

**SECTION 23 57 33**  
**GEOHERMAL 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.

**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.

SPEC WRITER NOTE: Edit the below to suite project.

- B. Geothermal for direct use heating applications: The system includes wellbores, open loop downhole piping, above grade plate-and-frame heat exchanger and associated circulation pumps for the generation of HVAC heating water. The geothermal source is separated from the HVAC heating equipment via the plate-and-frame heat exchanger.

**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 11, COMMON WORK RESULTS FOR HVAC: General mechanical requirements.  
 D. Section 23 05 93, TESTING, ADJUSTING AND BALANCING FOR HVAC: System operations test procedures.  
 E. Section 23 07 11, HVAC AND BOILER PLANT INSULATION: Insulation products and procedures.  
 //F. Section 23 09 23, DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC.//  
 //G. Section 23 21 12 HYDRONIC PIPING: Gauges and thermometers.//  
 //H. Section 23 21 23, HYDRONIC PUMPS: Hydronic pump requirements.//

**1.3 DEFINITIONS**

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

**1.4 QUALITY ASSURANCE**

- A. The Wellbore Drilling Contractor shall be a National Ground Water Association (NGWA) Certified Well Driller (CWD).  
 B. Local and state laws and ordinances as they pertain to buried pipe systems shall be strictly followed or a variance obtained.

- C. 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.
- D. Warranties: The geothermal energy system shall be subject to the terms of FAR Clause 52.246-21, except that the warranty period shall be as noted for the items below:
  - 1. Polyethylene piping: 25 year manufacturer's warranty against defects in materials and workmanship.

SPEC WRITER NOTE: Local authorities are likely to have requirements in place to protect resources such as groundwater. Research local requirements with the Authority Having Jurisdiction and consult with VA to determine applicability to project. Insert applicable authorities and regulations below.

**1.5 PERMITS AND FEES**

- A. The Wellbore Driller/Installer of downhole piping shall, without additional expense to the Government, be responsible for obtaining and paying for any and all necessary licenses and permits in connection with the performance of its services; installer shall maintain said licenses and permits current until the work has been accepted by the Government, and alone shall bear financial responsibility for any and all violations of said licenses and permits. //Permit Agencies with jurisdiction over this project include, but are not limited to, the following:
  - 1. //

**1.6 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// //COR//.
- 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  
//Resident Engineer// //COR//.

- 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, 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. As-built drawings of geothermal heat field well and piping locations provided on no less than 3/16" scale drawings in AutoCAD .dwg digital file format.

**1.7 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):
- 662-11.....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-13.....Energy Standard for Buildings Except Low-Rise  
Residential Buildings
- 90.1-SI-13.....Energy Standard for Buildings Except Low-Rise  
Residential Buildings
- D. American Society of Mechanical Engineers (ASME):
- B31.1-14.....Power Piping
- B40.100-13.....Pressure Gauges and Gauge Attachments
- E. American Society for Testing and Materials (ASTM):
- D92-12b.....Standard Test Method for Flash and Fire Points  
by Cleveland Open Cup Tester
- D1177-16.....Standard Test Method for Freezing Point of  
Aqueous Engine Coolants
- D2513-14e1.....Standard Specification for Polyethylene (PE)  
Gas Pressure Pipe, Tubing, and Fittings
- D2683-14.....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
- D2837-13e1.....Standard Test Method for Obtaining Hydrostatic  
Design Basis for Thermoplastic Pipe Materials  
or Pressure Design Basis for Thermoplastic Pipe  
Products
- D3035-15.....Standard Specification for Polyethylene (PE)  
Plastic Pipe (DR-PR) Based on Controlled  
Outside Diameter
- D3261-15.....Standard Specification for Butt Heat Fusion  
Polyethylene (PE) Plastic Fittings for  
Polyethylene (PE) Plastic Pipe and Tubing
- D3350-14.....Standard Specification for Polyethylene  
Plastics Pipe and Fittings Materials

- E1-14.....Standard Specification for ASTM Liquid-in-Glass Thermometers
- E957-03(2011)e1.....Standard Terminology Relating to Geothermal Energy
- E975-13.....Standard Guide for Specifying Thermal Performance of Geothermal Power Systems
- F714-13.....Standard Specification for Polyethylene (PE) Plastic Pipe (DR-PR) Based on Outside Diameter
- F876-15a.....Standard Specification for Crosslinked Polyethylene (PEX) Tubing
- F877-11a.....Standard Specification for Crosslinked Polyethylene (PEX) Hot- and Cold-Water Distribution Systems
- F1055-15.....Standard Specification for Electrofusion Type Polyethylene Fittings for Outside Diameter Controlled Polyethylene and Crosslinked Polyethylene (PEX) Pipe and Tubing
- F1105-14.....Standard Practice for Preparing Aircraft Cleaning Compounds, Liquid-Type, Temperature-Sensitive, or Solvent-Based, for Storage Stability Testing
- F2080-15a.....Standard Specification for Cold-Expansion Fittings With Metal Compression-Sleeves for Cross-Linked Polyethylene (PEX) Pipe
- F. International Code Council (ICC):
- IBC-15.....International Building Code
- IECC-15.....International Energy Conservation Code
- IMC-15.....International Mechanical Code
- G. International Ground Source Heat Pump Association (IGSHPA):
- #21035-15.....Closed Loop/Geothermal Heat Pump Systems: Design and Installation Standards
- H. International Organization for Standardization (ISO):
- 9001-15.....Quality Management Systems - Requirements
- 14531-2-04.....Plastics pipes and fittings - Crosslinked polyethylene (PE-X) pipe systems for the conveyance of gaseous fuels - Metric series - Specifications - Part 2: Fittings for heat-fusion jointing

15547-1-05.....Petroleum, petrochemical and natural gas industries-Plate-type heat exchangers - Part 1: Plate-and-frame heat exchangers

I. National Fire Protection Association (NFPA):

704-12.....Standard System for the Identification of the Hazards of Materials for Emergency Response

**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 DOWNHOLE PIPING AND SPECIALTIES**

SPEC WRITER NOTE: Take caution when specifying polyethylene piping in high temperature applications. Coordinate pressure rating at design temperatures and product temperature tolerances, including effects on product warranty.

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

B. Polyethylene piping 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.

C. Cross-linked polyethylene piping 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 2014, 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.

SPEC WRITER NOTE: Single-wall heat exchanger are the intent of the relatively high temperature system described in this Section. However, verify with local Authority Having Jurisdiction (AHJ) that double wall vented systems are not required to protect the local resources. Double wall systems are limited in their temperature



and pressure tolerances. Coordinate with AHJ regarding code and certification requirements (e.g. NSF).

### **2.3 DOWNHOLE PLATE-AND-FRAME HEAT EXCHANGER**

- A. Single wall heat exchanger conforming to API 662 and ISO 15547.
- B. Fixed frame with bolted, removable plate assembly.
- C. Plates shall be type 316 or 304 stainless steel arranged for counter flow operation.
- D. Shall not be used for design pressures above 3.00 MPa [435 psig] and design temperatures above 120°C [250°F].
- E. 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, SYSTEM, AND COMPONENTS**

- A. Comply with Section 23 21 23, HYDRONIC PUMPS as well as the additional requirements below.
- B. The circulator wattage for closed loop systems shall not exceed 150 watts/ton.
- C. Proper sizing of the circulating pump shall be within the heat pump manufacturer's required flow rate range for the specified unit.
- D. Particulate contaminants shall be removed from piping system prior to initial start-up.
- E. 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.
- F. 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. Comply with Section 23 21 23, HYDRONIC PUMPS as well as the additional requirements below.
- B. Shall be ISO 9001 certified.
- C. Shall be sized according to manufacturer's guidelines and end user's needs.

- D. Hydronic systems with a total pump power exceeding 10 hp shall be variable flow. 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 2014, 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 704 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. Comply with Section 23 07 11, HVAC AND BOILER PLANT INSULATION.

## 2.8 INSTRUMENTATION

SPEC WRITER NOTE: Either reference the applicable section (A) or specify products herein (A-C).

//A. See Section 23 21 13, HYDRONIC PIPING, for pressure gauge and thermometer requirements.//

//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, do not use monitoring system, due to high initial cost and the labor to maintain it. For projects where a direct-digital control system exists or is otherwise being installed, consider integrating the geothermal system into 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.//

//D. System Controls and Monitoring:

1. Comply with Section 23 09 23, DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC.//

### **PART 3 - EXECUTION**

#### **3.1 INSTALLATION**

- A. Install the geothermal energy 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. Surface discharge shall be compliant per the Environmental Protection Agency (EPA) National Pollutant Discharge Elimination System (NPDES) regulations.//

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

E. Borehole Construction shall be performed per IGSHPA 2014, 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.

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

G. 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.

#### H. 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.

- I. Any penetrations of walls or horizontal assemblies shall be compliant with ICC IBC Section 714.
- J. Instrumentation: Install instruments as recommended by the control manufacturers.// Locate control panels //inside mechanical room//  
//\_\_\_\_\_//.
- //K. Meters shall tie into the building direct digital control system per the requirements of Section 23 09 23, DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC.//

### 3.2 FIELD QUALITY CONTROL

- A. Field Inspection: Prior to initial operation, inspect the geothermal energy 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 //Resident Engineer// //COR//.
  - 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 geothermal energy system, including pumps, controls, controlled valves, and other components in accordance with manufacturer's written recommendations.
  - 3. 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 energy 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 energy 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 energy system, on the dates requested by the //Resident Engineer// //COR//.

**3.5 COMMISSIONING**

- A. Provide commissioning documentation in accordance with the requirements of Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS for all inspection, start up, and Contractor testing required above and required by the System Readiness Checklist provided by the Commissioning Agent.
- B. Components provided under this section of the specification will be tested as part of a larger system. Refer to Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS and related sections for Contractor responsibilities for system commissioning.

---END---