PPFA Plastic Pipe and Fittings Association

PUBLICATIONS | USER BULLETIN 19-12

# Recommendations for Geothermal Ground Loop Piping Systems

Published by the
Plastic Pipe and Fittings Association
800 Roosevelt Road
Building C, Suite 312
Glen Ellyn, Illinois 60137
ppfahome.org

*Heat pumps that utilize water-based geothermal ground loops are promoted in multiple green and sustainable rating systems, standards and codes. These systems use plastic pipe for the ground heat exchange and are expected to increase in popularity. Currently, the building codes offer the contractor and code inspector little to no guidance on material selection and basic installation. The following is offered as a guide, until the codes properly address the issue. You are also expected to verify material selection and installation issues with the manufacturer and check local code requirements.*

## GENERAL

Geothermal systems use the relatively stable and moderate temperatures underground as a heat sink in cooling climates or seasons and as a heat source in heating climates or seasons and are more efficient than air exchange heat pump systems.

While the majority of the systems use polyethylene piping with heat-fused joints, other products can be utilized. Consult this User Bulletin, the product manufacturers, IGSHPA Standards, CSA C448 and the Authority Having Jurisdiction for applicable materials.

Geothermal system piping layouts should be designed by a registered design professional.

## Section 1: MATERIAL

**1.1 Geothermal Ground-Loops.** Geothermal ground-loop piping and tubing material for water-based systems shall conform to the standards cited in this section.

**1.2 Used materials.** Reused pipe, fittings, valves, or other materials shall not be permitted in geothermal ground-loop systems.

**1.3 Material rating.** Pipe and tubing shall be rated for the operating temperature and pressure of the geothermal ground-loop system. Fittings shall be suitable for pressure applications and recommended by the manufacturer for installation with the pipe and tubing material installed. If used underground, materials shall be suitable for burial.

**1.4 Piping and tubing materials standards.** Geothermal ground-loop pipe and tubing shall conform to the standards listed in Table 1.4.

TABLE 1.4
GEOTHERMAL GROUND LOOP PIPE and TUBING

| MATERIAL | STANDARD |
|---|---|
| Chlorinated polyvinyl chloride (CPVC) | ASTM D2846; ASTM F441; ASTM F442 |
| Cross-linked polyethylene (PEX) | ASTM F876; ASTM F877 CSA B137.5; AWWA C904 |
| Polyethylene/aluminum/ polyethylene (PE-AL-PE) pressure pipe | ASTM F1282; CSA B137.9 |
| High Density Polyethylene (HDPE) | ASTM D3035; ASTM D2737; ASTM F714; AWWA C901; CSA B137.1; CSA C448 |
| Polypropylene (PP-R) | ASTM F2389; CSA B137.11 |
| Polyvinyl chloride (PVC) | ASTM D1785; ASTM D2241 |
| Raised temperature polyethylene (PE-RT) | ASTM F2623 |

**1.5 Fittings.** Geothermal pipe and tubing fittings shall be recommended for installation with the piping materials to be installed and suitable for use under-

ground if buried, and shall conform to the standards listed in Table 1.5.

| TABLE 1.5 GEOTHERMAL GROUND LOOP PIPE and TUBING FITTINGS | |
|---|---|
| PIPE MATERIAL | STANDARD |
| Chlorinated polyvinyl chloride (CPVC) | ASTM D 2846; ASTM F437; ASTM F438; ASTM F439; CSA B137.6 |
| Cross-linked polyethylene (PEX) | ASTM F 877; ASTM F1807; ASTM F 1960; ASTM F 2080; ASTM F2159; ASTM F2434; CSA B137.5 |
| Polyethylene/aluminum/polyethylene (PE-AL-PE) | ASTM F 2434; ASTM F1282, CSA B137.9 |
| High Density Polyethylene (HDPE) | ASTM D2683; ASTM D3261; ASTM F1055; CSA B137.1; CSA C448 |
| Polypropylene (PP-R) | ASTM F2389; CSA B137.11 |
| Polyvinyl chloride (PVC) | ASTM D2464; ASTM D2466; ASTM D2467; CSA B137.2; CSA B137.3 |
| Raised temperature polyethylene (PE-RT) | ASTM D3261; ASTM F1807; ASTM F2159; B137.1 |

**1.6 Marking.** The pipe shall be permanently or indelibly marked at intervals not exceeding 5 feet (1.5 m) with at least the following:
(a) the nominal size;
(b) the manufacturer's name or trademark;
(c) the date or date code of manufacture;
(d) the material designation, e.g. ("PE3408");
(e) the intended service e.g.("Geothermal" or "Geo");

## SECTION 2: JOINTS AND CONNECTIONS

**2.1 Approval.** Joints and connections shall be of an approved type in the local code. Joints and connections shall be tight for the pressure of the geothermal ground-loop system. Joints used underground shall be suitable for buried applications.

**2.1.1 Joints between different piping materials.** Joints between different piping materials shall be made with transition fittings.

**2.1.2 Compression Connections.** Compression fittings should only be used in accessible locations.

**2.2 Preparation of pipe ends.** Pipe shall be cut square, reamed, and shall be free of burrs and obstructions. CPVC, PE, and PVC pipe shall be chamfered. Pipe ends shall have full-bore openings and shall not be undercut.

**2.3 Joint preparation and installation.** When required by Sections 2.4 through 2.6, the preparation and installation of mechanical or thermoplastic-welded joints shall comply with Sections 2.3.1 through 2.3.2.

**2.3.1 Mechanical joints.** Mechanical joints shall be installed in accordance with the manufacturer's instructions.

**2.3.2 Thermoplastic-welded joints.** Joint surfaces shall be cleaned. Joints shall be welded according to the manufacturer's instructions.

**2.4 CPVC plastic pipe.** Joints between CPVC plastic pipe or fittings shall be solvent-cemented or threaded joints in accordance with the local code.

**2.5 Cross-linked polyethylene (PEX) plastic tubing.** Mechanical PEX joints shall conform to Section 2.3.1 Joints between cross-linked polyethylene plastic tubing and fittings shall conform to Sections 2.5.1 and 2.5.2.

**2.5.1 Compression-type fittings.** When compression- type fittings include inserts and **f**errules or O-rings, the fittings shall be installed without omitting the inserts and ferrules or O-rings.

**2.5.2 Plastic-to-metal connections.** Soldering on the metal portion of the system shall be performed at least 18 inches (457 mm) from a plastic-to-metal adapter in the same water line.

**2.6 Polyethylene plastic pipe and tubing for ground source heat pump loop systems.** Joints between polyethylene plastic pipe and tubing or fit-

tings for ground source heat pump loop systems shall be heat fusion joints conforming to Section 2.6.1, electro-fusion joints conforming to Section 2.6.2, or stab-type insertion joints conforming to Section 2.6.3.

**2.6.1 Heat-fusion joints.** Joints shall be of the socket-fusion, saddle-fusion or butt-fusion type, joined in accordance with ASTM D 2657. Joint surfaces shall be clean and free of moisture. Joint surfaces shall be heated to melt temperatures and joined. The joint shall be undisturbed until cool. Fittings shall be manufactured in accordance with ASTM D 2683 or ASTM D 3261.

**2.6.2 Electro-fusion joints.** Joints shall be of the electro-fusion type. Joint surfaces shall be clean and free of moisture, and scoured to expose virgin resin. Joint surfaces shall be heated to melt temperatures for the period of time specified by the manufacturer. The joint shall be undisturbed until cool. Fittings shall be manufactured in accordance with ASTM F 1055.

**2.6.3 Stab-type insert fittings.** Joint surfaces shall be clean and free of moisture. Pipe ends shall be chamfered and inserted into the fittings to full depth.

**2.6.4 Polyethylene Resin Classification.** PE 3408 or PE4710 resin shall be used for underground or submerged geothermal ground loops.

**2.7 Polypropylene (PP) plastic.** Joints between PP plastic pipe and fittings shall comply with Sections 2.7.1 and 2.7.2.

**2.7.1 Heat-fusion joints.** Heat-fusion joints for polypropylene (PP) pipe and tubing joints shall be installed with socket-type heat-fused polypropylene fittings, electro-fusion polypropylene fittings or by butt fusion. Joint surfaces shall be clean and free from moisture. The joint shall be undisturbed until cool. Joints shall be made in accordance with ASTM F 2389.

**2.7.2 Mechanical and compression sleeve joints.** Mechanical and compression sleeve joints shall be installed in accordance with the manufacturer's instructions.

**2.8 Raised temperature polyethylene (PE-RT) plastic tubing.** Joints between raised temperature polyethylene tubing and fittings shall conform to Sections 2.8.1 and 2.8.2. Mechanical joints shall conform to Section 2.3.

**2.8.1 Compression-type fittings.** Where compression-type fittings include inserts and ferrules or O-rings, the fittings shall be installed without omitting the inserts and ferrules or O-rings.

**2.8.2 PE-RT-to-metal connections.** Solder joints in a metal pipe shall not occur within 18 inches (457 mm) of a transition from such metal pipe to PE-RT pipe.

**2.9 PVC plastic pipe.** Joints between PVC plastic pipe and fittings shall be solvent-cemented or threaded joints in accordance with the local code.

## SECTION 3: PIPING INSTALLATION

**3.1 General.** Piping, valves, fittings, and connections shall be installed in accordance with the conditions of approval.

**3.2 Protection of potable water.** Where geothermal ground loop systems have a connection to a potable water supply, the potable water system shall be protected from backflow in accordance with the local code.

**3.3 Pipe penetrations.** Openings for pipe penetrations in walls, floors or ceilings shall be larger than the penetrating pipe. Openings through concrete or masonry building elements shall be sleeved. The annular space surrounding pipe penetrations shall be protected in accordance with the local code.

**3.4 Clearance from combustibles.** A pipe in a geothermal piping system in which the exterior temperature exceeds 250°F (121°C) shall have a minimum clearance of 1 inch (25 mm) from combustible

materials.

**3.6 Contact with material.** A geothermal ground-loop piping system shall not be in direct contact with materials that cause the piping or fitting material to degrade or corrode, or that interfere with the operation of the system.

**3.7 Strains and stresses.** Piping shall be installed so as to prevent detrimental strains and stresses in the pipe. Provisions shall be made to protect piping from damage resulting from expansion, contraction and structural settlement. Piping shall be installed so as to avoid structural stresses or strains within building components.

**3.7.1 Flood hazard.** Piping located in a flood hazard area shall be capable of resisting hydrostatic and hydrodynamic loads and stresses, including the effects of buoyancy, during the occurrence of flooding to the design flood elevation.

**3.8 Pipe support.** Pipe shall be supported in accordance with local code and manufacturers instructions.

**3.9 Velocities.** Flow velocities in geothermal ground-loop systems shall be designed not to exceed the maximum flow velocity recommended by the pipe and fittings manufacturer and shall be controlled to reduce the possibility of water hammer.

**3.10 Labeling and Marking.** Geothermal ground-loop system piping shall be marked with tape, metal tags or other method where it enters a building indicating "GEOTHERMAL GROUND-LOOP SYSTEM". The marking shall indicate any antifreeze used in the system by name and concentration.

**3.11 Chemical Compatibility.** Antifreeze and other materials used in the system shall be chemically compatible with the pipe, tubing, fittings, and mechanical systems.

## SECTION 4: WORKING FLUID

**4.1 Makeup water.** The transfer fluid shall be compatible with the makeup water supplied to the system.

## SECTION 5: TESTS

**5.1 Testing ground source heat pump loop systems.** If there is no local code determining testing requirements, before connection (header) trenches are backfilled, the assembled loop system shall be pressure tested with water at 100 psi (689 kPa) for 30 minutes with no observed leaks. Flow and pressure loss testing shall be performed and the actual flow rates and pressure drops shall be compared to the calculated design values. If actual flow rate or pressure drop values differ from calculated design values by more than 10 percent, the cause shall be identified and corrective action taken.

## SECTION 6: EMBEDDED PIPING

**6.1 Pressurizing during installation.** Geothermal ground loop piping to be embedded in concrete shall be pressure tested prior to pouring concrete. During pouring, the pipe shall be maintained at the proposed operating pressure.

*NOTE: This PPFA User Bulletin is designed to provide guidance in achieving the efficient, effective and informed use of plastic pipe. The suggestions and advice contained in this Bulletin are offered merely to provide plastic pipe users with a general frame of reference. Because specific situations may, and often do require special treatment, the suggestions and advice are obviously not universally applicable. Therefore, the user should carefully assess the requirements of his specific situation before making practical application of anything contained in this publication.*

*Also available online at www.ppfahome.org/landing_pages/UB19_12.pdf*