SECTION 23 57 33
GEOTHERMAL ENERGY – DIRECT USE (HEATING APPLICATIONS)

SPEC WRITER NOTES:
Delete between // --- // if not applicable to project. Also delete any other item or paragraph not applicable in the section and renumber the paragraphs. The spec writer shall review the Physical Security Design Manual for VA Facilities to determine and include in this section any Mission Critical or Life Safety requirements called out.

PART 1 - GENERAL

1.1 DESCRIPTION
A. The requirements of this Section apply to all sections of Division 23 related to Geothermal Energy Direct Use Systems.

1.2 RELATED WORK
A. Section 01 00 00, GENERAL REQUIREMENTS: General construction practices.
B. Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES: Submittals.
C. Section 23 05 93, TESTING, ADJUSTING AND BALANCING FOR HVAC: System operations test procedures.
D. Section 23 07 11, HVAC, PLUMBING, AND BOILER PLANT INSULATION: Insulation products and procedures.
E. Section 25 10 10, ADVANCED UTILITY METERING SYSTEM: Requirements for connection to AUMS.

1.3 DEFINITIONS
A. Unless otherwise specified or indicated, geothermal energy terms used in these specifications, and on the drawings, shall be defined in ASTM E957-03.

1.4 QUALITY ASSURANCE
A. Local and state laws and ordinances as they pertain to buried pipe systems shall be strictly followed or a variance obtained.
B. Geothermal Energy Direct Use System installer(s) shall demonstrate that they have successfully installed at least eight projects that, in aggregate, equal or exceed the size of the proposed project. References shall be provided for each of these installed projects.
C. For pump equipment warranty, furnish five year manufacturer’s warranty against defects in materials and workmanship.
D. For piping materials warranty, furnish fifty year manufacturer’s warranty against defects in materials and workmanship.
1.5 SUBMITTALS

A. Submit six copies in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES, and with requirements in the individual specification sections, to the //Resident Engineer (RE)// //Contracting Officer’s Technical Representative (COTR)//.

B. Contractor shall make all necessary field measurements and investigations to assure that the geo-exchange field layout, equipment, and assemblies will meet contract requirements.

C. If equipment submitted differs in arrangement from that shown on the submittals, provide drawings that show the rearrangement of all associated systems. Approval will be given only if all features of the equipment and associated systems, including accessibility, are equivalent to that required by the contract and acceptable to the //RE// //COTR//.

D. Prior to submitting shop drawings for approval, Contractor shall certify in writing that manufacturers of all major items of equipment have each reviewed drawings and specifications from the applicable other manufacturers, and have jointly coordinated and properly integrated their equipment and controls to provide a complete and efficient installation.

E. Submittals and shop drawings for independent items, containing applicable descriptive information, shall be furnished together and complete in a group. Coordinate and properly integrate materials and equipment in each group to provide a completely compatible and efficient installation. Final review and approvals will be made only by groups.

F. Shop Drawings: Include structural supports, //control sequences, //monitoring instruments and controls, battery back-up systems, interconnections and all other components, parts and pieces required to complete the functioning assembly. Where applicable, include shop drawings for foundations or other support structures.

G. Product Data: Include detailed information for components of the geothermal energy system.
   1. Geothermal Well
   2. Grouts
   3. Ground Heat Exchanger
   4. Geothermal Pump Unit
   5. Circulation System
6. Wiring
7. Wiring Specialties
8. Valves
9. Piping Specialties
10. Heat Transfer Fluid
11. Heat Exchanger
12. Insulation
13. Instrumentation

H. Certificates: Submit technical representative’s certification that the installation has been implemented as intended by the system designer and where applicable, recommended by the manufacturer.

I. Manufacturer’s Instructions

J. Operation and Maintenance Geothermal Energy Systems Data Package:
   1. Safety precautions
   2. Operator restart
   3. Startup, shutdown, and post-shutdown procedures
   4. Normal operations
   5. Emergency operations
   6. Operator service requirements
   7. Environmental conditions
   8. Lubrication data
   9. Preventive maintenance plan and schedule
  10. Cleaning recommendations
  11. Troubleshooting guides and diagnostic techniques
  12. Wiring and control diagrams
  13. Maintenance and repair procedures
  14. Removal and replacement instructions
  15. Spare parts and supply list
  16. Corrective maintenance man-hours
  17. Product submittal data
  18. O&M submittal data
  19. Parts identification
  20. Warranty information
  21. Personnel training requirements
  22. Testing equipment and special tool information
  23. Testing and performance data
  24. Contractor information

K. Closeout Submittals
1. Posted operating instructions for Geothermal Energy Direct Use Systems that provide for wiring identification codes and diagrams, operating instructions, control matrix, and troubleshooting instructions.

2. Detail of as-built of geo-heat exchange field well and piping locations provided on no less than 3/16” scale drawings in AutoCAD .dwg digital file format.

1.6 APPLICABLE PUBLICATIONS

A. Publications listed below (including amendments, addenda, revisions, supplements and errata) form a part of this specification to the extent referenced. Publications are referenced in the text by the basic designation only.

B. American Petroleum Institute (API):
   662-06 ............... Plate Heat Exchangers for General Refinery Services - Part 1 - Plate-and-Frame Heat Exchangers; Ed. 1.0

C. American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE):
   90.1-IP-10 ............ Energy Standard for Buildings Except Low-Rise Residential Buildings
   90.1-SI-10 ............ Energy Standard for Buildings Except Low-Rise Residential Buildings

D. American Society of Mechanical Engineers (ASME):
   B31.1-10 .............. Power Piping
   B40.100-05 ............ Pressure Gauges and Gauge Attachments

E. American Society for Testing and Materials (ASTM):
   D92-12 ............... Standard Test Method for Flash and Fire Points by Cleveland Open Cup Tester
   D1177-07 ............... Standard Test Method for Freezing Point of Aqueous Engine Coolants
   D2513-12a ............. Standard Specification for Polyethylene (PE) Gas Pressure Pipe, Tubing, and Fittings
   D2683-10 ............. Standard Specification for Socket-Type Polyethylene Fittings for Outside Diameter-Controlled Polyethylene Pipe and Tubing
   D2765-11 ............. Standard Test Methods for Determination of Gel Content and Swell Ratio of Crosslinked Ethylene Plastics
D2837-11 Standard Test Method for Obtaining Hydrostatic Design Basis for Thermoplastic Pipe Materials or Pressure Design Basis for Thermoplastic Pipe Products

D3035-10 Standard Specification for Polyethylene (PE) Plastic Pipe (DR-PR) Based on Controlled Outside Diameter


D3350-12 Standard Specification for Polyethylene Plastics Pipe and Fittings Materials


E957-03 Standard Terminology Relating to Geothermal Energy

E975-00 Standard Guide for Specifying Thermal Performance of Geothermal Power Systems

F714-12 Standard Specification for Polyethylene (PE) Plastic Pipe (DR-PR) Based on Outside Diameter

F876-10 Standard Specification for Crosslinked Polyethylene (PEX) Tubing


F1055-11 Standard Specification for Electrofusion Type Polyethylene Fittings for Outside Diameter Controlled Polyethylene and Crosslinked Polyethylene (PEX) Pipe and Tubing

F1105-09 Standard Practice for Preparing Aircraft Cleaning Compounds, Liquid-Type, Temperature-Sensitive, or Solvent-Based, for Storage Stability Testing

F2080-09 Standard Specification for Cold-Expansion Fittings With Metal Compression-Sleeves for Cross-Linked Polyethylene (PEX) Pipe

F. International Code Council (ICC):

IBC-12 International Building Code

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PART 2 – PRODUCTS

SPEC WRITER NOTE: Geothermal Direct Use heating applications are suited for low to moderate temperature source wells: 32°C to 120°C [90°F to 250°F].

2.1 GENERAL

A. Provide materials to fabricate geothermal energy systems in accordance with this section. At the Contractor’s option, provide factory-prefabricated geothermal equipment packages which meet the requirements of this section.

2.2 SHELL-AND-TUBE GROUND HEAT EXCHANGER PIPING AND SPECIALTIES

A. The acceptable pipe and fitting materials for the underground portion of the ground heat exchanger shall be polyethylene and cross-linked polyethylene.

B. Polyethylene heat exchanger shall meet the following requirements:
   1. Pipe and heat fused materials shall be manufactured from virgin polyethylene extrusion compound material per ASTM D-2513, Section 4.1 and 4.2. Pipe shall be manufactured to outside diameters, wall thickness, and respective tolerances as specified in ASTM, D-3035 or F-714. Fittings shall be manufactured to diameters, wall thickness, and respective tolerances as specified in ASTM D-3261 for butt-fusion fittings, ASTM D-2683 for socket fusion fittings and ASTM F-1055 for electro-fusion fittings.
SPEC WRITER NOTE: As of the approval date (10/28/07) of PE 4710, there is a limited number of pipe manufacturers offering a geothermal pipe produced from 4710 material.

2. The material shall have a Hydrostatic Design Basis of 11 MPa [1600 psi] at 23°C [73°F] per ASTM D-2837. The material shall be listed in PPI TR4 as either a PE 3408/3608 or PE 4710 piping formulation. The material shall be a high-density polyethylene compound having a minimum cell classification of PE345464C per ASTM D-3350.

3. The total system pressure shall remain below the working pressure of the pipe.

4. Sufficient information shall be permanently marked on the length of the pipe as defined by the appropriate ASTM pipe standard.

5. Manufacturer shall supply a notarized document confirming compliance with the above standards.

C. Cross-linked polyethylene heat exchanger shall be:

1. Tubing manufactured by the high-pressure peroxide method (known as PEXa), and shall conform to ASTM F-876, and F-877 or D-2513. Polymer electro-fusion fittings for PEXa pipes of each dimensional specification shall conform to ASTM F-1055 or ISO 14531-2; metal cold compression-sleeve fittings shall conform to ASTM F-2080.

2. PEXa tubing material of high-density cross-linked polyethylene manufactured using the high-pressure peroxide method of cross-linking with a minimum degree of cross-linking of 75% when tested in accordance with ASTM D-2765, Method B. The tubing material designation code as defined in ASTM F-876 shall be PEX 1006 or PEX 1008.

3. Polymer electron-fusion fittings manufactured using a material in accordance to IGSHPA 2011, Section 1C.2.2.

4. PEXa tubing manufactured in accordance to the dimensional specifications of ASTM F-876, and F-877 with a minimum working pressure rating of 1.1 MPa [160 psi] at 23°C [73°F].

5. Fittings used with PEXa tubing intended for geothermal applications that shall be polymer electro-fusion fittings or cold expansion compression-sleeve metal fittings. Polymer electro-fusion fittings shall conform to ASTM F-1055 or ISO 14531-2 whereas cold-expansion compression-sleeve fittings shall conform to ASTM F-2080, and shall have a minimum inside diameter of 82% of inside pipe diameter.
6. Required to have product standard information marked on PEXa tubing and fittings.

2.3 DOWNHOLE PLATE-AND-FRAME HEAT EXCHANGER
A. Heat exchanger shall conform to API 662 and ISO 15547.
B. Shall not be used for design pressures above 3.00 MPa [435 psia] and design temperatures above 120°C [250°F].
C. Nominal thickness of gasketed plates before pressed shall be sufficient to meet design conditions but no less than 0.5 mm [0.02 inches].

2.4 CIRCULATOR SIZING AND SYSTEM AND COMPONENTS
A. Proper sizing of the circulating pump shall be within the heat pump manufacturer’s required flow rate range for the specified unit.
B. Particulate contaminants shall be removed from piping system prior to initial start-up.
C. Start-up pressurization of the circuit to a minimum of 1.38 – 2.07 bar [20 to 30 psi] when installed in the summer with circulating water temperature of 20 – 30°C [70 – 90°F] and 2.76 – 3.45 bar [40 to 50 psi] when installed in the winter with circulating water temperature of 5 – 10°C [40 – 50°F] is required. Standing column designs of circulating systems that ensure a flooded volute and meet the manufacturer’s requirements are excluded from these pressure requirements.
D. The circulation system shall incorporate provisions for flow and temperature-sensing capability for testing the performance of the water side of the heat pump system. Pressure and temperature-sensing ports shall be within 600 mm [24 inches] of the heat pump.

2.5 DOWNHOLE AND CIRCULATION PUMPS
A. Shall be ISO 9001 certified.
B. Shall be sized according to manufacturer’s guidelines and end user’s needs.
C. Hydronic systems with a total pump power exceeding 10 hp shall be variable flow and each water source heat pump shall have a two position isolating valve that closes when the compressor is not operating as per ASHRAE 90.1.

2.6 HEAT TRANSFER FLUID
A. Shall meet local and state requirements and be acceptable by component manufacturers.
B. Shall meet requirements of ICC IMC Section 1207.
C. The geothermal heat pump system shall have a permanent label at the loop charging valve identifying the antifreeze type and concentration, service date, and the name and phone number of the service company.

D. Heat transfer fluids used shall be one of the following:

1. Food-grade propylene glycol-water solution at a concentration specified by the product manufacturer.
2. Methanol-water solution up to 20 percent methanol by volume.
3. Ethanol-water solution up to 20 percent ethanol by volume.
4. Nontoxic compounds meeting IGSHPA 2011, Sections 3B and 3C, and which are compatible with heat pump manufacturers’ specifications.

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

1. Flash point shall not be lower than 90°C [194°F], determined in accordance with ASTM D-92.
2. Five days biological oxygen demand (BOD) at 10°C [50°F] shall not exceed 0.2 gram oxygen per gram not be less than 0.1 gram oxygen per gram.
3. Freezing point shall not exceed -8°C [+18°F], determined in accordance with ASTM D-1177.
4. Toxicity shall not be less than LD 50 (oral-rats) of 5 grams per kilogram. The NFPA hazardous material rating for health shall not be more than 1 (slight).
5. The fluid, tested in accordance with ASTM F-1105, shall show neither separation from exposure to heat or cold, nor show an increase in turbidity.

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

G. Water used to dilute the antifreeze heat transfer fluids shall be of potable quality. Final heat transfer fluid solutions shall not be flammable.

H. Packaging and Identification

1. Fluid shall be packaged in containers of a type and size agreed upon by purchaser and vendor, or shall be delivered in bulk, as ordered.
2. Containers of fluid shall be prepared for shipment in accordance with commercial practice and in compliance with applicable rules and regulations pertaining to the handling, packaging, and
transportation of the fluid to ensure carrier acceptance and safe delivery.

3. An up-to-date Material Safety Data Sheet (MSDS) shall be supplied to each purchaser on request and concurrent with each delivery.

2.7 INSULATION

A. R-5 shall be the minimum insulation for piping handling temperatures greater than 40°C [105°F] or less than 13°C [55°F] per IECC R403.3.

2.8 INSTRUMENTATION

A. Use corrosion resistant materials for wetted parts of instruments.

B. Pressure Gages: ASME B40.100, brass body, and minimum 90 mm [3.5 inches] diameter dial face.

C. Thermometers: ASTM E1, //liquid-in-glass type// //dial type, liquid-filled tube and bulb//.

SPEC WRITER NOTE: For small systems such as family housing, do not use monitoring system, due to high initial cost and the labor to maintain it.

D. Monitoring System:

1. Kilojoule Btu Meter: Sensing and Monitoring device to measure and display the heat energy produced by the geothermal system, with minimum sensitivity of 0.5 percent over the entire scale. Provide electromechanical kJ Btu counter plus digital-panel meter indicating sensor temperatures, differential temperature, flow rate, and watt Btu per minute or hour.

2. //Water// //and// //Heat Transfer Fluid// Leak Detection: UL-listed system consisting of a sensor probe, control panel, and LED indicators for //water; yellow,// //and// //heat transfer fluid; red,// with audible alarm at minimum 75 dB sound level; reference 10 exponential minus 12 watts.

PART 3 – EXECUTION

3.1 INSTALLATION

A. Install the geothermal system in accordance with this section and the printed instructions of the manufacturer.

B. Prior to any excavation, trenching, or drilling, all buried utilities, drainage, and irrigation systems shall be located and flagged by the appropriate utility and contractor representative.

C. Drilling Contractor shall be a National Ground Water Association (NGWA) Certified Well Driller (CWD).
D. Surface Discharge shall be compliant per the Environmental Protection Agency (EPA) National Pollutant Discharge Elimination System (NPDES) regulations.//

E. Reinjection Well shall be compliant per the Environmental Protection Agency (EPA) Underground Injection Control (UIC) regulations for Class V (Shallow Non-Hazardous Injection) wells.//

F. Borehole Construction shall be performed per IGSHPA 2011, Section 2B.

1. Surface water shall not be used as a source of water during the drilling of a borehole unless it is obtained from a municipal water supply system. Water used for drilling purposes shall be potable water that contains a free chlorine residual of no less than 10 milligrams per liter. Chlorine residual level shall be checked with chlorine test strips.

G. Piping installation shall be compliant with ICC IMC Section 1206.

H. Pipe Joining Methods

1. The only acceptable methods for joining buried polyethylene pipe systems are: 1) a heat fusion process or 2) stab-type fittings quality controlled to provide a leak-free union between pipe ends that is stronger than the pipe itself.

2. Polyethylene pipe shall be heat fused by butt, socket, sidewall or electro-fusion in accordance with the piping manufacturer’s procedures.

3. Polyethylene fusion transition fittings with threads shall be used to adapt to copper. Polyethylene fusion transition fittings with threads or barbs shall be used to adapt to high strength hose. Barbed fittings utilizing mechanical clamps are not permitted to be connected directly to polyethylene pipe, with the exception of stab-type fittings as described above. All mechanical connections shall be accessible.

4. PEXa tubing may not be butt-fused or socket-fused to fittings. Polymer electro-fusion fittings may be used with PEXa tubing when installed in accordance with manufacturer’s published procedures. Cold-expansion compression-sleeve fittings may be used for all PEXa connections when installed according to the manufacturer’s published procedures and is permitted to be direct buried with manufacturer approved corrosion covering.

I. Circulator System
1. Loop charging valve handles shall be removed and/or the ports sufficiently plugged to prevent accidental discharge of system fluid and pressure.

2. Boiler-type service valves shall not be used.

3. Transition fittings between dissimilar materials shall be located inside or accessible.

4. All indoor piping shall be insulated where condensate may cause damage.

5. All aboveground piping subject to condensation or freezing shall be insulated.

6. All pipes passing through walls shall be sleeved and sealed with non-hardening caulking material.

   SPEC WRITER NOTE: Some antifreeze solutions require more fitting torque than others to prevent leaks and corrosion of external surfaces when the antifreeze is exposed to oxygen.

7. Threaded fittings shall be visually inspected for quality and a thread sealant specified for use with the antifreeze selected shall be used.

   J. Any penetrations of walls or horizontal assemblies shall be compliant with ICC IBC Section 714.

   K. Instrumentation: Install instruments as recommended by the control manufacturers. // Locate control panels //inside mechanical room// //_____//.

   L. Meters shall tie into building Utility Monitoring and Control System (UMCS) or Direct Digital Control (DDC) system, and ultimately to the VA Advanced Utility Metering System (AUMS) per Section 25 10 10, ADVANCED UTILITY METERING SYSTEM.

3.2 FIELD QUALITY CONTROL

A. Field Inspection: Prior to initial operation, inspect the piping system for conformance to drawings, specifications and ASME B31.1. Inspect the following information on each unit:

1. Manufacturer's name or trademark.

2. Model name or number.

3. Certifying agency label and rating.

B. Tests: Provide equipment and apparatus required for performing tests. Correct defects disclosed by the tests and repeat tests. Conduct
testing in the presence of the //Contracting Officer// //QC Representative// //RE// //COTR//.

1. Piping Test: //Pneumatically test new piping for leakage using air at a pressure of 200% of design operating pressure.\// //Test new water piping for leakage using water at a pressure of at least 690 kPa (gage) [100 psig] per ICC IMC Section 1208, but no less than 150% of design operating pressure.\// Install a calibrated test pressure gage in the system to indicate loss in pressure occurring during the test. Apply and maintain the test pressure for one hour, during which time there shall be no evidence of leakage, as detected by a reduction in test pressure. Should a reduction occur, locate leaks, repair, and repeat the test.

SPEC WRITER NOTE: Use pneumatic test if non-aqueous heat transfer fluid is used, to avoid contamination of fluids with water and to eliminate seepage problems.

2. Operation Tests: Perform tests on mechanical systems, including pumps, controls, controlled valves, and other components in accordance with manufacturer's written recommendations. Test entire system in accordance with Section 23 05 93, TESTING, ADJUSTING AND BALANCING FOR HVAC.

3.3 FOLLOW-UP VERIFICATION

A. Upon completion of acceptance checks, settings, and tests, the Contractor shall show by demonstration in service that the geothermal direct use system is in good operating condition and properly performing the intended function.

3.4 INSTRUCTION

A. A complete set of operating instructions for the geothermal direct use system shall be laminated or mounted under acrylic glass and installed in a frame near the equipment.

B. Furnish the services of a factory-trained technician for one, 4-hour training period for instructing personnel in the maintenance and operation of the geothermal direct use system, on the dates requested by the //RE// //COTR//.

---END---