

SECTION 23 81 49
GROUND-SOURCE HEAT PUMPS

PART 1 - GENERAL

1.1 DESCRIPTION

- A. The requirements of this Section apply to all sections of Division 23 related to Ground-Source Heat Pump 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: Systems operations test procedures.
- D. Section 23 07 11, HVAC, PLUMBING, AND BOILER PLANT INSULATION: Insulation products and procedures.
- E. Section 23 21 13, HYDRONIC PIPING: Requirements for water piping to connect to HVAC equipment.
- F. Section 25 10 10, ADVANCED UTILITY METERING SYSTEM: Requirements for connection to AUMS.
- G. Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS: Seismic Restraint of Equipment.

1.3 DEFINITIONS

- A. Unless otherwise specified or indicated, ground source heat pump terms used in these specifications, and on the drawings, shall be defined in AHRI 330.

1.4 QUALITY ASSURANCE

- A. The contractor shall be accredited by the International Ground Source Heat Pump Association (IGSHPA), or an equivalent accreditation or certification from a nationally-recognized association.
- B. Local and state laws and ordinances as they pertain to buried pipe systems shall be strictly followed or a variance obtained.
- C. Installer(s) shall demonstrate that they have successfully installed at least four projects that, in aggregate, equal or exceed the size of the proposed project. References shall be provided for each of these installed projects.
- D. Soil thermal values shall be used in calculating loop length. For horizontal ground heat exchanger applications, determination of the soil's thermal properties with a conductivity test is unnecessary. For larger projects in which the heat exchanger will be installed

vertically, the thermal properties of the soil/rock formation shall be determined by performing a thermal conductivity (in-situ) test per ASTM D5334.

- E. For Heat Pump equipment warranty, furnish five 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 Contracting Officer's Representative (COR).
- B. Contractor shall make all necessary field measurements and investigations to assure that the 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 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 on complete groups.
- F. Shop Drawings: Include heat pump equipment 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 ground-source heat pump system.

1. Geothermal Source Well and Grouts
 2. Ground Heat Exchanger
 3. Ground-Source Heat Pump Unit
 4. Circulation System
 5. Wiring
 6. Wiring Specialties
 7. Valves
 8. Piping and Piping Specialties
 9. Header Assemblies
 10. Heat Transfer Fluid
 11. Heat Exchanger
 12. Insulation
 13. Instrumentation consisting of monitoring systems and control systems compatible with the facility's existing data and control systems.
- 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 Ground-Source Heat Pump System 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 Ground-Source Heat Pump System 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, piping locations, and distribution system 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. Air-Conditioning, Heating, and Refrigeration Institute (AHRI):
330-98.....Standard for Ground Source Closed-Loop Heat Pumps
- C. American National Standards Institute (ANSI):
60-11.....Drinking Water Treatment Chemicals - Health Effects
- D. 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
- E. American Society of Mechanical Engineers (ASME)
B31.1-10.....Power Piping
B40.100-05.....Pressure Gauges and Gauge Attachments
- F. 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

D3261-10a.....Standard Specification for Butt Heat Fusion
 Polyethylene (PE) Plastic Fittings for
 Polyethylene (PE) Plastic Pipe and Tubing

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

D5084-10.....Standard Test Methods for Measurement of
 Hydraulic Conductivity of Saturated Porous
 Materials Using a Flexible Wall Permeator

D5334-08.....Standard Test Method for Determination of
 Thermal Conductivity of Soil and Soft Rock by
 Thermal Needle Probe Procedure

E1-07.....Standard Specification for ASTM Liquid-in-Glass
 Thermometers

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

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

F877-11.....Standard Specification for Crosslinked
 Polyethylene (PEX) Hot- and Cold-Water
 Distribution Systems

- 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
- G. International Code Council (ICC)
IBC-2012.....International Building Code
IECC-2012.....International Energy Conservation Code
IMC-2012.....International Mechanical Code
- H. International Ground Source Heat Pump Association (IGSHPA)
11.....Closed Loop/Geothermal Heat Pump Systems:
Design and Installation Standards
- I. International Organization for Standardization (ISO)
9001-08.....Quality Management Systems - Requirements
13256-1-98.....Water-source heat pumps -- Testing and rating
for performance -- Part 1: Water-to-air and
brine-to-air heat pumps
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

PART 2 - PRODUCTS

2.1 GENERAL

- A. Provide materials to fabricate ground-source heat pump systems in accordance with this section. At the Contractor's option, provide factory-prefabricated ground-source heat pump equipment packages which meet the requirements of this section.

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

4. Of 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 [73.4°F].
5. Of fittings used with PEXa tubing intended for geothermal applications 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 product standard information shall be marked on PEXa tubing and fittings as defined by the appropriate product standard specifications.

2.3 GROUND-SOURCE HEAT PUMP UNIT

- A. Water source heat pumps used in conjunction with ground heat exchangers shall be appropriately ISO 13256 GLHP or GWHP certified.
- B. Provide controls as indicated on drawings.
- C. The maximum and minimum ground heat exchanger system entering temperature shall not exceed the manufacturer's recommendations.
- D. The heat pump load flow (air or fluid) shall be within the manufacturer's specifications.
- E. Shall meet or exceed ENERGY STAR guidelines as necessary to achieve a 30% better energy efficiency than required by ASHRAE 90.1, and display label.
- F. Shall be rated by the Air-Conditioning, Heating, and Refrigeration Institute (AHRI).
- G. Shall have stainless steel condensate pans
- H. Shall have integral power disconnects
- I. Shall have microprocessor digital control units which communicate directly with the facility's existing building automation system
- J. Shall have galvanized steel cabinets
- K. Water-to-Air Unit
 1. Shall have 2" MERV 13 filters.
 2. Shall have braided stainless steel water hose kit connections.

2.4 CIRCULATOR SIZING AND SYSTEM AND COMPONENTS

- A. The circulator wattage for closed loop systems shall not exceed 150 watts/ton.

- B. Proper sizing of the circulating pump shall be within the heat pump manufacturer's required flow rate range for the specified unit. Pumps shall be selected to operate within 5% of maximum efficiency. Circulating system shall also include lead and lag pumps.
- C. Particulate contaminants shall be removed from piping system prior to initial start-up.
- D. 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.
- E. 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 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 ground-source 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. 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 [$+18^{\circ}\text{F}$], 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. Isolation Valves
1. Each incoming loop leg shall be isolatable by manual shut off valves. The main loop supply and return lines shall contain manual or powered isolation valves. There shall be access ports in the main loop supply and return lines to allow for loop flushing.
- I. 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.

2.6 INSULATION

- A. R-5 shall be the minimum insulation for piping handling temperatures greater than 40.6°C [105°F] or less than 13°C [55°F] per IECC R403.3.

2.7 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.

D. Monitoring System:

1. Heat Transfer Fluid Leak Detection: UL-listed system consisting of a sensor probe and LED indicators for water and heat transfer fluid with connection to DDC system.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install the ground-source heat pump system in accordance with this section and the printed instructions of the manufacturer.
- B. Prior to any excavation, trenching, or drilling, all existing buried utilities, drainage, and irrigation systems shall be located and flagged by the appropriate utility and contractor representative.
- C. Vertical Closed Loop Source Well
 1. Borehole Construction
 - a. Loop installation shall be in accordance with IGSHPA Configuration C, and modeling to determine loop lengths shall be in accordance with IGSHPA Configuration B.
 - b. Surface water shall not be used as a source of water during the drilling of a Vertical Closed Loop 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.
 - c. Boreholes shall have a minimum diameter such that it is large enough to accommodate the specified u-bend assembly and tremie pipe (grout pipe). The tremie pipe shall have a minimum nominal diameter of 25.4 mm [1.00 inch].
 - d. When penetrating more than one aquifer, all vertical boreholes shall be grouted bottom to top within 24 hours with a material that is certified by the National Sanitation Foundation International to ANSI/NSF 60 and has a known heat transfer capacity and an adequate sealing characteristic. The grouting material shall be classified as either a pliable (such as a bentonite-based material) or rigid (such as a cement based material) material.

2. Grouting - The following provisions are recommended for grouting (sealing) of the void space between the piping and borehole of a Vertical Closed Loop:
- a. Grouting is to be completed in a manner that prevents the introduction of surface or near surface contaminants into an aquifer, the interchange of water from different aquifers, or the loss of natural artesian pressure from an aquifer.
 - b. The void space between the piping and the borehole shall be grouted in a continuous operation from bottom to top using grout placement procedures set forth in the IGSHPA Grouting for Vertical Heat Pump Systems, Engineering Design and Field Manual, 2000.
 - c. A tremie pipe (grout pipe) not less than 25.4 mm [1.00 inch] nominal diameter shall be placed to the bottom of the borehole before grouting. The tremie pipe may be used to push the closed-loop piping into the borehole and shall be retracted as grouting proceeds. The tremie pipe shall be removed from the borehole upon completion of grouting.
 - d. Grout shall be pumped through the tremie pipe until the density of the grout flowing from the borehole at the ground surface equals the density of the grout being pumped in. Each borehole shall be grouted upon completion. The contractor shall monitor each borehole for settling for a period of not less than 12 hours. Additional grout shall be added and the monitoring period shall be extended until the settling of grout stops.
 - e. A borehole drilled using horizontal directional drilling techniques shall be grouted by pumping grout as the tremie pipe is retracted through the borehole.
 - f. Grout manufacturer's product specifications shall be followed when mixing and pumping grout.
 - g. To minimize potential leaching of chemical constituents into an aquifer, grouts, drilling fluids, and additives to grouts and drilling fluids, including sand added to grout as thermal-enhancer for Vertical Closed Loop applications, shall meet ANSI 60.

- h. The maximum allowable permeability value of the set grout shall be 1×10^{-7} cm per second, as determined in accordance with ASTM D-5084.
- D. Tracer wire shall be installed along entire length of header piping.
- E. Piping installation shall be compliant with ICC IMC Section 1206 with HDPE and joints rated for 300 psig working pressure at geothermal system temperatures.
- F. Pipe Joining Methods
 - 1. The only acceptable methods for joining buried polyethylene pipe systems is heat fusion process 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.
 - a. Heat-Fusion Joints: Joint surfaces shall be clean and free of moisture. Joint surfaces shall be heated to melt temperatures and joined. The joint shall be undisturbed until cool. Fittings shall be manufactured in accordance with ASTM D-2683.
 - b. Electro-fusion Joints: Joint surfaces shall be clean and free of moisture, and scoured to expose virgin resin. Joint surfaces shall be heated to melt temperatures for the period of time specified by the manufacturer. The joint shall be undisturbed until cool. Fittings shall be manufactured in accordance with ASTM F-1055.
 - 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.
- G. 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 inside or accessible.
 4. All indoor piping shall be insulated where condensate may cause damage.
 5. All above ground 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.
 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.

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 COR.
1. Polyethylene piping, tubing, fusion joints and loops shall be pretested before installation per IGSHPA 2011 Section 1E.
 2. Piping Test: Pneumatically test new piping for leakage using air at a pressure of 200% of design 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.
 3. 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 ground-source heat exchange system and associated heat pump system are in good operating condition and properly performing the intended function.
- B. Testing the thermal-transfer capacity of the well field shall be completed prior to demobilizing the well drilling equipment.
- C. Shall pressure test the well field piping to verify no leaks in the system and shall occur prior to backfill or burring and element of the well field. No element of the well field horizontal distribution shall be buried until after acceptance testing via pressure test.

3.4 INSTRUCTION

- A. A complete set of operating instructions for the ground-source heat pump 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, 8-hour training period for instructing personnel in the maintenance and operation of the ground-source heat pump system, on the dates requested by the COR.

---END---