Closed-Loop/Geothermal Heat Pump Systems

Design and Installation Standards 2016

International Ground Source Heat Pump Association
Oklahoma State University

IGSHPA®

Closed-Loop/Geothermal Heat Pump Systems

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Funding for this manual comes from the members of IGSHPA whose contributions are vastly appreciated. Errors in the manuscript may have occurred in spite of our best efforts. Any suggested corrections and/or comments should be made in writing to:

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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 the IGSHPA Standards 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 8. 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.*

1

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.

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 2015 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 ±0.5°F (±0.28°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 ±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 IGSHPA 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

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 electron-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 sittings 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.

2

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".

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 1x10-7 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.

3

Source Water Piping, Circulation, Antifreeze, Water Quality and Treatment

3A. (2016) CIRCULATION SYSTEMS

Circulation systems as referenced in this section includes all piping, fittings, valves, flow centers, and any specialty items included in the source water circuit.

3A.1 Buried Piping
Note: buried piping material specification and installation standards are covered under Section 1.

3A.1.1 (2016) All pipes passing through walls shall be sleeved to prevent damage. The pipe/sleeve interface shall be sealed with non-hardening caulking material or other appropriate durable rubber or flexible material.

3A.2 Interior Piping

3A.2.1 (2016) Transitions between dissimilar piping materials shall be located inside or be accessible at all times of the year and shall not be buried.

3A.2.2 (2016) All above ground pipe shall be specified and installed per the Authority Having Jurisdiction. PVC pipe is not recommended due to incompatibility with some heat pump refrigerants and oils, issues related to expansion and contraction at solvent joints, and impact fracture risk at low temperatures.

3A.2.3 (2016) All above ground and indoor piping subject to condensation or freezing shall be insulated. Closed cell insulation or other appropriate vapor barrier should be used where condensation is a concern. Condensation is possible any time the source water temperature falls below the ambient temperature.

3A.2.4 (2016) Where appropriate, a make-up water fill line shall be provided with appropriate metering, isolation valve, and cross-contamination control. A permanent make-up water fill line should not be plumbed into the closed loop system when the make-up water is of unknown or unacceptable quality, or where dilution of antifreeze may occur. In these cases, a stand-alone fluid make-up or active pressurization system should be substituted.

3A.3 Pumps and Flow Centers

3A.3.1 (1996) Proper sizing of the circulating pump will be within the heat pump manufacturer’s required flow rate range for the specified unit.

3A.3.2 (2016) The pump specified shall be rated by the manufacturer for the maximum and minimum fluid temperatures expected (generally 110 F (43 C) to 20 F (-6.7 C), the maximum system pressure, and the ambient conditions of the installation location.

3A.3.3 (2016) The circulator pump wattage for closed loop systems shall not exceed 120 watts/ton. For commercial projects, the GSHP System Pump Power Benchmarks by Kavanaugh and Rafferty (ASHRAE RP-1674) are recommended:

Table 3.1 GSHP System Pump Power Benchmarks

Installed Pump Power	Power into Pump Motor	Grade	Available Head with 70% Efficient Pump at 3gpm/ton
< 5 hp/100 tons	< 45 W/ton	A	< 46 ft of water
5 < hp/100 tons ≤ 7.5	45 < W/ton ≤ 65	B	46 to 69 ft of water
7.5 < hp/100 tons ≤ 10	65 < W/ton ≤ 85	C	69 to 92 ft of water
10 < hp/100 tons ≤ 15	85 < W/ton ≤ 125	D	92 to 138 ft of water
> 15 hp/100 tons	> 125 W/ton	F	> 138 ft of water
Installed Pump Power	**Power into Pump Motor**	**Grade**	**Available Head with 70% Efficient Pump at 3 L/m-kW**
< 10.5 W_m/kW_t	<13 W_e/kW_t	A	< 140 kPa
10.5 < $W_m/kW_t \leq 16$	13 < $W_e/kW_t \leq 19$	B	140 to 210 kPa
16 < $W_m/kW_t \leq 21$	19 < $W_e/kW_t \leq 25$	C	210 to 280 kPa
21 < $W_m/kW_t \leq 32$	25 < $W_e/kW_t \leq 36$	D	280 to 420 kPa
> 32 W_m/kW_t	> 36 W_e/kW_t	F	>420 kPa

W_m = watts mechanical, W_e= watts electrical, kW_t= kilowatts thermal

3A.3.4 (2016) The circulation system shall maintain at least the minimum NPSHr (net positive suction head required) at the pump inlet per the manufacturer’s specifications. This can be achieved through system static pressurization, or through the use of a flow center that provides a tank and water column at sufficient height to meet the NPSHr.

a) Systems with static pressurization should include a method to maintain loop pressure above the NPSHr at all times. These methods include: 1) an active loop pressurization or fluid make-up system (commonly referred to as a glycol feed system) 2) a properly sized expansion tank 3) an initial pressurization and/or annual inspection program that maintains the required static pressure.

b) Water column style flow centers (commonly referred to as non-pressurized flow centers) shall provide a means to prevent sub-atmospheric pressure inside the tank which reduces the affective NPSHa (net positive suction head available) provided by the water column.

3A.3.5 (2016) Pumps and flow centers shall be installed following the manufacturer’s instructions for location and orientation.

a) Water column style flow centers’ installation shall follow the manufacturer’s recommendation for maximum system piping or component height above the flow center, typically 25-30 ft (7.6-9.1m), and shall not overflow in the event of a leak of a system component at this maximum height

b) Pressurized flow centers and/or pumps should not be installed at the high point of the system.

3A.3.6 (2016) Pumps and/or flow centers shall include isolation valves to allow for replacement of the motor with minimal system fluid loss.

3A.3.7 (2016) Circulation system shall include purge valves to allow the system to be flushed during initial startup. The purge valves should preferably be located between the ground loop and the heat pump allowing 1) separate flushing of the ground loop circuit and the heat pump circuit, and 2) flushing without pushing fluid through the circulators, and 3) installation and flushing of the ground loop prior to the installation of the heat pump.
a) Boiler type service valves shall not be used as flush/purge valves due to the high pressure drop induced by these valves.

3A.3.8 (2016) Pump volutes and valves included in flow centers or installed individually in the circulation system shall be insulated with closed cell insulation to provide protection from condensation in installations where condensation could occur.

3A.4 Pipe Fittings, Valves and Specialties

3A.4.1 (1996) Particulate contaminants shall be removed from piping system prior to initial start-up. Refer to Section 1E and Section 3.C.1.

3A.4.2 (2016) 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 should be located at the “water in” and “water out” connections at the heat pump. If the ports are located at a remote location, the installer shall utilize a correction factor for the pressure drop between the heat pump source water (and load water, as applicable) connections and the test port location based on the piping material utilized. For larger systems, it is also recommended that temperature and pressure testing ports be installed across major system components.

3A.4.3 (1996) Loop charging valve handles shall be removed and/or the ports sufficiently plugged to prevent accidental discharge of system fluid and pressure.

3A.4.4 (2016) Transition fittings between dissimilar piping materials shall be located inside or accessible at all times of the year, and shall not be buried. Fittings shall be compatible with the piping material joined, and the antifreeze selected at the fluid/fitting interface.

3A.4.5 (2016) If threaded joints are included, good quality fittings and a thread sealant specified for use with the piping material and 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.

3A.4.6 (2016) An expansion tank shall be provided, if required. The expansion tank shall be constructed of material compatible with the loop fluid, and should be installed in manner to prevent condensation formation on the tank. A thermal break between the plumb-in point and the tank, or complete insulation of the tank with a closed cell insulation should be provided where condensation is possible.

3A.4.7 (2016) An air separator should be provided for continuous air removal and to improve the longevity of the system.

3A.4.8 (2016) Y-strainers shall be provided at the inlet or “Source In” side of all heat pumps of brazed-plate heat exchanger design as recommended by the heat pump’s manufacturer. For all other systems, in lieu of a Y-strainer, a combination air-dirt separator or other means of particulate removal should be considered. Y-strainers shall be cleaned prior to the start-up of the system.

3

3A.5 System Preparation

3A.5.1 (2016) The minimum start-up static pressure of a newly installed ground loop system measured at the system fill point shall be equal to the sum of the pump's NPSHr plus the pressure required to fill the system to its highest elevation plus a factor of safety of 5 psig (34.5 kPa) [NPSHr + water column pressure + 5 psig (34.5kPa)]. Additional system static pressure at start-up may be applied to alleviate eventual pressure drop due to the expansion and relaxation of the HDPE earth loop heat exchanger. In general, a start-up static pressurization of 30-50 psig (207-345 kPa) is recommended.

3A.5.2 (2016) The maximum start-up static pressure of a newly installed ground loop is limited by the working pressure rating of each component including pumps, valves, and the piping material used. The maximum pressure at any point in the system shall be no greater than the working pressure rating of each component at the point of installation in the system minus the dynamic pressure generated when the system pumps are operating Borehole depth should be considered when determining maximum system static pressure.

3A.5.3 (2016) System static pressure should be maintained at or above the minimum value calculated in 3A.5.1 for the life of the system.

3A.5.4 (2016) Water column style flow centers (commonly referred to as non-pressurized flow centers) are excluded from these static pressurization requirements.

3B. (2016) WATER QUALITY

3B.1 (2016) Water quality for closed-loop, ground-source heat pump piping shall minimize corrosion, scale buildup, and biological growth to promote optimum system efficiency without creating a hazard to operating personnel or the environment.

3B.2 (2016) A water quality analysis of the source water which will be used as the water component of the heat transfer circulation fluid should be performed. From this analysis, the baseline water quality will be determined in addition to any required water treatment procedures to follow. Water quality shall be maintained through monitoring and testing processes as deemed necessary. Where other regulations or specification do not exist, commercial systems should be checked annually and residential systems every five (5) years, minimum. In general, use of demineralized water is recommended.

Water quality shall meet equipment or component manufacturers' specifications. If no specification is provided. Typical values for suitable water quality are as follows:

- Typical pH Range: 7.0-8.5
- Total dissolved Solids (TDS): 10 - 1000 ppm
- 10 – 30 ppm for demineralized water
- Turbidity: <15 NTU
- Hardness: < 150 ppm
- Chlorides: Depends on Heat Exchanger/Piping Material
  - < 20 ppm for copper
  - <125 ppm for 90/10 Cupro-Nickel
  - <125 ppm for 316 Stainless Steel
- Sulphates: <125 ppm
- Ammonium: <2 ppm
- Free Chlorine: <0.5 ppm
- Hydrogen Sulfide: <0.5 ppm
- Free Carbon Dioxide: <50 ppm
- Nitrate: <0.5 ppm
- Iron (Fouling): <0.2 ppm
- Langelier Index: -0.5 to +0.5

3B.3 (2016) For systems that do not require freeze protection, (e.g. – water only), corrosion inhibitors may be necessary. Refer to Section 3D.1 for guidelines pertaining to corrosion inhibitor selection.

In systems requiring the use of freeze protection, demineralized water may be used in conjunction with the appropriate type and concentration of antifreeze provided that approved corrosion inhibitors are also used. Refer to Section 3D for guidelines pertaining to antifreeze selection.

3B.4 (2016) The external closed-loop, ground-source heat pump piping shall be cleaned, flushed and filled with the heat transfer circulation fluid that is consistent with the products or method of treatment used in the interior piping loop as specified in the design documents, before connection to the building. Fill water quality shall meet manufacturer specifications, or have properties as specified in Section 3B.2. If the fill water quality does not meet the specifications listed, the use of an approved water treatment program, as discussed in Section 3C, shall be used. Flushing and purging procedures shall follow those provided in Section 1E.

3B.5 (2016) Source water, including fill water, shall be filtered to remove suspended solids in order to ensure long-term reliability of the circulation system components, particularly valves and pumps. The level of filtration should be based on the expected exposure in the installation area.

Note: Filtration to 100 microns will remove larger solids such as pipe shavings, gravel, and some sand particles. However, if the loop is installed in an area where the system is exposed to fine sand or clay, further filtration is recommended. Antifreeze manufacturers commonly recommend filtration down to 20 microns.

3C. (2016) WATER TREATMENT AND MONITORING

3C.1 (2016) Numerous methods are available to prevent or correct water quality-related issues. Water treatment shall be based on quality of water available, the material characteristics of all equipment and piping components and functional performance of the treatment system. Water treatment methods shall be consistent with manufacturer recommendations and selected based on economics, maintenance requirements, system size and operating conditions, source water quality, system metallurgy and the training and qualifications of maintenance personnel.

In general, water treatment can be divided into two categories:

- Physical water treatment
- Chemical water treatment

3C.1.1 Physical Water Treatment. Physical water treatment consists of mechanical processes to separate of air, dirt and suspended solids from the circulating fluid. Air and dirt removal devices include strainers, filters and separators.

- Air removal/separation. Methods to remove air from closed-loop piping systems generally include high-point vents or central air separators.

- Dirt removal/separation. Methods to capture and remove dirt from closed-loop piping systems generally include filters, strainers, particle separators, or chemical flocculants. The optimum level of removal can be determined by a particle size analysis of the suspended solids in the fluid. In general, filtration down to 100 microns is recommended. If used, chemical flocculants shall be completed flushed from the system prior to introduction of heat transfer fluid per Section 3D and 3E.

3C.1.2 Chemical Water Treatment. Chemical water treatment consists of the modification or elimination of certain substances in the water to ensure its chemical makeup is suitable for contact with the various components in the system. Chemical water treatment may include the removal of chemical impurities, pH value adjustment, or the addition of antifreeze, corrosion inhibitors, and/or microbial control products, as necessary.

The chosen chemical water treatment shall be compatible with all materials that are used in the system. Chemical water treatments for closed-loop systems are generally comprised of several elements. Refer to the chemical manufacturer's recommendations for proper application and use and ensure that selected chemicals are allowed by the Authority Having Jurisdiction.

3C.2 (2016) When an automatic make-up water system is used, the closed-loop piping system design shall include a water meter or other means to measure the amount of water and/or antifreeze being added to the system. Likewise, when an automatic chemical feeder system is used, provisions shall be made to measure the amount and frequency of chemical addition to the system. Each reading should be recorded and kept to assist in leak detection, verify proper operation and chemical addition levels, etc.

3C.3 (2016) Monitoring is essential to ensure that the water treatment program being applied is adequate. At minimum, water quality shall be tested once per year in commercial systems and once every five years in residential systems to check pH, specific conductance, turbidity, suspended solids, alkalinity, hardness, inhibitor levels, antifreeze levels, as applicable. Refer to Section 3B for water quality recommendations.

3D. (2016) HEAT TRANSFER FLUIDS

Note: This section provides guidance for water-based heat transfer fluids only. For direct exchange systems, see Section 7.

3D.1 (2016) Water-only Systems

For systems that do not require freeze protection, refer to section 3B for water quality requirements.

3D.1.1 For closed-loop systems which are integrated with building piping constructed of materials other than those listed in 1.C Ground Heat Exchanger Materials, corrosion inhibitors may be required. Water treatment chemicals shall meet the local and state requirements. If no guidance is given, use chemicals compliant with NSF Standard 60 Certified Drinking Water Treatment Chemicals.

3D.2 Antifreeze Systems

For systems that require freeze protection, the following requirements are provided.

3D.2.1 (1996) Antifreeze solutions shall meet local and state requirements and be acceptable by component manufacturers.

3D.2.2 (1996) Scope

3D.2.2.1 (1996) Form. This standard is intended to cover corrosion-inhibited, biodegradable, liquid anti- freeze materials as received at the job site.

3D.2.2.2 (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.

3D.2.2.3 (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 installing contractor and the building owner (or his representative) 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.

3D.2.3 (1996) Technical Requirements

3D.2.3.1 (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 3D.2.4.

3D.2.3.1.1 (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.

3D.2.3.1.2 (2016) Corrosion. The fluid shall demonstrate adequate corrosion protection for all materials commonly found in geothermal heat pump systems as determined by ASTM D1384.

3D.2.4 (1996) Properties. The fluid shall conform to the following requirements, and tests shall be performed in accordance with specified test methods on the fluid:

3D.2.4.1 (2016) Flash Point. Shall not be less than 50°F (28°C) above the maximum system operating temperature.

3D.2.4.2 (2016) Biological Oxygen Demand. Five days BOD at 20°C (68°F) shall not exceed 0.25 gram oxygen per gram in accordance with Standard Method 5210B.

Note: The Standard Method 5210B was jointly produced by the American Public Health Association, the American Water Works Association, and the Water Environment Federation

3D.2.4.3 (2016) Freezing Point. Unless the system design specifies otherwise, the freezing point shall not exceed +18°F (-8°C), determined in accordance with ASTM D-1177.

3D.2.4.4 (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).

3D.2.4.5 (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.

3D.2.5 (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.

3D.2.5.1 When adding antifreeze to the purge tank, the antifreeze should enter the tank before the water line. In this way, less air is entrained with the added antifreeze.

3D.3 (1996) Packaging and Identification

3D.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.

3D.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.

3D.3.3 (1996) An up-to-date Safety Data Sheet shall be supplied to each purchaser on request

3D.3.4 (1996) All GHP systems shall be labeled and identified at the loop charging valves. The labels shall 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.

3E. (2016) SOURCE WATER SYSTEM START-UP

3E.1 (2016) Ensure that the external closed-loop, ground source heat pump piping has been filled and purged of air and debris, pressure tested, and filled with proper quality water and heat transfer fluid, if necessary. On a commercial system, this may be completed a period of time prior to the completion of the interior piping system. On residential systems, this may be competed in conjunction with the interior piping system preparation.

3E.1.1 (2016) The flushing/purging flow rate shall completed with a minimum flow rate of 2 feet per second (0.6 m/s) to remove air, but not in excess of the maximum flow velocity recommended by the pipe and fittings manufacturer to remove debris. All sections of the piping system shall be flushed and purged per Section 1E.

Table 3.2 Flow Rates for water to achieve 2 ft/sec (0.6m/s) in common HDPE Pipe Sizes

MIMINUM FLUSHING FLOW RATE FOR WATER IN HDPE PIPE		
HDPE Nominal Pipe Size in (mm)	Flow rate gpm (l/s)	
	DR-11	DR-17
¾ (19)	3.6 (0.23)	4.2 (0.26)
1 (25)	5.7 (0.36)	6.6 (0.42)
1-1/4 (32)	9.0 (0.57)	10.5 (0.66)
1-1/2 (38)	11.8 (0.74)	13.8 (0.87)
2 (50)	18.5 (1.17)	21.5 (1.36)
3 (75)	40.1 (2.53)	46.7 (2.95)
4 (100)	66.4 (4.19)	77.2 (4.87)
6 (150)	144 (9.08)	167 (10.54)
8 (200)	244 (15.39)	284 (17.92)
10 (250)	379 (23.91)	440 (27.76)
12 (300)	533 (33.63)	620 (39.12)

For other fluids, pipe materials, sizes, and DR values, the minimum flow rate should be calculated.

3E.2 (2016) Interior piping system shall be filled with water and flushed of air and debris.

3E.3 (2016) Interior piping system shall be hydrostatically pressure tested to ensure no leaks are present in the piping system. Particular attention should be made inspecting connections between piping segments, valves, and unit connections.

3E.3.1 Hydrostatic test pressure shall be per Section 1E.

3E.4 (2016) Interior piping system shall be cleaned to ensure that the fluid system is free from flux, oil, chemicals, or any other foreign material that may contaminate or damage the system.

3E.4.1 If metallic piping is used in the system, a cleaning solution compatible with all wetted materials should be used to clean the system

3E.5 (2016) Cleaning water/solution should be replaced by displacement with the final heat transfer fluid, including antifreeze, if required. The heat transfer fluid shall be of the recommended quality (see section 3B).

3E5.1 Antifreeze solution used for interior piping system shall be of the same type, quality, and ratio as the antifreeze solution in the external piping. To prevent reactions between chemicals, the antifreeze used in the interior piping systems should preferably be sourced from the same manufacturer as used in the external piping.

3E.5.2 When adding pure propylene glycol or other viscous antifreeze by displacement to the water in the loop system, thorough mixing per the manufacturer's instructions is required prior to system start up

3E.5.2.1 The antifreeze concentrations should be measured and recorded using repeated tests. The fluid is considered thoroughly mixed when the required concentration stabilizes over multiple measurements. Each test sample should be taken after the fluid has passed from the loop through the mixing tank a minimum of ten (10) times. The time between sample collection can be calculated by dividing the total loop volume by the mixing flow rate.

3E5.2.2 The concentration should be measured by an appropriate instrument based on the type of antifreeze used. Refractometers and hydrometers are commonly used.

3E.5.2.3 The thoroughly mixed concentration level shall equal the concentration level specified for the system based on the level of freeze protection required.

3E.6 The exterior and interior piping systems should be coupled by opening the isolation valves between the two systems.

3E.6.1 Flushing the combined system with a minimum velocity of 2 ft/sec (0.6m/s) to remove air may be required when coupling the two systems introduces air, and when air elimination devices are not present in the system.

3E.7 The combined system should be pressurized as described in Section 3A.5.

4

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.

5

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.

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.

6

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 bore-field. In the future, situations may arise where a previously decommissioned loop field is breeched 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.

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.

7

DIRECT GEOEXCHANGE EARTH LOOP SYSTEMS

In addition to the following please refer to ANSI/CSA C448 Series-16 "*Design and installation of ground source heat pump systems for commercial and residential buildings*" to provide additional guidance.

7A. Closed-Loop Ground Heat Exchangers

7A.1 (2016) Installation Personnel and Training Required

7A.1.1 (2016) 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.

7A.1.2 (2016) The Loop contractor, or contractor designate, must have successfully completed and passed the manufacturer's system installation training course which includes earth loop installation, service and decommissioning procedures.

7A.1.3 (2016) The Loop contractor, or contractor designate, installing earth loops shall be trained and current in brazing techniques by a recognized trades training organization.

7A.1.4 (2016) The Loop contractor, or contractor designate, shall be (1) a licensed HVAC contractor; and (2) licensed in accordance with the rules of the authority(ies) having jurisdiction in the geographic area where the contractor provides services.

7A.1.5 (2016) Local and state laws and ordinances as they pertain to buried refrigerant pipes in underground earth loop systems shall be strictly followed or a variance obtained.

7A.2 (2016) Design and Installation Methods and Compliance

7.A.2.1 (2016) The specific earth loop configuration shall be designed consistent with the land area available, local code requirements, site geology, and system performance requirements. Follow manufacturer's instruction regarding the type of soil and geology that are compatible with the installation of earth loops.

7.A.2.2 (2016) It is the responsibility of the Loop contractor, or contractor designate to ensure the compatibility of the soil with the earth loop in accordance with manufacturer's instruction. Soil samples in the earth loop field may be required. Soil samples shall be analyzed and documented for pH and other corrosive soil contaminants in accordance with the manufacturer's printed instructions. If soil samples are required, design and installation of the earth loop field shall not proceed until the test results for the soil samples are available and provide evidence of acceptable site conditions.

7

7.A.2.3 (2016) The ground loop should be installed according to the equipment manufacturer's instructions. General guidelines for installing and testing the loop are as follows.

7.A.2.3.1 (2016) Earth loops shall be seal tested as described in section 7A.5.

7.A.2.3.2 (2016) Horizontal earth loop systems shall be at least 5 feet below grade or 1-1/2 feet below the local frost line, whichever is deeper.

7.A.2.3.3 (2016) For all earth loop systems, the line sets and manifolds shall be at least 5 feet below grade or 1-1/2 feet below the local frost line, whichever is deeper.

7.A.2.4 (2016) The selected earth loop configuration must be matched to the appropriate compressor bearing unit in accordance with the manufacturer's published design instruction and must be clearly documented with regard to size, configuration, and detailed location.

7.A.2.5 (2016) Bored vertical and horizontal earth loops shall be grouted with a grout approved by the authority(ies) having jurisdiction and by the heat pump manufacturer. The grout mixture shall surround the earth loop over its full length. The grout mixture must be compatible with the earth loop heat exchanger material to ensure lasting system integrity.

7.A.2.6 (2016) An earth loop cathodic protection system is to be applied to the earth loop system in accordance with the manufacturer's instructions.

7A.3 (2016) Earth Loop Heat Exchanger Materials

7A.3.1 (2016) Earth loop heat exchanger and line set tubing shall be type ACR (Air Conditioning & Refrigeration Tubing) copper, or a material equivalent or better, with diameter and length dimensions specified by the manufacturer. For practical purposes, copper will be considered the material of the Earth Loop Heat Exchanger in the entire Section 7 of this standard.

7A.3.1.1 (2016) Type ACR tubing shall meet standard ASTM B-280.

7A.3.1.2 (2016) Tube dimensions and pressure values are specified in The Copper Tube Handbook, published by the Copper Development Association, Inc., www.copper.org.

7A.3.2 (2016) Brass distributors or manifolds that are part of the earth loop system shall meet, as a minimum, material standards UNS No. C36000 and ASTM B249.

7A.4 (2016) Earth Loop Connection Method

7A.4.1 (2016) Copper–to-copper and copper-to-brass joints are to be joined by brazing as described in 7A.4.2 and 7A.4.3 or by using mechanical connections compatible with copper-to-copper tube connection.

7A.4.2 (2016) Brazing material shall be 15% silver brazing alloy.

7A.4.3 (2016) All brazing shall be done utilizing the nitrogen brazing process. This method displaces oxygen with nitrogen, eliminates carbonization inside the earth loop joint being brazed, and maintains cleanliness within the earth loop system.

7A.5 (2016) Leak Checking

7A.5.1 (2016) When the earth loop system is installed, after joints are brazed, and prior to connecting (and brazing) it to the HVAC system compressor bearing unit, and backfilling, the earth loop system shall be checked to determine if it is sealed.

7A.5.2 (2016) The earth loop system is to be pressurized to a minimum of 315 psig with dry nitrogen.

7A.5.2.1 (2016) Check for leaks with an ultrasonic leak detector, bubble solution leak detector or an electronic leak detector to determine if there is a leak.

7A.5.2.2 (2016) If a leak occurs, depressurize the system, repair the leak, re-pressurize the system and check again for leaks.

7A.5.2.3 (2016) Valve off the nitrogen source and monitor the earth loop pressure and ensure that the 315 psig pressure is maintained for a minimum of 8 hours.

7B. (2016) Earth Loop Placement and Backfilling

7B.1 (2016) Placement and Backfilling

7B.1.1 (2016) Follow the manufacturer's printed instructions regarding the placement of earth loops regarding depth and configuration of earth loops, spacing of refrigerant lines, pitch of the trench, etc.

7B.1.2 (2016) Backfill materials should be free from any material that may damage the heat exchanger pipes. This includes frozen lumps, organic matter, refuse, ashes, sharp-edged rocks and boulders over 12in in any dimension.

7B.1.3 (2016) All buried earth loop and line set tubing passing parallel to a wall, structure, or water line shall be separated by a minimum of at least 10 feet. If the tubing is insulated using R3 minimum closed cell elastomeric pipe insulation with a minimum wall thickness of 1/2 inch, the distance can be reduced to a minimum of 5 feet.

7B.2 (2016) Horizontal (Trenched) Earth Loops

7B.2.1 (2016) Follow the manufacturer's printed instructions regarding the placement of horizontal earth loops regarding depth and configuration of earth loops, spacing of refrigerant lines, pitch of the trench, etc.

7B.2.2 (2016) Avoid sharp-edged rocks or other materials from coming into contact with the earth loop tubing as it is placed in the trench, and during the backfilling processes. Ensure good contact between the earth loop and the surrounding backfill. When the composition of the backfill is such that it does not make continuous and full contact with the earth loop, the partially covered earth loop should be soaked with water to accelerate the settling and compaction process.

7B.3 (2016) Horizontal (Boreholed) Earth Loops

7B.3.1 (2016) Horizontal boreholes are to be drilled and earth loops placed in accordance with the manufacturer's printed instructions.

7B.3.2 (2016) 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 earth 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.

7B3.2.1 (2016) When penetrating more than one aquifer, all horizontal boreholes must be grouted bottom to top within 24 hours with a grout 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 adequate sealing characteristics. The grouting material shall be classified as pliable (such as bentonite-based grout) or rigid (such as cement-based grout).

7B.4 (2016) Vertical (Boreholed) Earth Loop

7B.4.1 (2016) Vertical boreholes shall have a minimum diameter such that it is large enough to accommodate the specified earth loop and tremie pipe. The tremie pipe shall have a minimum nominal diameter of 1 inch.

7B.4.2 (2016) When penetrating more than one aquifer, all vertical boreholes must be grouted bottom to top within 24 hours with a grout 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 adequate sealing characteristics. The grouting material shall be classified as pliable (such as bentonite-based grout) or rigid (such as cement-based grout).

7B.5 (2016) Thermal Grout

7B.5.1 (2016) Thermal grout shall be selected consistent with the manufacturer’s printed instructions – including but not limited to instructions regarding thermal conductivity levels and pH levels –, geology of the site, and state and local regulations.

7B.5.2 (2016) Thermal grout shall be mixed and applied in accordance with the grout manufacturer’s printed instructions or state and local regulations, whichever is more restrictive.

7B.5.3 (2016) Thermal conductivity and permeability of the grouting material will be determined based on the grout manufacturer’s batch mix instructions.

7B.5.4 (2016) If it is necessary to validate compliance with state or local regulations, thermal conductivity and permeability of the selected grout (mixed per the grout manufacturer’s instructions) shall be independently verified by a third party laboratory 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. Copies of the individual reports shall be made available when requested.

7C. (2016) Earth Loop System Start-Up Procedure

7C.1 (2016) The earth loop system is connected to the refrigerant compressor bearing unit by means of a line set, comprised of a copper liquid line and a copper vapor line. The following describes the system start-up procedure (evacuation and charging) as it affects the earth loop system.

7C.2 (2016) The earth loop line set is connected and brazed to the appropriate ports on the compressor bearing unit utilizing the nitrogen brazing process (Section 7A.4.).

7C.3 (2016) The complete system (HVAC components and earth loop system) shall be pressurized to a maximum of 150 psig with dry nitrogen and leak checked (Sections 7A.5.2.1 and 7A.5.2.2).

7C.4 (2016) The system shall be evacuated utilizing a high quality vacuum pump with a capacity of at least 7 cfm until internal pressure of the refrigeration system is no more than 400 microns, read on a digital micron gage.

7C.5 (2016) The vacuum pump is isolated from the system. The system pressure must not exceed 500 microns within 15 minutes after isolation of the vacuum pump.

7C.6 (2016) When the criteria in Section 7C.5 are met, the system shall be charged with refrigerant in accordance the manufacturer’s printed instructions. If the criteria in Section 7C.5 are not met, the evacuation process shall be repeated.

7D. (2016) Direct GeoExchange Heat Pump System

7D.1 (2016) The compressor bearing unit of Section 7C.1 contains a refrigerant compressor, mechanical and electrical controls, and a refrigerant distribution system connected to one or more of the following indoor components: (1) air handler (for a forced air system), (2) hydronic water module (for a hydronic system), and (3) heat recovery module for domestic water heating. These indoor components shall be packaged in one or more enclosures.

7D.2 (2016) The compressor bearing unit shall be performance listed by AHRI Standard 870 (latest edition) in accordance with ANSI/ASHRAE Standard 194 (latest edition) and safety listed by an industry recognized safety standards organization.

7D.3 (2016) Other system components supplied by the manufacturer of the compressor bearing unit shall be safety listed by an industry recognized safety standards organization.

7D.4 (2016) Optional field specified and supplied components shall be safety listed by an industry recognized safety standards organization.

7E. (2016) Site Planning, System Design Records, and Site Restoration

7E.1 (2016) Site Planning prior to any excavation trenching or drilling

7E.1.1 (2016) All applicable local and state regulations regarding excavation, trenching or drilling restrictions must be verified with the appropriate agencies.

7E.1.2 (2016) All appropriate permits, variances, inspection forms, etc. shall be completed and approved by the appropriate agencies.

7E.1.3 (2016) All buried utilities (including impressed current systems), drainage, and irrigation systems shall be located and flagged by the appropriate utility and Loop contractor representative, or contractor designate.

7E.1.4 (2016) The Loop contractor representative or contractor designate should gain approval by the local utilities prior to installing the cathodic protection system.

7E.2 (2016) System Design Records

The following System Design Records shall be maintained by the Loop contractor, or contractor designate, in documented form.

7E.2.1 (2016) Plan view (dimensioned) of site with boundaries including all items in Section 7E.1.3 and all permanent structures identified and illustrated.

7E.2.2 (2016) Plan view (dimensioned) of the earth loop system overlaid on the plan view in section 7E.2.1.

7E.2.3 (2016) Earth loop system manifold locations (as appropriate) shall be triangulated with respect to a permanent structure; or, if a permanent structure is not available, manifolds can be located using GPS coordinates or underground detectable utility marking tape.

7E.2.4 (2016) Earth loop protection system anode location (as appropriate) shall be triangulated with respect to a permanent structure.

7E.2.5 (2016) Compressor Unit model number and serial number, Earth Loop model number and (as appropriate) Earth Loop Protection System model number.

7E.2.6 (2016) Soil analysis, including pH (as appropriate), conducted by licensed materials testing laboratory.

7E.2.7 (2016) Documented results of pressurized leak test conducted on earth loop system.

7E.2.8 (2016) Record of number of bores, bore diameter and depth, and bore spacing.

7E.2.9 (2016) Record of thermal grout type, mix composition, thermal conductivity, and placement method.

7E.2.10 (2016) The Loop contractor, or contractor designate, shall provide necessary documented information for commissioning and/or registering the earth loop system.

7E.3 (2016) Restoration

7E.3.1 (2016) Prior to any excavation, trenching, or drilling, the Loop contractor, or contractor designate, and owner shall agree in writing to site restoration requirements.

7E.3.2 (2016) The Loop contractor, or contractor designate, shall provide the owner as- installed documented information (Section 7E.2.2) for the location of the earth loops, manifolds, and line set.

7F. (2016) Permanent Earth Loop Decommissioning

It may become necessary to decommission an individual vertical or horizontal earth loop. The following also applies to decommissioning entire earth loop systems.

Prior to decommissioning an earth loop, the Loop contractor, or contractor designate, or owner may be required to obtain the necessary permits from local or state permitting authorities.

The primary purpose for the proper sealing of an earth loop is to maintain the existing hydrogeological conditions.

7F.1 (2016) Earth Loop Sealing

To seal an earth loop properly, the refrigerant must be removed from the earth loop and appropriate steps must be taken to prevent ground water contamination. The procedure is as follows:

7F.1.1 (2016) Isolate and recover all refrigerant from the earth loop, consistent with local and state regulations for environmental protection, and known to authorized and trained HVAC service technicians.

7F.1.2 (2016) Cut the appropriate earth loop vapor and liquid tubes at least 12 inches from the manifolds, and at least 5 feet underground.

7F.1.3 (2016) With pressurized dry nitrogen, blow out the earth loop to expel any residual lubricant.

7F.1.4 (2016) Mix and fill the earth loop completely with grout, pumping the grout mixture into the vapor tube and observing a steady flow of grout coming out of the liquid tube to ensure complete filling of the earth loop.

7F.1.5 (2016) Grouting materials shall consist of neat cement, high solids bentonite, bentonite-cement mixture, or other local or state-approved material.

7F.1.5.1 (2016) 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 1, or API-10A, Class A; and five (5) to six (6) gallons of potable water.

7F.1.5.2 (2016) 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/sec when installed according to the manufacturer's recommendation.

7F.1.5.3 (2016) 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].

7F.1.5.4 (2016) Other acceptable grout or sealant mixtures may be appropriate depending on applicable state or local regulations.

7F.1.6 (2016) After the earth loop is completely filled with grout (Section 7F.1.4), pinch off the vapor and liquid tube and braze shut with 15% silver alloy braze material. Cover the tube ends with native earthen fill.

7F.1.7 (2016) If an entire earth loop system is to be decommissioned, the procedure described in Sections 7F.1.1 through 7F.1.6 is repeated for each earth loop in the system.

7F.1.8 (2016) In addition, when an entire earth loop system is being decommissioned, the manifolds are removed and the line set is cut at each end (at the underground depth of the line set) and removed or filled with grout, pinched off, and brazed.

7F.2 (2016) Special Conditions

7F.2.1 (2016) 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, depending on the depth of the open borehole. The excavation shall be backfilled with native earthen fill.

7F.3 (2016) Decommissioning Records

7F.3.1 (2016) All information relative to the decommissioning procedures of the abandoned earth loop(s) or earth loop system, shall be documented, prepared, and assembled, including any requirements of a state or local regulatory agency, with copies supplied to the respective agency and owner of the land.

8

Standards Change Procedure

8A. (2009) PURPOSE

8A.1 (2009) The purpose of these rules is to establish procedures for initiating, receiving, studying, challenging, and processing IGSHPA standards changes.

8B. (2009) INITIATING AND PROCESSING OF STANDARDS CHANGES

8B.1 (2009) General. Any individual or organization may submit a standards change.

8B.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.

8C. (2009) PROCESSING

8C.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.

8C.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 8D. At that time, the committee may suggest or require changes to the submittal or return the submittal for further information.

8C.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.

8C.4 (2011) No vote on the proposed change presented under 8C.2 and/or 8C.3 may be taken at the same meeting as the change is presented.

8C.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
8D.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 8D.
c. (2011) At this time, the Committee shall follow those procedures as specified in Section 8E.

8D. (2009) MEETINGS

8D.1 (2009) Meeting Procedures
a. (2011) The standard committee shall meet via teleconference or e-mail, 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.

8E. (2009) STANDARDS COMMITTEE RECOMMENDATIONS AND REPORT

8E.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 IGSHPA Board of Directors.

8E.2 (2009) Proponents may withdraw submittals at any regularly scheduled meeting. In such an event, the committee may choose to sponsor the proposal.

8F. (2016) BOARD ACTION

8F.1 (2016) The IGSHPA Board of Directors shall take one of the above-mentioned actions (see Sections 8E.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.