

# **MODEL SPECIFICATION FOR PLASTIC PIPING MATERIALS FOR GROUND SOURCE GEOTHERMAL APPLICATIONS**

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## Foreword

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The Plastics Pipe Institute, Inc.

<https://plasticpipe.org/>

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# MODEL SPECIFICATION FOR PLASTIC PIPING MATERIALS FOR GROUND SOURCE GEOTHERMAL APPLICATIONS

## INTRODUCTION

This Model Specification applies to plastic piping materials (e.g., pipes, tubing, and fittings) for open- and closed-loop, horizontal and vertical, direct-buried, and submerged water-based ground-source geothermal heat exchange systems, also known as “geothermal exchange,” systems, “ground-coupled” systems, or “earth energy” systems. The outdoor piping in such systems may be referred to as the “geothermal ground loop”, “ground heat exchanger”, “ground loop heat pump piping”, and other such derivations. This Model Specification includes sections for four types of plastic piping materials which have been proven for use in ground-source geothermal heat exchange systems and are approved in existing model codes:

- Section 2.2: High-density polyethylene (HDPE)
- Section 2.3: Polyethylene of raised temperature (PE-RT)
- Section 2.4: Crosslinked polyethylene (PEX)
- Section 4.2: Polypropylene (PP)

For each of these materials, this model specification provides language related to pipe and tubing materials, fittings, and joining procedures. Installation and pressure testing recommendations are also provided.

**Note 1:** The term “tubing” typically refers to products where the actual outside diameter (OD) is 1/8 inch (0.125”) larger than the nominal size, the same as copper tube sizes (e.g., 3/4 NTS). The term “pipe” typically refers to products where the actual OD matches that of steel pipe of the same nominal size, otherwise known as Iron Pipe Sizing (e.g., 4 IPS), or products in which the actual OD matches the nominal size directly (e.g., 63 mm). In both cases, specified tolerances apply, as per relevant standards.

This publication is intended for use as a guide to support designers and specifiers of ground source geothermal heat exchange systems, but it should not be used in lieu of the advice of a professional engineer.

In all cases, ground source geothermal systems, including piping, must be installed, tested, and operated in accordance with local regulations which may include the mechanical code that is enforced at the project location or other codes or regulations.

The Plastics Pipe Institute (PPI) has made every reasonable effort to ensure the accuracy of this publication, but it may not provide all necessary information, particularly with respect to special or unusual applications.

This publication may be changed without notice. Visit <https://www.plasticpipe.org> for the most current edition.

**Note 2:** The user may choose to adopt part or all this Model Specification. However, users should ensure that all parts which are used are appropriate for the intended purpose.

**Note 3:** Users should review PPI TN-55 “Plastic Piping Materials for Ground Source Geothermal Heating and Cooling Applications” for more information about plastic piping materials and the standards listed within this Model Specification. Users should also review relevant and applicable model codes such as ANSI/CSA/IGSHPA C448, IAPMO Uniform Mechanical Code, IAPMO Uniform Solar, Hydronics and Geothermal Code, and ICC’s International Mechanical Code.

## 1.0 **GENERAL**

### 1.1. **Scope**

This model specification applies to plastic piping materials (e.g., pipes, tubing, and fittings) for open- and closed-loop, horizontal and vertical, direct-buried, and submerged water-based ground-source geothermal heat exchange systems, also known as “geothermal exchange,” systems, “ground-coupled” systems, or “earth energy” systems. The outdoor piping in such systems may be referred to as the “geothermal ground loop”, “ground heat exchanger”, “ground loop heat pump piping”, and other such derivations.

This model specification also applies to so-called indoor piping for geothermal exchange systems, such as that which connects buried ground loop piping to heat pump/s which are typically located within buildings.

This model specification does not apply to indoor piping for hot- and cold-water plumbing distribution or to hydronic heating and cooling system piping. Specifications for those piping products should follow local regulations.

Ground loop field size, depth and spacing, as well as grouting specifications, are not covered within this model specification and are the responsibility of the geothermal system designer.

**Note 4:** This specification does not apply to refrigerant-filled direct exchange systems.

## 1.2. Definitions

**Antifreeze:** An additive used in water-based heat transfer fluids to decrease the freezing temperature of the fluid to protect piping systems against freezing

**Bend radius:** the measure of pipe curvature from a center point to the mid-line of the pipe diameter when a pipe is bent

**Borehole:** a hole into the earth at any angle that is typically drilled, bored, cored, driven, hydraulically advanced, or otherwise constructed into the earth

**Borehole heat exchanger:** a borehole with a piping loop installed within for the purpose of exchanging heat with the earth

**Closed-loop heat exchange system:** a continuous, sealed, underground or submerged ground heat exchanger (i.e., ground loop) through which heat-transfer fluid (e.g., water plus antifreeze) passes to and returns from a heat pump

**Electrofusion:** a heat fusion joining process where the heat source is an integral part of fitting, such that when an electrical current is applied, heat is produced that melts and permanently joins two or more plastic components (e.g., pipe and fitting)

**Heat fusion:** a method of joining two similar materials (e.g., HDPE-HDPE) by the application of heat to melt the mating surfaces and then pressing them together with sufficient force to become one monolithic piece

**Ground heat exchanger:** (also known as ground loop, vertical loop ground heat exchanger, horizontal loop ground heat exchanger, submerged heat exchanger): a continuous, sealed, underground or submerged network of piping serving as the ground heat exchanger through which a heat-transfer fluid passes to and returns from a heat pump

**Note 5:** Ground heat exchangers may be vertically, diagonally, or horizontally configured or submerged in surface water.

**Ground loop:** the underground or submerged piping network of a ground loop heat exchanger through which the heat transfer fluid is circulated and thermal energy is exchanged with the earth

**Ground source heat pump (GSHP) system:** a heat pump system that is connected to a ground loop heat exchanger

**Note 6:** Other terms used in the industry include “earth energy heat exchange system”, “ground loop heat pump system”, “geothermal heat pump”, “geothermal exchange”, “ground coupled heat pump”, and “water source heat pump”.

**Grout:** a bentonite material or fluid mixture pumped into annular cavities between pipes and the earth to seal the cavity and conduct heat between the pipe and earth

**HDPE:** High-density polyethylene (pipe and fitting material)

**Header:** a pipe assembly that connects multiple parallel pipe circuits to supply or return piping; also called a “manifold”

**Horizontal loop:** an installation of ground heat exchanger piping that does not penetrate an aquifer and that can be inserted into a trench, open excavation, or installed by a horizontal directional drilling (HDD) method

**Hydrostatic pressure:** static pressure created by pressurizing a non-moving fluid inside a closed vessel, including pipes

**IGSHPA:** International Ground Source Heat Pump Association

**Indoor piping:** piping that is installed in geothermal system vaults or mechanical rooms and used to transition from buried ground loop piping to indoor mechanical systems. May include headers and manifolds when installed in indoor spaces. Sometimes referred to as “interior piping”

**Open-loop (surface water or ground water) system:** a system designed to utilize ground water or surface water for the purpose of exchanging thermal energy by circulation through a mechanical heat pump

**PEX:** Crosslinked polyethylene (piping material)

**PE-RT:** Polyethylene of raised temperature resistance (piping material)

**PP:** Polypropylene in one of two types known as PP-R and PP-RCT (piping material)

**PP-R:** Polypropylene random copolymer

**PP-RCT:** Polypropylene random copolymer with modified crystallinity & temperature resistance

**Standard dimension ratio (SDR):** a specific ratio of the average specified outside diameter to the minimum specified wall thickness (OD/t) for outside diameter-controlled plastic pipe, the value of which is derived by adding one to the pertinent number selected from the ANSI Preferred Number Series 10.

*Extracted, with permission, from ASTM F412 Standard Terminology Related to Plastic Piping Systems, copyright ASTM International, 100 Barr Harbor Drive, West Conshohocken, PA 19428. A copy of the complete standard may be obtained from ASTM International, [www.astm.org](http://www.astm.org)*

**U-Bend assembly:** A 180-degree directional change in a ground loop pipe, typically used at the bottom of a vertical borehole, that is fabricated or formed using a one-piece molded fitting attached to HDPE pipes via butt fusion, approved fittings for PE-RT or PEX pipe and tubing, or jointless hot-forming techniques

**Vertical borehole:** a vertical hole into the earth at any angle typically drilled, bored, cored, driven, hydraulically advanced, or otherwise constructed into the earth for the purpose of containing ground loop pipes for exchanging heat with the earth and not for the purpose of producing water

**Vertical borehole heat exchanger:** a vertical borehole with a piping loop installed within for the purpose of exchanging heat with the earth

### 1.3. Referenced Standards

Where all or part of a national or international standard specification by standards development organizations such as ASTM, CSA, or NSF is incorporated by reference in this Specification, the reference standard shall be the latest edition and revision.

- ANSI/CSA/IGSHPA C448 *Design and installation of ground source heat pump systems for commercial and residential buildings*
- ASTM D2683 *Standard Specification for Socket-Type Polyethylene Fittings for Outside Diameter-Controlled Polyethylene Pipe and Tubing*
- ASTM D2774 *Standard Practice for Underground Installation of Thermoplastic Pressure Piping*
- ASTM D3035 *Standard Specification for Polyethylene (PE) Plastic Pipe (DR-PR) Based on Controlled Outside Diameter*
- ASTM D3261 *Standard Specification for Butt Heat Fusion Polyethylene (PE) Plastic Fittings for Polyethylene (PE) Plastic Pipe and Tubing*
- ASTM D3350 *Standard Specification for Polyethylene Plastics Pipe and Fittings Materials*
- ASTM F645 *Standard Guide for Selection, Design, and Installation of Thermoplastic Water-Pressure Piping Systems*
- ASTM F714 *Standard Specification for Polyethylene (PE) Plastic Pipe (DR-PR) Based on Outside Diameter*
- ASTM F876 *Standard Specification for Crosslinked Polyethylene (PEX) Tubing*

- *ASTM F877 Standard Specification for Cross-linked Polyethylene (PEX) Hot-and Cold-Water Distribution Systems*
- *ASTM F1055 Standard Specification for Electrofusion Type Polyethylene Fittings for Outside Diameter Controlled Polyethylene and Crosslinked Polyethylene (PEX) Pipe and Tubing*
- *ASTM F1290 Standard Practice for Electrofusion Joining Polyolefin Pipe and Fittings*
- *ASTM F1807 Standard Specification for Metal Insert Fittings Utilizing Copper Crimp Ring for SDR9 Crosslinked Polyethylene (PEX) Tubing and SDR9 Polyethylene of Raised Temperature (PE-RT) Tubing*
- *ASTM F1960 Standard Specification for Cold Expansion Fittings with PEX Reinforcing Rings for Use with Crosslinked Polyethylene (PEX) Tubing*
- *ASTM F2080 Standard Specification for Cold Expansion Fittings with Metal Compression-Sleeves for Cross-linked Polyethylene (PEX) Pipe and SDR9 Polyethylene of Raised Temperature (PE-RT) Pipe*
- *ASTM F2159 Standard Specification for Plastic Insert Fittings Utilizing a Copper Crimp Ring for SDR9 Cross-linked Polyethylene (PEX) Tubing and SDR9 Polyethylene of Raised Temperature (PE-RT) Tubing*
- *ASTM F2164 Standard Practice for Field Leak Testing of Polyethylene (PE) and Cross-linked Polyethylene (PEX) Pressure Piping Systems Using Hydrostatic Pressure*
- *ASTM F2389 Standard Specification for Pressure-rated Polypropylene (PP) Piping Systems*
- *ASTM F2620 Standard Practice for Heat Fusion Joining of Polyethylene Pipe and Fittings*
- *ASTM D2737 Standard Specification for Polyethylene (PE) Plastic Tubing*
- *ASTM F2769 Standard Specification for Polyethylene of Raised Temperature (PE-RT) Plastic Hot- and Cold-Water Tubing and Distribution Systems*
- *ASTM F3347 Standard Specification for Metal Press Insert Fittings with Factory Assembled Stainless Steel Press Sleeve for SDR9 Crosslinked Polyethylene (PEX) Tubing and SDR9 Polyethylene of Raised Temperature (PE-RT) Tubing*