

Closed-Loop/Geothermal Heat Pump Systems Design and Installation Standards 2014



**International Ground Source Heat Pump Association
Oklahoma State University**



Closed-Loop/Geothermal Heat Pump Systems

Design and Installation Standards 2014 Edition

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Closed-Loop/Geothermal Heat Pump Systems: Design and Installation Standards

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FOREWORD

The Closed-Loop/Geothermal Heat Pump Systems Design and Installation Standards manual is intended as a source of minimum standards and guidelines for the design and installation of Closed-Loop/Geothermal Heat Pump Systems. It is a necessary tool for product developers and manufacturers, contractors, architects, engineers, utility representatives, and anyone else concerned with proper and efficient design and installation. It is designed to be an important part of the complete set of guides and manuals available through the International Ground Source Heat Pump Association, including the Residential and Light Commercial design and Installation Manual, Closed-Loop/Ground-Source Heat Pump Systems Installation Guide, Soil and Rock Classification for the Design of Ground-Coupled Heat Pump Systems Field Guide, Grouting for Vertical Geothermal Heat Pump Systems, and the Closed-Loop/Geothermal Heat Pump Systems SLINKY™ Installation Guide.

This manual was developed with funds from members of the International Ground Source Heat Pump Association. Through the strength of its membership, which now numbers over 5,000, IGSHPA has consistently played a vital leadership role in the GHP industry.

The principle reasons for the existence of these standards have always been to ensure quality products and installations, as well as the safety of the consumer. They are generated by IGSHPA's Standard Committee, which consists of representatives from throughout the industry. The standards are subject to peer review for accuracy and completeness. Changes and adaptations to these standards can be made by contacting the Standards Committee through IGSHPA at 1 (800) 626-4747 and following the guidelines in Section 7. This manual is updated periodically to be as current as possible.

These standards are intended to be used for both Commercial and Residential installations unless otherwise referenced in this document.

These standards are intended to cover materials, processes, and procedures for the benefit of the entire industry and for all manufacturers. It is not the intent of the IGSHPA Standards Committee or any affiliated sub-committee to endorse or approve any specific product or brand.

The Standards Committee Mission:

The objective of this committee is to write industry standards that:

- *help protect the environment and our natural resources*
- *help to ensure thermal performance of the critical components of the system, and*
- *are written in such a manner as to allow for new innovations and ideas that might improve the first two objectives.*

Closed-Loop Ground Heat Exchangers

1A. (1996) INSTALLATION PERSONNEL AND TRAINING REQUIRED

- 1A.1 (2000) The Loop contractor, or contractor designate, must have a current IGSHPA accreditation, having completed an IGSHPA training course in the fundamentals of design, installation, and operation of geothermal systems, and having passed the IGSHPA accreditation examination and pipe fusion tests.
- 1A.2 (2005) Ground heat exchanger fabricators must attend an IGSHPA approved heat fusion training in which each participant has performed heat fusion procedures under direct supervision of a qualified IGSHPA heat fusion technician. The fusion technician must be thoroughly familiar with heat fusion procedures, and have had formal training and testing at an IGSHPA approved heat fusion training session under direct supervision of an IGSHPA approved Instructor.
 - 1A.2.1 (2005) Pipe fusion technicians must attend a retraining session every three years. A single failure of a fusion joint will require that the technician attend an additional training session and be retested in order to demonstrate satisfactory performance.
- 1A.3 (1996) Local and state laws and ordinances as they pertain to buried pipe systems shall be strictly followed or a variance obtained.

1B. (1996) DESIGN METHODS AND COMPLIANCE

- 1B.1 (1996) The manufacturer's design procedures must follow a recognized methodology as presented in the most recent editions of:
 - a. (2009) Ground Source Heat Pump Residential and Light Commercial Design and Installation Guide, IGSHPA Publications, Oklahoma State University
 - b. (2014) Geothermal Energy Chapter in the ASHRAE Handbook – HVAC Applications, current edition.
 - c. (2014) Ground-Source Heat Pumps – Design of Geothermal Systems for Commercial and Institutional Building, Kavanaugh and Rafferty, current edition.
 - d. (2014) IGSHPA's Slinky Installation Guide.
- 1B.2 (1996) The ground heat exchanger design must be clearly documented in order to determine compliance with the heat pump manufacturer's and / or utility's specification.
- 1B.3 (2003) 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. Refer to IGSHPA Soil and Rock Classification Manual, and Soil Conservation Service Survey for county/parish data, which can be obtained from the local SCS office.

(2004) For larger, commercial 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.

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- 1B.3.1 (2007) Method as developed and recommended by ASHRAE (American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.) and which can be found in the 2011 ASHRAE Handbook on HVAC Applications, Chapter 34.
 - 1B.3.1.1 (2004) Test durations shall be a minimum of 36 hours.
 - 1B.3.1.2 (2003) The collected data shall be analyzed using the line source method.
 - 1B.3.1.3 (2004) Acceptable power:
 - 1B.3.1.3.1 (2004) The standard deviation of the power shall be less than or equal to 1.5% of the average power.
 - 1B.3.1.3.2 (2004) The maximum variation (spikes) in power shall be less than or equal to 10%.
 - 1B.3.1.3.3 (2004) If 1B.3.1.3.1 or 1B.3.1.3.2 are not met, acceptable results can still be obtained if the maximum deviation of the u-bend loop temperature is less than or equal to 0.5°F (0.28°C) when compared to a trend line of the full data set.
 - 1B.3.1.3.4 (2004) The heat rate supplied to the u-bend loop shall be between 15 and 25 Watts per bore foot (49.2 and 82.0 Watts per bore meter).
 - 1B.3.1.4 (2004) The undisturbed formation temperature shall be measured by observing the temperature of the water as it returns from the u-bend loop to the test equipment at startup. An acceptable alternate method is to directly measure the loop temperature at various depths with a thermocouple probe.
 - 1B.3.1.5 (2003) A minimum delay of five days shall be observed between loop grouting and test startup.
 - 1B.3.1.6 (2004) Minimum test equipment specifications:
 - 1B.3.1.6.1 (2004) Entering/leaving water temperatures shall be measured with $\pm 0.5^{\circ}\text{F}$ ($\pm 0.28^{\circ}\text{C}$) combined transducer-recorder accuracy.
 - 1B.3.1.6.2 (2004) Heat Input rate shall be measured with 2.0% combined trans-recorder accuracy of reading (not full scale accuracy).
 - 1B.3.1.6.3 (2004) Actual u-bend length shall be measured to within $\pm 1\%$ accuracy.
 - 1B.3.1.6.4 (2004) Piping length between the test unit and the u-bend shall be equal to or less than 4 feet (1.22 m) per leg and shall be sufficiently insulated to minimize ambient heat loss.
 - 1B.3.1.6.5 (2004) All hydronic components within the test unit shall be sufficiently insulated to minimize ambient heat loss.
 - 1B.3.1.7 (2004) Test bore diameter should not exceed 6 inches (15.24 cm), and shall be grouted in accordance with IGSHA Standard 2B.1. It is recommended that the minimum grout thermal conductivity should be equal to or greater than 0.75 Btu/hr-ft-°F (1.30 W/m °K).

- 1B.3.1.8 (2004) In the event a test should prematurely fail, the measured u-bend loop temperature shall naturally return to within 0.5°F (0.28°C) of the initial undisturbed formation temperature as measured in 1B.3.1.4.

1C. (1996) GROUND HEAT EXCHANGER MATERIALS

- 1C.1 (2008) The acceptable pipe and fitting materials for the underground portion of the ground heat exchanger is polyethylene, as specified in Section 1C.2 and cross-linked polyethylene, as specified in Section 1C.3.

- 1C.2 (1996) Specifications for the polyethylene heat exchanger are as follows:

- 1C.2.1 (2010) General. All pipe and heat fused materials shall be manufactured from virgin polyethylene extrusion compound material in accordance with 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.

- 1C.2.2 (2007) Material. The material shall have a Hydrostatic Design Basis of 1600 psi (11.03 MPa) at 73°F (23°C) 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.

- 1C.2.3 (1996) Dimensions.

- 1C.2.3.1 (2010) Pipe with a diameter of 2 inches (6.033 cm) (nominal) and smaller shall be manufactured in accordance with ASTM D-3035 with a minimum (based on pressure rating) dimension ratio of 11.

- 1C.2.3.2 (2010) Pipe 3 inches (7.62 cm) (nominal) and larger shall be manufactured in accordance with ASTM D-3035 or F-714 with a minimum (based on pressure rating) dimension ratio of 17.

- 1C.2.3.3 (2007) Table of Working Pressure Ratings of water filled pipe at 73.4°F (23°C) for DR-PR PE 3408/3608 Plastic Pipe

Dimension Ratio	Pressure Rating, psi
9	200
11	160
13.5	128
15.5	110
17	100

- 1C.2.3.4 (2007) Table of Water Pressure Ratings of water filled pipe at 73.4°F (23°C) for DR-PR PE 4710 Plastic Pipe

Dimension Ratio	Pressure Rating, psi
9	252
11	202
13.5	161
15.5	139
17	126
21	101

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Please note that as of the approval date (10/28/07) of 4710, there is a limited number of pipe manufacturers offering a geothermal pipe produced from 4710 material.

- 1C.2.4 (1996) Markings. Sufficient information shall be permanently marked on the length of the pipe as defined by the appropriate ASTM pipe standard.
- 1C.2.5 (1996) Certification Materials. Manufacturer shall supply a notarized document confirming compliance with the above standards (1C.2.1 - 1C.2.4).
- 1C.3 (2008) Specifications for the cross-linked polyethylene heat exchanger are as follows:
- 1C.3.1 (2008) General. Cross-linked polyethylene tubing shall be manufactured by the high-pressure peroxide method (known as PEXa), and shall conform to ASTM Standard Specifications F-876, and F-877 or D-2513, or DIN 16892 and 16893. 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.
- 1C.3.2 (2008) Tubing Material. PEXa material shall be 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.
- 1C.3.3 (2008) Polymer electro-fusion fitting material. Polymer electro-fusion fitting shall be manufactured using a material in accordance to IGSHPA Standard 1C.2.2.
- 1C.3.4 (2008) Dimensions.
- 1C.3.4.1 (2008) PEXa tubing shall be manufactured in accordance to the dimensional specifications of ASTM F-876, and F-877 with a minimum working pressure rating of 160 psi (1.103 MPa) at 73.4°F (23°C).
- 1C.3.4.2 (2008) Table of Working Pressure Ratings of water filled tubing at 73.4°F (23°C) for DR-PR PEX 1006 or PEX 1008 Plastic Pipe
- | Dimension Ratio | Pressure Rating, psi |
|-----------------|----------------------|
| 9 | 160 |
- 1C.3.5 (2008) Fittings. All 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 with ASTM F-1055 or ISO 14531-2 whereas cold-expansion compression-sleeve fittings shall conform with ASTM F-2080, and shall have a minimum inside diameter of 82% of inside pipe diameter.
- 1C.3.6 (2008) Markings. Required product standard information shall be marked on PEXa tubing and fittings as defined by the appropriate product standard specifications.

1D. (1996) PIPE JOINING METHODS

- 1D.1 (2008) 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.

- 1D.2 (1997) Polyethylene pipe shall be heat fused by butt, socket, sidewall or electro-fusion in accordance with the pipe manufacturer's procedures.
- 1D.3 (2008) Polyethylene fusion transition fittings with threads must be used to adapt to copper. Polyethylene fusion transition fittings with threads or barbs must 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 must be accessible.
- 1D.4 (2008) 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.

1E. (1996) FLUSHING, PURGING, PRESSURE AND FLOW TESTING

- 1E.1 (1996) All fusion joints and loop lengths shall be checked to verify that no leaks have occurred due to fusion joining or shipping damage.
- 1E.2 (2014) Each supply and return circuit shall be flushed and purged in the forward and reverse directions with water at a minimum velocity of 2 ft/sec (0.6096 m/sec) through each piping section. Flow must be maintained for a minimum of 15 minutes in each direction to remove all debris and air. To verify that all air is removed from the system, the return water valve to the tank shall be closed. A change in the level of fluid in the purge pump tank during pressurization indicates air still trapped in the system. The heat exchanger system purging shall be completed separately from the building system.
- 1E.3 (2014) Flow rates and pressure drops will be compared to calculated values to assure that there is no blockage or kinking of any pipe. If actual flow rate or pressure drop values differ from calculated design values by more than 10 percent, the problem shall be identified and corrected.
- 1E.5 (2014) Pressure tests for both polyethylene and cross-linked polyethylene pipe shall be conducted in accordance with ASTM F2164, which provides information on apparatus, safety, pre-test preparation, and procedures for conducting field tests of PE and PEX pressure piping systems by filling them with liquid and applying pressure to determine if leaks exist in the system.
 - 1E.5.1 (2014) The maximum test pressure shall be 1.5 times the design static pressure less the elevation hydrostatic head.
 - 1E.5.1.1 (2014) Where the design static pressure is not known, a default value of 100 psi (690 kPa) may be used.
 - 1E.5.1.2 (2014) At no time shall the maximum test pressure exceed the pressure rating of the lowest pressure-rated component of the system.
- 1E.6 (2014) System components or devices with lower pressure ratings than the pipe shall be protected from excessive pressure during testing by removing or isolating them from the system.
- 1E.7 (2014) Pressure-testing of the ground loop to determine if there are any leaks shall be conducted at the following points as a minimum:
 - 1E.7.1 (2014) After each circuit has been assembled, including connection to the boreholes or horizontal loops, and before backfilling; and
 - 1E.7.2 (2014) after the complete ground heat exchanger system has been installed, flushed and purged of air and debris, and before the entire ground heat exchanger system is connected to the building system.

(2014) **EXCEPTION:** Site conditions may dictate backfilling prior to testing with water. A minimum air pressure of 45 psi shall be maintained on the ground heat exchanger during backfilling and until the final pressure test with water can be conducted.

- 1E.8 (2014) The duration of the pressure test shall be no less than 1 hour after the stabilization of pressure. If no visual leakage is observed and pressure test phases remains steady (within 5% of the test phase pressure), a passing test is indicated.

(2013) After the conclusion of the ground heat exchanger pressure test, the ground heat exchanger shall be left filled with clean water and maintained under pressure until final connection to the building system.

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Pipe Placement and Backfilling

2A. (1996) HORIZONTAL PIPING SYSTEMS

- 2A.1 (2000) Sharp bending of pipe around trench corners must be prevented by using a shovel to round corners, or by installing an appropriate elbow fitting. Manufacturer's procedures must be followed.
- 2A.2 (1997) Backfilling procedures will include prevention of any sharp-edged rocks from coming into contact with the pipe by removal of the rocks before backfilling. Use the IGSHPA Slinky backfilling procedures found in IGSHPA's Slinky Installation Guide to assure elimination of air pocket around the pipes.
- 2A.3 (1996) Return bends in narrow trenches must be partially backfilled by hand to properly support the pipes and prevent kinking.
- 2A.4 (1997) All buried GHP pipes in systems containing an antifreeze and passing parallel within 5 feet (1.524 m) of any wall, structure, or water pipe shall be insulated with R2 minimum closed cell insulation.

2B. (1997) BOREHOLES

- 2B.1 (2003) Vertical Boreholes.
 - 2B.1.1 (2009) Vertical boreholes shall have a minimum diameter such that it is large enough to accommodate the specified u-bend assembly and tremie pipe. The tremie pipe have a minimum nominal diameter of 1 inch (2.54 cm).
 - 2B.1.2 (2009) When penetrating more than one aquifer, all vertical bore holes must be grouted bottom to top within 24 hours with a material that is certified by the National Sanitation Foundation International to ANSI/NSF Standard 60, "Drinking Water Treatment Chemicals Health Effects" 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.
 - 2B.1.2.1 (2003) The thermal conductivity of the grouting material shall be determined by using the following method for the specific material classification:
 - 2B.1.2.1.1 (2009) Pliable Materials such as Bentonite-Based Grouts - ASTM D-5334, "Standard Test Method for Determination of Thermal Conductivity of Soils and Soft Rock by Thermal Needle Probe Procedure".

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2B.1.2.1.2 (2009) Rigid Materials such as Cement-Based Grouts - ASTM C-177, “Standard Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded-Hot-Plate Apparatus”

2B.1.2.2 (2003) The hydraulic conductivity (permeability) of the grouting material shall be determined using ASTM D-5084, “Measurement of Hydraulic Conductivity of Saturated Porous Materials using a Flexible Wall Permeameter”.

2B.1.2.2.1 (2003) The maximum allowable permeability value shall be 1×10^{-7} cm/sec or lower if specified by State and/or Local code, regulation or law.

2B.1.2.3 (2004) The thermal and hydraulic conductivity characteristics of the grouting material mixture as specified by the manufacturer shall be independently verified by an “outside the company” laboratory in order to validate compliance to these standards.

2B.1.2.3.1 (2004) The laboratory verifying hydraulic conductivity shall be certified by AMRL (American Association of State Highway & Transportation Officials, Materials Reference Laboratory) and validated by the US Army Corps of Engineers to perform ASTM D-5084 at the time of verification.

2B.1.2.3.2 (2004) Copies of the individual reports shall be made available when requested.

2B.1.2.3.3 (2004) Thermal conductivity shall be determined and verified using the specific mixing instructions and specified additive materials of the manufacturer.

2B.1.3 (2003) Grouting procedures shall follow IGSHPA’s ‘Grouting for Vertical Geothermal Heat Pump Systems, Engineering Design and Field Procedures Manual’ or State or Local codes, whichever are more restrictive.

2B.2 (1997) Horizontal boreholes must have water (and bentonite if used for drilling) injected into the cuttings left in the holes as each drill pipe is pulled out, to keep the hole full so that air pockets cannot be pulled in with the u-bend loop as it is pulled in. An alternative is to enlarge the opening of the exit hole and keep it filled with a water-bentonite slurry.

2C. (1996) POND AND LAKE LOOP SYSTEMS

2C.1 (1996) The GHP manufacturer’s procedures must be followed.

Indoor Piping and Circulation System

3A. (1996) CIRCULATOR SIZING AND SYSTEM AND COMPONENTS

- 3A.1 (1996) The circulator wattage for closed loop systems must not exceed 150 watts/ton.
- 3A.2 (1996) Proper sizing of the circulating pump will be within the heat pump manufacturer's required flow rate range for the specified unit.
- 3A.3 (1996) Particulate contaminants must be removed from piping system prior to initial start-up.
- 3A.4 (2000) Start-up pressurization of the circuit to a minimum of 20 to 30 psi (1.38 - 2.07 bar) when installed in the summer with circulating water temperature of 70 - 90°F (20 - 30°C) and 40 to 50 psi (2.76 - 3.45 bar) when installed in the winter with circulating water temperature of 40 - 50°F (5 - 10°C) 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.
- 3A.5 (1996) The circulation system must 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 must be within two (2) feet (0.6096 m) of the heat pump.
- 3A.6 (1996) Loop charging valve handles must be removed and/or the ports sufficiently plugged to prevent accidental discharge of system fluid and pressure.
- 3A.7 (1996) Boiler-type service valves are not to be used.
- 3A.8 (1996) Transition fittings between dissimilar materials must be inside or accessible.
- 3A.9 (1996) All indoor piping must be insulated where condensate may cause damage.
- 3A.10 (1996) All above ground piping subject to condensation or freezing shall be insulated.
- 3A.11 (1996) All pipes passing through walls shall be sleeved and sealed with non-hardening caulking material.
- 3A.12 (1996) Good quality threaded fittings and a thread sealant specified for use with the antifreeze selected shall be used. Some antifreeze solutions require more fitting torque than others to prevent leaks and corrosion of external surfaces when the antifreeze is exposed to oxygen.

3

3B. (1996) ANTIFREEZE SELECTION AND USE

- 3B.1 (1996) Antifreeze solutions must meet local and state requirements and be acceptable by component manufacturers.
- 3B.2 (1996) All GHP systems must be labeled and identified at the loop charging valves. The labels must be of a permanent type with the following information:
 - a. (1996) Antifreeze type and concentration;
 - b. (1996) Service date;
 - c. (1996) Company name;
 - d. (1996) Company phone number and responsible party or person.

3C. (1996) ANTIFREEZE STANDARDS FOR GHP SYSTEMS

3C.1 (1996) Scope

- 3C.1.1 (1996) Form. This standard is intended to cover corrosion-inhibited, biodegradable, liquid antifreeze materials as received at the job site.
- 3C.1.2 (1996) Application. For use in closed-loop geothermal heat pump systems for the transfer of energy to provide heating and cooling in residential and commercial applications.
- 3C.1.3 (1996) Safety. While these standards attempt to define antifreeze materials characteristics that are safe to the environment and personnel, it is the sole responsibility of the user to become familiar with the safe and proper use of materials provided under these standards and to take necessary precautionary measures to insure the health and safety of all personnel involved.

3C.2 (1996) Technical Requirements

- 3C.2.1 (1996) Material. The composition of the fluid shall be at the option of the manufacturer. The fluid may contain corrosion inhibitors, etc., as required to produce a product meeting the requirement of 3C.2.2.
 - 3C.2.1.1 (1996) Biodegradability. The fluid shall not be less than 90% biodegradable. Results of biodegradability studies conducted in accordance with “Standard Methods for the Examination of Water and Waste Water” of biodegradability and bioassay shall, when requested by purchaser, be provided by the fluid manufacturer to purchaser and shall contain not less than the following information:
 - a. (1996) A statement of ecological behavior of the fluid;
 - b. (1996) The total oxygen demand (TOD) of the fluid, expressed in pounds of oxygen per pound of fluid;
 - c. (1996) The percent of the fluid degraded in five days.
 - 3C.2.1.2 (1996) Corrosion. The fluid shall demonstrate low corrosion to internal surface of all materials commonly found in geothermal heat pump systems.
- 3C.2.2 (1996) Properties. The fluid shall conform to the following requirements, and tests shall be performed in accordance with specified test methods on the fluid:
 - 3C.2.2.1 (1996) Flash Point. Shall not be lower than 194°F (90°C), determined in accordance with ASTM D-92.

3C.2.2.2 (1996) Biological Oxygen Demand. Five days BOD at 10°C (50°F) shall not exceed 0.2 gram oxygen per gram nor be less than 0.1 gram oxygen per gram.

3C.2.2.3 (1996) Freezing Point. Shall not exceed +18°F (-8°C), determined in accordance with ASTM D-1177.

3C.2.2.4 (1996) 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).

3C.2.2.5 (1996) Storage Stability. The fluid, tested in accordance with ASTM F1105, shall show neither separation from exposure to heat or cold, nor show as increase in turbidity.

3C.2.3 (1996) Quality. The fluid, as received by purchaser, shall be homogeneous, uniform in color, and free from skins, lumps, and foreign materials detrimental to usage of the fluid.

3C.3 (1996) Packaging and Identification

3C.3.1 (1996) 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.

3C.3.2 (1996) 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.

3C.3.3 (1996) An up-to-date Material Safety Data Sheet shall be supplied to each purchaser on request and concurrent with each delivery.

Geothermal Heat Pumps

4A. (1996) GEOTHERMAL HEAT PUMPS

- 4A.1 (2009) Water source heat pumps used in conjunction with ground heat exchangers must be appropriately ISO 13256 GLHP or GWHP certified.
- 4A.2 (2009) The maximum and minimum ground heat exchanger system entering fluid temperatures shall not exceed the manufacturer's published literature.
- 4A.3 (2009) The heat pump load flow (air or fluid) must be within the manufacturer's specifications.

4

Site Planning, Records, and Restoration

5A. (1996) PLANNING

- 5A.1 (1996) 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.

5B. (2010) DESIGN RECORDS

- 5B.1 (2010) For commercial applications, the building owner shall provided detailed construction documents which include the following minimum information. This same information is recommended for residential applications.
- 5B.1.1 (2010) Heat pump specifications at rated conditions.
 - 5B.1.2 (2010) Pump(s) specifications, expansion tank size, and air separator.
 - 5B.1.3 (2010) Fluid specifications [system volume, inhibitors, antifreeze concentration (if required), water quality, etc.].
 - 5B.1.4 (2010) Design operating conditions (entering leaving ground loop temperatures, return air temperatures (including wet bulb in cooling), air flow rates and liquid flow rates and calculated pressure drops.
 - 5B.1.5 (2010) Pipe header details with ground loop layout including pipe diameters, spacing, and clearance from a permanent structure, building(s) and underground utilities.
 - 5B.1.6 (2010) Bore quantity, depth, bore diameter and bore spacing.
 - 5B.1.7 (2010) Written verification certifying piping material, visual inspection and pressure testing.
 - 5B.1.8 (2010) Grout/fill specification (thermal conductivity, acceptable placement methods to eliminate any voids).
 - 5B.1.9 (2010) Purge provisions and flow requirements to ensure removal of air and debris without reinjection of air when switching to adjacent sub-header circuits (if applicable).
 - 5B.1.10 (2010) Instruction on connections to building loop(s) and coordination of building and ground loop flushing. All testing to be in compliance with IMC section 1208.1.

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5B.1.11 (2010) Provide Sequence of Operation for controls and System Schematic as required.

5B.1.12 (2010) Provide record (as built) drawings.

5B.2 (2010) The contractor shall provide a certificate describing the specifications and the start-up performance test results of the system as applicable.

5B.3 (1996) Any loop registration program shall conform to IGSHPA specifications.

5C. (1996) RESTORATION

5C.1 (2010) Prior to any excavation, trenching, or drilling, the contractor and owner shall agree in writing to site restoration requirements.

5C.2 (2010) Provide a means for proper underground detection or utility location of the buried pipe system.

Permanent Loop Piping Decommissioning

(2009) There are several cases where it may be necessary to decommission closed loop vertical boreholes or a closed loop borehole system. A reasonably common instance will be a test borehole or boreholes drilled to evaluate a site for a closed loop system. Less frequently, or rarely, it may be necessary to decommission a portion or a full vertical borefield. In the future, situations may arise where a previously decommissioned loop field is breached and will require assessment and re-decommissioning.

(2009) Prior to the abandonment/decommissioning of a borehole/loop the owner or de-commissioning company may be required to obtain the necessary permits from the local or state permitting authority.

(2009) The basic concept governing the proper sealing of the loop piping is to maintain the existing hydrogeologic conditions. Unsealed abandoned loop piping may constitute a hazard to public health, safety, welfare, and to the preservation of the ground water resource. To seal abandoned vertical loop piping properly, several things must be accomplished: (1) removal of heat transfer fluids; (2) prevention of ground water contamination; (3) conservation of yield and maintenance of hydrostatic head of aquifers; and (4) prevention of the intermingling of desirable and undesirable waters.

(2009) Improperly decommissioned vertical loop piping can serve as an uncontrolled invasion point for contaminants. Any vertical loop piping that is to be permanently abandoned should be completely flushed and filled with potable water and capped in such a manner that vertical movement of water within the vertical loop piping is effectively and permanently prevented. If these guidelines and state regulations have been followed closely, items (6A.2) and (6A.3) will normally be satisfied.

6A. (2009) PROCEDURES

6A.1 (2009) Loop Pipe Testing, Flushing, and Cleaning - The closed loop system (including the borehole and header piping) should be pressure tested as described in Section 1E to insure system integrity. If there are leaks in the loop pipe or the system, all leaks must be isolated and sealed according to section 6A.3 or in accordance with state and local regulations.

(2009) Flushing of the loop piping prior to decommissioning is necessary. It may be advisable, or even required by state or local regulations, to submit a sample of the loopfield fluid for quality testing. Loop fluids that contain anti-freeze or other additives should be captured and disposed of according to local, state, or federal requirements.

6A.2 (2009) Permanent Loop Fluid - At the point in time that the decommissioning company and/or the appropriate regulatory agency reasonably believe that the contaminants from the system are purged, the loop fluid should be displaced with potable water. Additional additives, such as a chlorinating agent, may be required by state and local jurisdictions. For both the owner's benefit and the decommissioning contractor's benefit, a sample of the final abandonment solution should be submitted for quality testing and the results recorded.

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- 6A.3 (2009) System Seal - Piping in test boreholes and isolated vertical borehole piping should be cut off at least five feet underground and sealed with permanent fusion caps. Decommissioned systems without leaks should have all reasonably accessible laterals sealed with a permanent fusion cap.

(2009) If a leak is discovered in a vertical loop it is recommended that the loop be isolated from the system, and filled with grout.

- 6A.4 (2009) Grout Materials - If, for any reason, it appears that the borehole grout seal has been compromised, it may be necessary to assess the breach and re-grout the deficient borehole seal. Grouting materials shall consist of neat cement, high solids bentonite grout, bentonite-cement mixture, or other local or state approved material.

(2009) A typical neat cement consists of a mixture of cement and potable water in the proportion of one bag of Portland cement, ninety-four (94) pounds, ASTM C150, Type I or API-10A, Class A; and five (5) to six (6) gallons of potable water.

(2009) A typical high solids grout consists of a mixture of sodium bentonite and potable water mixed so as to achieve permeability less than 10^{-7} cm/second when installed according to the manufacturer's recommendation.

(2009) A typical bentonite-cement mixture consists of up to five (5) percent bentonite by dry weight (five (5) pounds of bentonite per ninety-four (94) pound bag of cement).

(2009) Other acceptable grout or sealant mixtures may be appropriate depending on applicable state or local regulations.

- 6A.5 (2009) Annular Grout Placement - During the decommissioning process there may be times when gaps in the borehole annulus surface seal are found. If grouting is part of the decommissioning process it should be pumped independently into each deficiently grouted borehole annulus. This may require locating, excavating, and cutting of the borehole annulus at the field headers. Each deficient borehole annulus shall be pumped in a continuous operation until undiluted grout returns are observed.

6B. (2009) SPECIAL CONDITIONS

(2009) Visual evidence of subsidence (greater than one (1) foot) observed at the ground surface above boreholes shall be excavated to the depth of the top of the boring. An open borehole shall be grouted using a tremie pipe or by surface methods, pending on the depth of the open borehole. The excavation shall be backfilled with native soil.

(2009) If a previously decommissioned loop system is breached the following steps are recommended. If no known contaminant is present, a permanent fusion cap may be used to reseal the system. If potential contaminants are known or suspected to have entered the piping, it is advisable to consider re-purging the damaged portion of the system.

6C. (2009) VERTICAL LOOP PIPING AND HEADER DECOMMISSIONING RECORDS

(2009) All information relative to the decommissioning procedures of the abandoned vertical loop piping and headers shall be prepared and assembled, including any requirements of a state or local regulatory agency, with copies supplied to the respective agency and the owner of the land.

Standards Change Procedure

7A. (2009) PURPOSE

- 7A.1 (2009) The purpose of these rules is to establish procedures for initiating, receiving, studying, challenging, and processing IGSHPA standards changes.

7B. (2009) INITIATING AND PROCESSING OF STANDARDS CHANGES

- 7B.1 (2009) General. Any individual or organization may submit a standards change.
- 7B.2 (2009) Format of Standards Change Submissions. Proposed standards change shall be submitted as follows:
- a. (2009) Each proposed change shall be submitted on separate 8-1/2 inch x 11 inch sheets, typewritten and double-spaced. A single proposal may include revisions to a number of related standard sections.
 - b. (2009) Wording to be deleted shall be shown with a line through such wording.
 - c. (2009) Words to be added shall be underlined.
 - d. (2009) Each change shall be accompanied by a reason. When reference to other related proposals is desired, an appropriate cross-reference shall be included.
 - e. (2009) Variations to this procedure when necessary due to the nature of the proposed change shall be in a manner consistent with the intent of these rules.

7C. (2009) PROCESSING

- 7C.1 (2010) Standards change proposals shall be submitted to each member of the standards committee for study and recommendations. The committee chairperson may assign the proposal to a subcommittee for further review and evaluation.
- 7C.2 (2011) Proposed changes that allow or disallow new specific products or procedures pertaining to the installation, use, or modification of a ground loop heat pump system must be brought before the committee of the whole convening with the requisite quorum as stated in 7D. At that time, the committee may suggest or require changes to the submittal or return the submittal for further information.
- 7C.3 (2011) Submissions for new products must include all relevant data necessary for the committee to evaluate the merits of the specific product(s) including:
- a. (2011) Any applicable quality control information inclusive of any outside Standards that apply to the product such as ARI, ASTM, or other.
 - b. (2011) Independent test data, if appropriate.
 - c. (2011) Appropriate data necessary for field design and/or sizing.
 - d. (2011) Appropriate methods for field installation and maintenance.

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7C.4 (2011) No vote on the proposed change presented under 7C.2 and/or 7C.3 may be taken at the same meeting as the change is presented.

7C.5 (2011) DELAY OF ACTION: After due consideration of the proposed products or procedures, the Committee shall schedule a follow-up meeting to act on said changes. That meeting shall be scheduled no less than thirty days or more than ninety days after the meeting at which the changes were presented. Standard

7D.1.b shall apply to this delayed vote. The following Meeting Procedures shall also apply to this Delayed Action:

- a. (2011) Interested parties may submit appropriate contact information and the Committee shall provide notification of the follow-up meeting so that the interested parties may participate and comment.
- b. (2011) Meeting procedures shall be followed as set forth in Section 7D.
- c. (2011) At this time, the Committee shall follow those procedures as specified in Section 7E.

7D. (2009) MEETINGS

7D.1 (2009) Meeting Procedures

- a. (2011) The standard committee shall meet via teleconference, e-mail, or fax to prepare information for the standards committee meeting.
- b. (2009) The standards committee shall schedule meeting open to the association and/or public of such length and frequency as required to accommodate the work load.
- c. (2011) Prior to conducting business, a minimum quorum shall be established consisting of a simple majority, of the listed members.
- d. (2009) Meeting shall be conducted in accordance with Robert's Rules or Order except as provided in the bylaws or in these rules of procedures.
- e. (2009) A record of the meetings shall be kept.

7E. (2009) STANDARDS COMMITTEE RECOMMENDATIONS AND REPORT

7E.1 (2009) The standards committee shall recommend that one of the following actions be taken on each change proposal: approval, approval as revised, disapproval, or further study. The recommendation shall include a reason and be presented to the advisory council.

7E.2 (2009) Proponents may withdraw submittals at any regularly scheduled meeting. In such an event, the committee may choose to sponsor the proposal.

7F. (2009) ADVISORY COUNCIL ACTION

7F.1 (2009) The IGSHPA Advisory Council shall take one of the above-mentioned actions (see Sections 7E.1) and issue a reason. All transactions relating to the change shall be filed at the IGSHPA executive offices. Records shall be kept for historical reasons.

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