where there is a requirement to isolate the outside loop that may have a glycol antifreeze fluid from the inside loop - where separation is necessary from the inside loop due to different heat transfer fluids. Also plate heat exchangers should be considered for use with systems using closed circuit coolers or cooling towers to isolate the ground heat exchanger loops from the building terminal loops.

2. It has been proposed as a forthcoming action that this specification paragraph for the plate heat exchanger be moved into Section 23 64 10 WATER CHILLERS, VAPOR COMPRESSION TYPE or Section 23 65 00 COOLING TOWERS AND REMOTE EVAPORATIVELY-COOLED CONDENSERS.

3. Provide the following flat plate heat exchanger information on the drawing:

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

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

c. Minimum plate thickness in mm inch.

****

Plates, frames, and gaskets are to 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 are to be located in accordance with the manufacturer's standard practice. Connections larger than 80 mm 3 inches must be ASME 2.07 MPa 300 pound flanged. Plates are to be corrugated[Type 304 stainless steel][Type 316 stainless steel][nickel-iron-chromium alloy conforming to ASTM B424][nickel-molybdenum alloy conforming to ASTM B333][titanium alloy conforming to ASTM B265].

]2.2 ELECTRICAL WORK

****

NOTES:

1. Show the electrical characteristics, motor starter type(s), enclosure type, and maximum rpm in the equipment schedules on the drawings.

2. Where reduced-voltage motor starters are recommended by the manufacturer or required otherwise, specify and coordinate the type(s) required in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Reduced-voltage starting is required when full voltage starting will interfere with other electrical equipment and circuits and when recommended by the manufacturer. Where adjustable speed drives (ASD) are specified, reference Section 26 29 23 ADJUSTABLE SPEED DRIVE (ASD) SYSTEMS UNDER 600 VOLTS. The methods for calculating the economy of using an adjustable speed drive is described in UFC 3-520-01, "Interior Electrical Systems".

3. Use the bracketed item where polyphase motors are part of an assembly. Premium efficiency motors are required by Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM for individual motors that are not part of an assembly.

4. For Air Force projects, the base or activity will designate which electrical specification section applies.

5. The designer should show the motor starter size

with the pump schedule. The pump schedule should be shown on the drawings.

****

a. Provide electrical motor driven equipment specified complete with motors, motor starters, and controls as specified herein and in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Provide high efficiency type, single-phase, fractional-horsepower alternating-current motors, including motors that are part of a system, in accordance with NEMA MG 10009. In addition to the requirements of Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM, provide polyphase, squirrel-cage medium induction motors, including motors that are part of a system, that meet the efficiency ratings for premium efficiency motors in accordance with NEMA MG 1. Provide motors in accordance with NEMA MG 1 and of sufficient size to drive the load at the specified capacity without exceeding the nameplate rating of the motor.

b. Motors are to be rated for continuous duty with the enclosure specified. Motor duty requirements must allow for maximum frequency start-stop operation and minimum encountered interval between start and stop. Motor torque must be capable of accelerating the connected load within 20 seconds with 80 percent of the rated voltage maintained at motor terminals during one starting period.

c. Motor bearings are to be fitted with grease supply fittings and grease relief to outside of the enclosure.

d. Manual or automatic control and protective or signal devices required for the operation specified and any control wiring required for controls and devices specified, but not shown, are to be provided. For packaged equipment, the manufacturer is to provide controllers including the required monitors and timed restart.

[e. Where two-speed or variable-speed motors are indicated, solid-state variable-speed controller may be provided to accomplish the same function. Use solid-state variable -speed controllers for motors rated 7.45 kW (10 hp) or less and adjustable frequency drives for larger motors.][Provide variable frequency drives for motors as specified in Section 26 29 23 ADJUSTABLE SPEED DRIVE (ASD) SYSTEMS UNDER 600 VOLTS.

][2.3 ABOVEGROUND PIPING SYSTEMS

****

NOTES:

1 Generally the above ground piping pertains to the interior building systems and the interior loop. Consider using a plate heat exchanger to avoid pumping glycol heat transfer fluids around the building. Minimize exposure of glycol fluids to personnel. For the interior building systems, consider using steel or copper piping. For the outside ground loop piping, use high density polyethylene piping.

2 For the interior loop, the designer should consider air separation and water treatment.

3 Refer to other sections for above ground piping systems, such as Section 23 64 26 CHILLED, CHILLED-HOT, CONDENSER WATER PIPING SYSTEMS.
****

Provide above ground piping as specified in Section 23 64 26 CHILLED, CHILLED-HOT, CONDENSER WATER PIPING SYSTEMS.

]2.4 GROUND HEAT EXCHANGER PIPING SYSTEM

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NOTE: When specifying pipe and fittings for the project, ensure that the total system pressure and temperature does not exceed the performance capabilities of the pipe and fittings.
****

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 require appropriate equipment and procedures for safe handling, installation, and use. Reels and coiled pipe must allow easy and thorough inspection of the pipe exterior for any shipping and handling damage. The reel is to be capable of securing the pipe coil while the pipe is being pressure tested. The reel and pipe coil are to allow easy access and handling while spooling the pipe coil off the reel for insertion into the bore hole.] Pipe coil on reel must be factory marked to show depth graduations.

For the pipe and piping components submittals, include recommendations for the connection of joints, including the preparation of joints for the electrofusion process.

2.4.1 High Density Polyethylene Pipe

Pipe is to be manufactured from virgin high density polyethylene extrusion material in accordance with ASTM D2513 with PE345434C or PE355434C cell classification and UV stabilizer of C, D, or E as specified in ASTM D3350. Provide ASTM D3035 pipe with a standard dimension ratio (SDR) of 11.0 for pipe less than 32 mm 1.25 inches diameter. Provide ASTM F714, Schedule 40 or ASTM D3035 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 D3035 pipe in vertical bores greater than 60 m 200 feet and up to 107 m 350 feet deep with a SDR of 11.0. Provide ASTM D3035 pipe in vertical bores greater than 107 m 350 feet deep with a SDR of 9.0.

2.4.2 Fittings

Provide ASTM D3261 butt and saddle fusion fittings and ASTM D2683 socket fusion fittings manufactured in accordance with ASTM D2513. Barbed fittings, compression type fittings, mechanical joint fittings, grove fittings, and hose clamps are not permitted in polyethylene[or polybutylene] pipe systems. All pipe fittings underground must be fusion type joints. Flange joints and fittings are not to be provided on

underground piping.

2.4.2.1 Threaded Transition Fittings

Provide ASTM D2513 reinforced threaded [steel][brass]-to-polyethylene fittings. Fittings must have a factory applied external epoxy coating.

2.4.3 U-Bend Assemblies

Provide factory-assembled and fused, injection-molded, 180 degree, U-bend assemblies equipped with anti-buoyancy devices. U-bend assemblies must be used for the vertical well field vertical loop heat exchangers. U bend assemblies must be prefabricated assemblies with u-bends and continuous pipe. The assemblies must be pre-marked[by the manufacturer] with depth graduations. Each assembly must be the indicated length of the vertical loop heat exchanger. Each assembly must be factory pressure tested to 689.5 kPa gage 100 psig. Each assembly must be provided with a factory pressure test report. Each U-bend assembly must be temporarily capped to prevent the entry of dirt during storage and installation.

2.5 PIPING ACCESSORIES

Provide piping accessories for above ground piping as specified in Section 23 64 26 CHILLED, CHILLED-HOT, CONDENSER WATER PIPING SYSTEMS.

2.5.1 Tracer Wire for Nonmetallic Piping

Provide bare copper or aluminum wire not less than 2.5 mm 0.10 inch in diameter in sufficient length to be continuous over each separate run of nonmetallic pipe.

2.5.2 Pipe Casings

Provide rigid nonmetallic conduit and fittings (PVC) as pipe casings at floor penetrations and underground building entries for the entry of ground heat exchanger piping. The conduit is to serve as a casing for ease of installation and removal of the piping into the building. The pipe casing diameter is to be at least four times the diameter of the carrier pipe to allow "pulling the pipe through the casing". Provide rigid nonmetallic conduit and fittings specified complete with fittings and necessary hardware as specified herein[and in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM].

****

NOTE: Use for small systems where the PVC conduit act as a casing and allows ease of installation of the high density polyethylene piping into the building.

****

Carrier Pipe Size		Casing Size	
(mm)	(Inches)	(mm)	(Inches)
19	3/4	100	4

Carrier Pipe Size		Casing Size	
25	1	100	4
32	1-1/4	100	4
38	1-1/2	150	6
50	2	200	8

2.6 HEAT TAPE

****

NOTES:

1. The designer should avoid requiring exposed piping outside on the drawings. All ground source heat pump system piping should be designed and installed underground below the frost line.

2. Water source heat pump system piping to a closed circuit cooling tower or other heat transfer device should be designed and installed underground below the frost line.

3. The designer should consider heat tracing any exposed piping and valves, depending on the climate, such as piping exposed at a closed circuit cooling tower or water piping to a condenser.

4. Where piping is required to be exposed outside, the designer should consider using steel or copper pipe and fittings. The designer should provide heat tape on steel or copper pipe.

****

Provide UL listed parallel conduction type heat tape, with electrical characteristics indicated, and adjustable thermostat for outdoor aboveground winterized piping. The heat trace system is to meet requirements of the NFPA 70, Section 427. The tape is not to 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 must 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[of [_____]] [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 is to 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 must 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 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. Drain pans are to be fully and freely draining in compliance with ASHRAE 62.1. Trap drain pans to ensure complete pan drainage. Provide drain lines full size of drain opening. Traps and piping to drainage disposal points to conform to Section 22 00 00 PLUMBING, GENERAL PURPOSE.

2.8 ANTIFREEZE PROTECTION

****

NOTES:

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

2. The designer should determine the need for antifreeze based on analysis of the system, loads, and the resulting fluid temperatures over the annual cycle.

3. The designer should determine the amount of antifreeze required. The designer should not

specify beyond what is required. The heat transfer fluid with antifreeze affects the pump power consumption and also quantity the heat transfer from the heat pump. Specify percent antifreeze solution in paragraph below.

4. The designer is to comply with local, state, and federal regulations regarding the use of antifreeze in the ground loop heat exchangers.

5. The designer should always evaluate the life-health safety risk and impact of the selected heat transfer fluid.

6. The designer should indicate the percentage of antifreeze required for the heat transfer fluid on the drawings.

****

Provide [_____] percent[ethylene glycol][propylene glycol] antifreeze fluid in a water based solution which meets local, State, and Federal requirements and is acceptable to heat pump component manufacturers. The antifreeze and water-based heat transfer fluid are to be used in closed-loop ground source heat pump systems for the transfer of energy to provide heating and cooling. The heat transfer fluid is to contain the necessary corrosion inhibitors to protect pipe and equipment from attack by the antifreeze solution utilized. The mixture of antifreeze and corrosion inhibitors in a water based solution is defined as a heat transfer fluid.

2.8.1 Biodegradability

The heat transfer fluid is not to be less than 90 percent biodegradable.

2.8.2 Properties of the Heat Transfer Fluid

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

2.8.2.1 Flash Point

The flash point of the heat transfer fluid is to not be lower than 90 degrees C 194 degrees F, determined in accordance with ASTM D92.

2.8.2.2 Biological Oxygen Demand (BOD)

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

2.8.2.3 Freezing Point

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NOTE: The designer should determine the resulting freeze point of the heat transfer fluid after careful analysis. The designer should indicate the required freezing point of the heat transfer fluid.

****

The freezing point must not exceed minus 9 degrees C 15 degrees F, determined in accordance with ASTM D1177.

2.8.2.4 Toxicity

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

2.8.2.5 Storage Stability

The heat transfer fluid, tested in accordance with ASTM F1105, must neither show separation from exposure to heat or cold nor show an increase in turbidity.

2.8.3 Quality

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

[2.9 CHEMICAL FEED PROVISIONS

Provide chemical feed provisions as specified in Section 23 64 26 CHILLED, CHILLED-HOT, CONDENSER WATER PIPING SYSTEMS.

[2.9.1 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/liter 0.5 ounce/gal] of system water if corrosion inhibitors are not contained in freeze protection solution in the ground heat exchanger loop.

][2.9.2 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/liter 0.5 ounce/gal] of system water if corrosion inhibitors are not contained in freeze protection solution in the ground heat exchanger loop.

][2.9.3 Ground Heat Exchanger Piping

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

]]2.10 PAINTING OF NEW EQUIPMENT

New equipment painting is to be factory applied or shop applied, and must be as specified herein. New equipment surfaces constructed of non-ferrous surfaces and materials do not have to be factory or shop painted.

2.10.1 Factory Painting Systems

Manufacturer's standard factory painting systems may be provided subject to certification that the factory painting system applied will withstand 125 hours in a salt-spray fog test, except that equipment located outdoors

which is to withstand [125][500][3000] hours in a salt-spray fog test. Field applied coatings are not acceptable. Provide a factory coating system on the fins of exterior heat transfer equipment that meets ASTM B117.85 salt-fog test duration for [125][500][3000] hr. Salt-spray fog test is to be in accordance with ASTM B117, and for that test the acceptance criteria must be as follows: immediately after completion of the test, the paint must show no signs of blistering, wrinkling, or cracking, and no loss of adhesion; and the specimen must show no signs of rust creepage beyond 3 mm 0.125 inch on either side of the scratch mark.

The film thickness of the factory painting system applied on the equipment is not to be less than the film thickness used on the test specimen. If manufacturer's standard factory painting system is being proposed for use on surfaces subject to temperatures above 50 degrees C 120 degrees F, the factory painting system is to be designed for the temperature service.

2.10.2 Shop Painting Systems for Metal Surfaces

Clean, pretreat, prime and paint metal surfaces; except stainless steel, aluminum, or bronze alloy surfaces need not be painted. Apply coatings to clean dry surfaces. Clean the surfaces to remove dust, dirt, rust, oil and grease by wire brushing and solvent degreasing prior to application of paint, except metal surfaces subject to temperatures in excess of 50 degrees C 120 degrees F must be cleaned to bare metal.

Where more than one coat of paint is specified, apply the second coat after the preceding coat is thoroughly dry. Lightly sand damaged painting and retouch before applying the succeeding coat. Color of finish coat is to be aluminum or light gray.

a. Temperatures Less Than 50 Degrees C 120 Degrees F: Immediately after cleaning, the metal surfaces subject to temperatures less than 50 degrees C 120 degrees F must receive one coat of pretreatment primer applied to a minimum dry film thickness of 0.0076 mm 0.3 mil, one coat of primer applied to a minimum dry film thickness of 0.0255 mm one mil; and two coats of enamel applied to a minimum dry film thickness of 0.0255 mm one mil per coat.

b. Temperatures Between 50 and 205 Degrees C 120 and 400 Degrees F: Metal surfaces subject to temperatures between 50 and 205 degrees C 120 and 400 degrees F are to receive two coats of 205 degrees C 400 degrees F heat-resisting enamel applied to a total minimum thickness of 0.05 mm 2 mils.

c. Temperatures Greater Than 205 Degrees C 400 Degrees F: Metal surfaces subject to temperatures greater than 205 degrees C 400 degrees F are to receive two coats of 315 degrees C 600 degrees F heat-resisting paint applied to a total minimum dry film thickness of 0.05 mm 2 mils.

2.11 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 is to meet NSF/ANSI 600. The grout is to 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.

[2.11.1 High Grade Bentonite Grout

****

NOTE: Check with local and State requirements regarding the use of bentonite for sealing of the bore hole. Consider the use of high grade bentonite grout where thermal performance is not an issue. The thermal conductivity of the grout will have to be considered the designer in the heat transfer calculation and well design and sizing. High grade bentonite grout is usually used for wells that have unconsolidated (sand and gravel or soil like) aquifers. The high grade bentonite grout mixture consists of 50 pounds of bentonite mixed with 23 gallons of potable water which gives a mixture of 27 gallons of high grade bentonite grout.

****

Provide high grade bentonite grout mixture. The grout is to be mixed with potable water. The grout is to be mixed per manufacturer instructions. The thermoconductivity of the grout must be 0.744 W/mK 0.43 Btu/hr-ft-F or greater. The minimum solids content must be 23 percent. The target grout weight must be 1140 kg/m3 9.5 lb/gallons to 1176 kg/m3 9.8 lb/gallon.

][2.11.2 Thermally-Enhanced Bentonite Grout

****

NOTE: Check with local and State requirements regarding the use of bentonite for sealing of the bore hole. Use thermally enhanced bentonite grout mixture where the thermal characteristic of the well is critical to the performance of the well system. The thermal conductivity of the grout will have to be considered by the designer in the heat transfer calculation and well design and sizing. Thermally enhanced bentonite grout is usually used for wells that have unconsolidated (sand and gravel or soil like) aquifers. The thermally enhanced bentonite grout mixture consists of 54 pounds of bentonite mixed with 350 pounds of silica sand, and 21.5 gallons of potable water which gives a mixture of 41 gallons of thermally enhanced bentonite grout.with a solids content of 69 percent, a weight of 14.2 lb/gallon, and a thermal conductivity of 1.12 Btu/hr-ft F.

****

Provide thermally enhanced bentonite grout mixture. Thermally enhanced bentonite grout mixture is to be a high solids bentonite grout. The grout is to be mixed per the manufacturer instructions. Potable water is to be used for mixing the grout. Grout is to have a minimum solids content of 65 to 70 percent. The thermal conductivity of the grout mixture compound must be a minimum of 1.73 W/mK 1.0 Btu/hr-ft-F or greater. The target grout weight must be 1596 kg/m3 13.3 lb/gallons to 1728 kg/m3 14.4 lb/gallon. The thermally-enhanced bentonite grout must have a thermal enhancement compound consisting of a high-grade silica compound that constitutes a minimum of 50 percent by weight of the aqueous slurry.

][2.11.3 Cementitious Thermally Enhanced Grout

****

NOTE: Use cementitious thermally enhanced bentonite grout mixture where the thermal characteristic of the well is critical to the performance of the well system. The thermal conductivity of the grout will have to be considered by the designer in the heat transfer calculation and well design and sizing. Cementitious thermally enhanced bentonite grout is usually used for wells that have consolidated (rock, limestone, sandstone, bed rock, granite, etc) aquifers. Use this grout where the ground water has a pH less than 5.0 and/or a total dissolved solids content greater than 1000 ppm. The cementitious thermally enhanced bentonite grout mixture consists of 94 pounds of portland cement mixed with 200 pounds of silica sand, 1.04 pounds of 200 mesh sodium bentonite, 6.19 gallons of potable water, and 21 fluid ounces of a superplasticizer (sulfonated naphthalene) which gives a mixture of 19 gallons of cementitious thermally enhanced bentonite grout.with a weight of 18 lb/gallon, and a thermal conductivity of 1.4 Btu/hr-ft F. For salt water zones, use a grouting material that is resistant to salt water.

****

Provide cementitious thermally enhanced grout mixture. The cementitious thermally enhanced grout mixture is to be a high solids sodium bentonite grout with portland cement, potable water, silica sand compound, and a super plasticizer compound. The grout is to be mixed per the manufacturer instructions. Use potable water for mixing the grout. The thermal conductivity of the grout mixture compound is to be a minimum of 2.42 W/mK 1.4 Btu/hr-ft-F or greater. The target grout weight must be 1920 kg/m3 16 lb/gallon.

]2.12 CONTROLS

Controls for the[ground-loop][water-loop] heat pump systems complete and ready for operation to be integrated with the HVAC system controls package specified in Section[23 09 53.00 20 SPACE TEMPERATURE CONTROL SYSTEMS,] 23 09 00 INSTRUMENTATION AND CONTROL FOR HVAC. Systems include heat pumps, system equipment, piping, pumps, electrical equipment, controls,[wells,] and condenser Controls are to be designed in accordance with the manufacturer's recommendations and to comply with the sequence of controls shown on the drawings.

PART 3 EXECUTION

3.1 INSTALLATION

3.1.1 Heat Pump System

Maintenance access to each piece of equipment is not to be compromised by any type of piping, electrical conduit, or any other utility. Further, install equipment in accordance with NFPA 70 and 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

][As-Built Drawings of the installed systems. As-built drawings are to also show and document the as-constructed locations of the well field with dimensions, including all wells and loop fields.

]3.1.2 Closed Circuit Cooler Installation

Installation, operation and maintenance of the closed circuit cooler must be in compliance with the requirements of ASHRAE 188. Provide Closed Circuit Coolers - Operating Instructions defining required maintenance, cleaning and operating procedures for the mitigation of legionellosis in accordance with ASHRAE 188.

3.1.3 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 FLUSHING AND PURGING GROUND HEAT EXCHANGER prior to making connections.

3.2 ABOVEGROUND PIPING

Provide above ground piping as specified in Section 23 64 26 CHILLED, CHILLED-HOT, CONDENSER WATER PIPING SYSTEMS.

a. 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.

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NOTE: It is extremely important to vent and purge all air out of the loops, especially the plastic piping systems. Leaving any air in the piping could lead to potential flow blockage and could lead to a catastrophic pipe failure by explosion.

****

b. Flushing and Purging of Piping: Before connection of the header to the polyethylene ground heat exchanger loops, flush and purge 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 are to be taped or capped. Purge and vent the above ground system piping of all air.

3.3 EARTHWORK

****

NOTES: For the designer to consider - geothermal piping do not require trenches with graded bottoms, load bearing bottoms, or sand fill bedding unless the piping is on rock. Backfill trenches with soil fine enough to fill completely around the pipe. Compacting to 150 mm 6 inch lifts is not required.

a. Consider for large systems: Lay all supply piping in an orderly way in one trench. Consider the same trench method for return systems.

b. Consider for residential systems: consider geothermal piping on one side of trench for utilities.

c. Aside from building entries or vault connection areas, the geothermal pipe loops are flexible, and contract and expand due to temperature variations.

****

Earthwork to be performed in accordance with applicable provisions of Section 31 00 00 EARTHWORK, except that bentonite and thermally enhanced grouts to be used where indicated.

3.4 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. Sharp bends and mitered joints are to 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 are to be radius type elbows. Make changes in piping sizes through tapered concentric fittings. Leaks are to 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 to 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 to be 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.]

3.4.1 Vertical Well Fields

****

NOTE: The designer must become familiar with the local and state regulations regarding geothermal wells and water wells. The designer must modify these specifications in accordance to the local and

state regulations. The designer must design and specify the heat exchanger systems to meet the specific local and state regulations and statutes that may be required, such as:

a. Well driller licensing and certification
b. Pump installer licensing
c. Well construction permit
d. Local and/or State approved well permit
e. Allowable grout requirements
f. Allowable heat transfer fluids
g. Allowable pipe materials
h. Well construction log record
i. Well abandonment and abandonment records
j. Well closing and closing records.
k. Antifreeze fluids, if any
l. Water treatment chemicals, if any
m. Corrosion inhibitors, if any
n. Groundwater conservation
o. Protection of different aquifers
p. Authorization to install and operate

****

Each vertical well and ground heat exchanger loop is to have a Well Construction Permit as required by local and state regulations. In addition, each well and ground heat exchanger loop is to have a local [and][or] state Approved Well Permit as required by local and state regulations. The contractor must maintain these permits during the construction contract period. Submit a copy of the permits with the As-built documentation. Construction and installation of each well are to be in accordance to these permits. Each well is to be performed by a state [_____] certified well driller. Certifications are to be in the state where the work occurs. Prior to installation of wells, verify the the well drillers and pump installers are certified. For any well that is abandon, abandonment must 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 to 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 are to have the names of the well drillers and pump installers, copies of their certifications.

Each U-bend loop is to be factory 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. 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.

a. The borehole is to be constructed[in accordance with all local and state regulations and guidelines for geothermal wells][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 is to be factory assembled and pressure tested to 689.5 kPa gage 100 psig prior to insertion into the vertical bore. All connections are to 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 is to be no joint in either leg of each vertical loop except for the factory assembled connection at the U-bend.

b. Vertical bores are to be 1.5 m 5 feet deeper than the length of the U-bend assembly loop, 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. Temporarily cap the ends of the U-bend assemblies until the actual testing begins. The cap must be fused to the pipe end in order to hold the pressure. Pressure testing can be performed while the bore hole is being drilled.

****

NOTE: The loop must be filled with water prior to insertion into the hole that has drilling mud and/or water in it. However, for dry holes (drilled with air and have very little water in them), consider installing tubing without water and fill and test after insertion. The disadvantage with this is during pressure testing - leaks will be hard to see visually.

****

c. Backfill the bores from the bottom up with a bentonite grout material and grouting process in conformance with IGSHPA 21015 to ensure pipe contact and compliance with local and State requirements for sealing. Prepare and mix bentonite grout in accordance with manufacturer's recommendations for water-to-mix ratio. Place grouting materials using a pressure pump with a tremie pipe system. Install the grouting material from the bottom to the top of the vertical borehole. If any settling occurs during the initial 24-hour period after installation, add additional material to insure the grouting material remains at the desired surface level. The bores are not to 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.

d. In the event that a geological formation is encountered, that prevents the grouting material from forming a solid seal, either a 9.5 mm 3/8 inch or 19 mm 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.

e. During installation of the vertical well, maintain a water and soils log indicating 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.

f. 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:

g. 19 mm 3/4 inch diameter for 30 to 60 m 100 to 200 feet loop length

h. 25 mm 1 inch diameter for 45 to 90 m 150 to 300 feet loop length

i. 32 mm 1-1/4 inch diameter for 76 to 150 m 250 to 500 feet loop length

j. Show and identify each well location on as built drawings.[Provide a tracer wire system.][The tracer wire system is to include a locator device to identify the well field. Locate the locator device in the mechanical room.]

k. Minimum vertical well distance: In absence of other requirements or as indicated, provide a minimum well separation distance between wells of 4.572 [_____] m 15 [_____] feet. Provide a minimum separation distance between wells and building foundation walls of 6.0 [_____]m 20 [_____] feet.

3.4.2 Horizontal Well Fields and Header Piping

****
NOTE: For insulation on buried piping: The intent with the option or bracketed requirement noted below is to prevent frost heave. The specifying engineer/designer should delete the option where fluid temperatures are not below 1.7 degrees C 35 degrees F.
****

Horizontal trenches for ground heat exchanger piping may be dug with a chain type trenching machine or a backhoe. Bury the piping 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 to 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. When laying pipe in trench, insure the bottom of the trench is smooth, free from rocks and debris. When laying pipe, use a fine to medium backfill to fill trench. If there are multiple pipes in the trench, insure each pipe is completely surrounded and supported with backfill before the next pipe is installed.

[3.4.2.1 Piping at Building Entries

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NOTE: For ease of pipe installation of small systems, consider using PVC conduit as a means of a pipe casing for pipe entries into buildings.
****

Install a rigid non-metallic conduit (PVC) as a pipe casing at building entries and floor penetration. The casing allows ease of installation of the ground heat exchanger piping into the building. The conduit should extend 610 mm 24 inches from the building foundation. The conduit should end 152 mm6 inches above the floor. The ends of the conduit where the pipe is located, fill the annular space with insulation and a silicone seal.

]3.4.3 Polyethylene Piping

Install piping in accordance with manufacturer's written instructions. Do not use polybutylene piping. Join piping components 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 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 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.

3.4.4 Heat Fusion Process

Joining is to 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 20 mm 3/4 inches diameter and less. Use butt fusion joints for pipe greater than 20 mm 3/4 inches diameter. Different plastics or grades of plastic are not to 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.

3.4.5 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.

3.4.6 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.

[3.4.7 Tracer Wire

****
NOTE: In lieu of a tracer wire system, consider a a metalized warning tape.
****

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. [Provide a tracer wire system with a locator device for identifying the well field.]

]3.4.8 Threaded Fittings

Seal threaded joints 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. Threaded joints may be used only above grade, within

mechanical spaces, or within valve pits.

3.5 FIELD PAINTING AND FINISHING

Requirements for field painting and finishing are specified in Section 09 90 00 PAINTS AND COATINGS.

3.6 FLUSHING AND PURGING GROUND HEAT EXCHANGER

Before connection of the plastic ground heat exchanger loops to the header, flush and purge 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 must be taped or capped. Purge and vent the ground heat exchanger system piping of all air.

3.7 ADJUSTMENTS

****

NOTE: All design water and air flowrates are to be indicated on the plans.

****

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.

3.8 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.

3.9 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. Perform and document that proper Indoor Air Quality During Construction procedures have been followed; this includes providing documentation showing that after construction ends, and prior to occupancy, new replaceable filters were provided and installed and permanent filters were cleaned.

3.9.1 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[1.5 times the system working pressure][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.

3.9.2 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: high volume, high head purge pump; open reservoir; filter assembly with bypass; flow meter; pressure gage; connecting piping; and connecting hoses.

****

NOTES:

1. These purging and venting requirements are for heat pump systems with a connected loop capacity of 35.2 kilowatt 10 tons or less of connected loop capacity.

2. In larger systems greater than 35.2 kilowatt 10 tons of connected loop capacity, the designer must indicate on the drawings a system design that allows purging and venting of air with high horsepower circulating pumps, air ejectors, and valved-off 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.

3. For larger ground source heat pump systems, greater than 35.2 Kilowatt 10 tons of connected loop capacity, the designer should show on the drawings ground exchanger loops with accessible valves and flushing/vent connections inside a building or in manholes for each section.

****

a. 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.

b. 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.

c. 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 is to be observed and approved

by the Contracting Officer.

d. 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 minus 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.]

e. Form 1, "Ground Heat Exchanger Inspection and Test Report" located in Appendix A of this section is to 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.

3.9.3 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 are to be pressure tested by hydrostatic test. Isolate the system from all connections to piping. Ensure that the piping system has been flushed of all dirt and debris. The piping must then be plugged or capped as necessary in preparation for the hydrostatic test(s).

3.9.3.1 Hydrostatic Test

The piping is to be hydrostatically pressurized to 150 percent of system pressure [or [1000][_____] kPa [150][_____] psi] and monitor piping. If there is any pressure loss or visible leakage during the testing, the leak must be identified and repaired in accordance with the piping components manufacturer's recommendations. Repeat the test 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.

3.9.4 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: Use a high vacuum pump and certified micron gage to reduce the 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.

3.9.5 Equipment Tests

3.9.5.1 Field Testing

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NOTE: It needs to be understood that this is a standard operation test, not a continuous operation test. A long continuous test of more than 24 hours, could artificially and unnecessarily load the ground mass around the ground heat exchanger.

****

Test each item of equipment in operation,[for continuous period of not more 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.

3.9.5.2 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:

[(1) Water-Source Water-to-Air Heat Pumps - Field Acceptance Test Plan

][(2) Water-Source Water-to-Water Heat Pumps - Field Acceptance Test Plan

][(3) Closed Circuit Coolers - Field Acceptance Test Plan

][(4) 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 23 09 53.00 20 SPACE TEMPERATURE CONTROL SYSTEMS 23 09 00 INSTRUMENTATION AND CONTROL FOR HVAC.

c. Prerequisite Testing: Equipment for which performance testing is dependent upon the completion of the work covered by 23 05 93 TESTING, ADJUSTING, AND BALANCING FOR HVAC must 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 is to 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 are to 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 lists 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 must acceptably operate.

f. Job Specific: Each test plan is to be job specific and to 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 is to include procedures for field testing and field adjusting specialized components, such as hot gas bypass control valves, or pressure valves.

3.9.5.3 Field Test Reports

a. Equipment Items to Test:

[(1) Water-Source Water-to-Air Heat Pumps - Field Acceptance Test Report

][(2) Water-Source Water-to-Water Heat Pumps - Field Acceptance Test Report

][(3) Closed Circuit Coolers - Field Acceptance Test Report

][(4) 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 standard[continuous 24 hour] operational test for each item of equipment. Equipment shutdown before the test period is completed must 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.

****

NOTE: It needs to be understood that this is a standard operation test, not a continuous operation test. A long continuous test of more than 24 hours, could artificially and unnecessarily load the ground mass around the ground heat exchanger.

****

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 are to be reviewed, approved, and signed by the Contractor's test director and the QC Manager. The manufacturer's field test representative is to review, approve, and sign the report of the manufacturer's recommended test. Signatures are required to be accompanied by the person's name, typed.

f. Deficiency Resolution: The test requirements acceptably met; deficiencies identified during the tests must be corrected in compliance with the manufacturer's recommendations and corrections retested to verify compliance.

3.9.6 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 FOR HVAC.][Begin testing, adjusting, and balancing only when the entire HVAC system, including controls, has been completed with the exception of performance tests. Where required, charge the heat pump systems with premixed antifreeze solution (type and concentration as indicated in paragraph ANTIFREEZE PROTECTION) prior to testing, adjusting, and balancing.]

****
NOTE: For Navy projects, 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 Navy projects.
****

[Balance air flows to that indicated in accordance with SMACNA 1966, as supplemented and modified by this section. Begin testing, adjusting, and balancing only when the entire HVAC system, including controls, has been completed with the exception of performance tests. Where required, charge the heat pump systems with premixed antifreeze solution (type and concentration as indicated in paragraph ANTIFREEZE PROTECTION) prior to 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 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.

]3.9.7 Soil Thermal Conductivity Testing

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NOTES:

1. This subparagraph is for the designer to establish the thermal and sub-surface conditions of the thermal well field.

2. In addition, this paragraph can be utilized as a requirement for the contractor to establish the well field conditions after installation for verification purposes.
****

Perform soil thermal conductivity testing of the well system project location. The test will establish the thermal properties for 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[multiple] locations as[indicated][determined by the designer]. Each test will contain a minimum of 48 hours of recorded data.[Use the test for verification of the design and installation.]

3.9.7.1 Soil Thermal Conductivity Testing Set-up

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

3.9.7.2 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.

a. Temperature Measurements: Measure inlet and outlet temperatures with immersion temperature sensors. The temperatures sensors must be calibrated every 6 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.

[b. Temperature Sensor calibration and accuracy: The combined rated sensor and data logger accuracy will be [as indicated] plus or minus 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 is to have been calibrated semi-annually by immersion in ice and water bath. A calibration certificate stamp with date must be on the test device.

The result from the verification test using ice water bath is not to 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 plus or minus 0.2 degrees C 0.5 degrees F when simultaneously immersed in the ice bath.

] c. Power Measurements: Measure heater and circulating pump power input.[Power measurements are to be independently determined by using power transducers with the manufacturer stated accuracy of plus or minus two percent or better at the level of power consumption for the test.]

d. Flow Rate Measurements: Measure the flow rate.[Measure flow rate using a variable flow meter calibrated by the flow meter manufacturer having a rated accuracy of plus or minus two percent of full scale. Full scale or maximum rated flow for the flow meter is not to exceed actual flow rate by more than 70 percent.]

3.9.7.3 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 must be as designed for the vertical well field. The bore hole depth is not to vary more than 5 percent from the indicated design depth. Materials of the test borehole and heat exchanger must be as utilized in the designed vertical well field.

a. At least 2 m 6 feet of excess pipe is to 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 must be factory assembled and pressure tested to 689.5 kPa gage 100 psig prior to insertion into the vertical bore. All connections are to 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 Test Borehole Well Construction Log Record

[3.9.8 On-Site Training

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NOTE: For the designer to consider - consider 8 hours of training for residential and light commercial projects. Consider 16 hours for large geothermal projects. Training should be attended by the appropriate operation and maintenance station personnel.
****

The[System Designer][Ground Source Heat Pump Specialist] is to conduct a training course for operating and maintenance personnel as designated by the Contracting Officer. Provide training for a period of [16][_____] hours of normal working time and start after the system is functionally complete but prior to the performance tests. The on-site training is to

cover all of the items contained in the approved Operation and Maintenance Data packages.

]3.10 APPENDIX A

Form 1 - Ground Heat Exchanger (Ghx) Inspection And Test Report

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: _____

-- End of Section --