1 General

1.1 Purpose

This Standard establishes the minimum physical and performance requirements for plastic piping system components. These criteria were established for the protection of property, public health and the environment.

1.2 Scope

The physical and performance requirements in this Standard apply to plastic piping system components as well as non-plastic components of the ground loop heat exchanger including but not limited to cross-linked polyethylene (PEX) pipes and fittings used in water-based ground-source heat pump systems. This standard does not cover refrigerant based ground loop heat exchangers such as direct expansion (DX) systems. This Standard does not cover hydronic heating or cooling systems within buildings.

2 Normative References

The following documents contain provisions that, through reference, constitute provisions of this NSF Standard. At the time this Standard was balloted, the editions listed below were valid. All documents are subject to revision, and parties are encouraged to investigate the possibility of applying the recent editions of the documents indicated below.

These are Normative References for Cross-linked Polyethylene (PEX) Pipe and Fittings for Water-Based Ground-Source (Geothermal) Heat Pump Systems.

ASTM F412-09. Terminology Relating to Plastic Piping Systems

ASTM F876-10. Standard Specification for Cross-linked Polyethylene (PEX) Tubing


ASTM F1055. Standard Specification for Electrofusion Type Fittings for Outside Diameter Controlled Polyethylene and Crosslinked Polyethylene (PEX) Pipe and tubing

ASTM F1807-10. Standard Specification for Metal Insert Fittings Utilizing a Copper Crimp Ring for SDR9 Cross-linked Polyethylene (PEX) Tubing

1 American Society for Testing Materials (ASTM), 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959 <www.astm.org>.
3 Definitions

Terms used in this Standard that have a specific technical meaning are defined here.

3.1 compound: A mixture of polymers with other ingredients such as fillers, stabilizers, catalysts, processing aids, lubricants, modifiers, pigments, or curing agents.

NOTE – Compounds are considered materials; however, not all materials are considered compounds.

3.2 contamination: The presence of a substance not intentionally incorporated in a product.

3.3 critical dimensions: Dimensions of a product (e.g., pipes and fittings) that directly affect the fit and function, or the capacity of making a sound joint, or both.

3.4 fitting: A piping component used to join, terminate, or provide changes of direction in a piping system.

2 Canadian Standards Association (CSA), 5060 Spectrum Way, Suite 100, Mississauga Ontario, Canada L4W 5N6 <www.csa.ca>.

3 Plastics Pipe Institute (PPI), 105 Decker Court, Suite 825, Irving, TX 75062 <plasticpipe.org>.
3.5 **ground-source heat pump system**: A terminology used to describe a variety of mechanical systems that use the ground, groundwater, or surface water as a heat source or heat sink. Systems can be further described as ground-coupled, groundwater and surface water heat pump systems.

3.6 **hydrostatic design basis (HDB)**: One of a series of established stress values specified in ASTM D 2837 for a plastic compound, obtained by categorizing the long-term hydrostatic strength determined in accordance with ASTM D2837.

3.7 **hydrostatic design stress (HDS)**: The estimated maximum tensile stress a material is capable of withstanding continuously with a high degree of certainty that failure of the pipe will not occur. This stress is circumferential when internal hydrostatic water pressure is applied.

3.8 **joint**: The location at which two pieces of pipe or a pipe and a fitting are connected together. Various joint types not defined in this standard shall be defined by ASTM F412.

3.9 **mechanical joint**: A connection between two pieces of pipe or a pipe and a fitting using a physical force to establish a seal or alignment.

3.10 **plastic pipe**: A hollow cylinder of plastic, in which the wall thicknesses are usually small when compared to the diameter, and in which the inside and outside walls are essentially concentric.

3.11 **plastic**: A material that contains as an essential ingredient one or more organic polymeric substances of large molecular weight, is solid in its finished state, and, at some stage in its manufacture or processing into finished articles, can be shaped by flow.

3.12 **pressure rating**: The estimated maximum water pressure at a specified temperature that a pipe is capable of withstanding continuously with a high degree of certainty that failure of the pipe will not occur.

3.13 **quality assurance**: A formal system for verifying that products conform to specific standards. Quality assurance is intended as an audit of quality control testing.

3.14 **quality control**: The methods used to ensure that a production process yields products in conformance with the appropriate specifications established by the quality assurance program.

3.15 **steady-state**: An operational condition of the manufacturing process that does not change with time.

3.16 **thermoplastic**: *noun* – A plastic that can be repeatedly softened by heating and hardened by cooling through a temperature range characteristic of the plastic, and in the softened state, can be shaped by flow through molding or extrusion. *adj.* – Capable of being repeatedly softened by heating and hardened by cooling through a temperature range characteristic of the plastic, and able in the softened state to be shaped by flow into articles by molding or extrusion.

### 4 Material Requirements

#### 4.1 Plastic Materials
Materials for cross-linked polyethylene pipe shall be produced from high density polyethylene meeting the material requirements of ASTM F876.

### 4.2 Long-term strength of plastic pipe

Materials for use in plastic pipe shall comply with long term strength compliance in 4.4. Listing in PPI Technical Report Number 4 (TR-4) is acceptable evidence of hydrostatic design stress compliance.

### 4.3 Hydrostatic design

The maximum hydrostatic design basis of polyethylene material shall be determined in accordance with PPI Technical Report Number 3 (TR-3) for the temperature and hydrostatic design stresses in Table 1.

<table>
<thead>
<tr>
<th>Table 1 Minimum Hydrostatic Design Stress per PPI TR-3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plastic Material</td>
</tr>
<tr>
<td>PEX</td>
</tr>
</tbody>
</table>

### 5 General Requirements

#### 5.1 Cross-Linked Polyethylene Pipe

Crosslinked polyethylene pipe shall conform to ASTM F876 or CSA B137.5.

#### 5.2 Fittings for Cross-Linked Polyethylene Pipe


U-bends containing assembled joints or formed from cross-linked polyethylene tubing shall comply with the sustained pressure requirements of section 7.6 of ASTM F876. Each test specimen shall contain assembled joints formed U-bends consistent with how the product is sold.

#### 5.3 Chemical Resistance

Plastic pipe and plastic fitting materials in direct contact with heat transfer fluids shall not exhibit a change in weight greater than 0.5% or a change in apparent tensile strength greater than 12% when tested according to 5.3.1 through 5.3.4.

##### 5.3.1 Determine the resistance to the chemicals in Table 2 in accordance with ASTM D543

##### 5.3.2 Ring specimens shall be cut from a minimum 1” diameter pipe where available. The specimens shall be ½ inches wide with a ¼ inch wide reduced section.

##### 5.3.3 Test five specimens with each chemical listed in Table 2. Weigh the specimens to the nearest 0.005 g and completely immerse in the chemicals for 72 hours. On removal from the chemicals, wipe the specimens with a clean dry cloth. Condition in air for 2 to 2 ¼ hours and reweigh. Calculate the change in weight to the nearest 0.01% on the basis of initial weight.
5.3.4 Test the specimens for tensile strength in accordance with ASTM D2290, Procedure B using 0.5 inch/minute testing speed within ½ hour after weighting. Examine the weight and apparent tensile strength of each specimen.

<table>
<thead>
<tr>
<th>Chemical</th>
<th>Concentration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ethanol</td>
<td>100%</td>
</tr>
<tr>
<td>Methanol</td>
<td>100%</td>
</tr>
<tr>
<td>Propylene glycol</td>
<td>100%</td>
</tr>
</tbody>
</table>

Table 2: Resistance of chemicals

Note – This test is designed to establish basic chemical resistance requirements of plastic piping materials to the major chemicals used in heat transfer fluids. Plastic materials are tested with the chemicals in pure form. Heat transfer fluids contain chemical additives packages such as corrosion inhibitors that are not considered qualified by this test. Heat transfer fluid manufacturers should be consulted regarding the chemical compatibility of each fluid formulation and the piping material.

5.4 Mechanical Joints

All mechanical joints designed for use in buried applications shall meet the requirements of 5.4.1 through 5.5.1.

5.4.1 Thermocycling

Pipe and fittings assembled using the manufacturer’s instructions shall not leak following thermocycling when tested in accordance with ASTM F877 section 7.5.

5.4.1.1 Pressure Test

Each specimen assembly shall again withstand for 2 hours, without leakage, separation or rupture, the internal hydrostatic pressure equivalent to the rated pressure of the lowest-rated component (pipe or fitting). Failure of any one of the six joints tested shall constitute failure of this test.

5.5 Constant Tensile Load Joint Test

Joints shall not fail by leakage or pullout when tested per the following. One specimen of smallest and largest nominal size shall be tested in accordance with ASTM F1588 for 1000 hours at an internal pressure of 100 psi with the joint loaded to an axial tensile stress of 1320 psi a load applied to the joint per Table 3.

<table>
<thead>
<tr>
<th>Nominal size (inch)</th>
<th>Load (lbs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>½</td>
<td>12</td>
</tr>
<tr>
<td>¾</td>
<td>38</td>
</tr>
<tr>
<td>1</td>
<td>144</td>
</tr>
<tr>
<td>1.5</td>
<td>764</td>
</tr>
<tr>
<td>2</td>
<td>2372</td>
</tr>
</tbody>
</table>

5.6 Joining
6 Marking Requirements

6.1 Pipe Marking

Pipe shall bear permanent identification markings that will remain legible during normal handling, storage, installation, and service life and that have been applied in a manner that will not reduce the strength or otherwise damage the products:

− Nominal Size
− Material Designation
− Third party certification mark (if applicable)
− End use of "Geo" or "Geothermal"
− This standard designation, i.e., NSF/ANSI 358-3
− Pressure rating at rated temperature

6.2 Fitting Marking

Fittings shall be marked with the following information:

− Nominal Size
− Third party certification mark (if applicable)
− Standard designation as referenced in 5.1 or 5.2

6.3 Manufacturers Instructions

6.3.1 Protection from UV Exposure

Manufacturers instructions shall contain instructions for the appropriate protection from UV exposure during shipping, handling, storage and installation.

6.3.2 Suitability for burial

Manufacturers instructions for fittings shall indicate whether or not the fittings are suitable for burial.

Fittings requiring exposed metallic components shall not be suitable for burial

7 Quality Assurance

7.1 General

A quality control program shall be operated and maintained to ensure that products conform to the applicable requirements of this Standard on a continuous basis. The manufacturer shall provide and maintain quality control testing facilities at each production facility.
7.1.1 Quality control testing shall be conducted at ambient temperature and humidity or standard laboratory conditions of 23 ± 2 °C (73 ± 3.6 °F) and 45 to 55% relative humidity.

7.1.2 The tests and testing frequencies shall conform to the minimum requirements listed in 7.8. Where quality control requirements are specified in the product standards, the tests and test frequencies specified in the product standards shall be conducted in addition to the requirements listed in 7.8. If the test frequencies specified in the product standard conflict with the frequencies contained in 7.8 then the more frequent requirement shall be followed. Variations from these minimum requirements shall be permitted if an alternate program is established in writing and determined to be equivalent.

7.1.3 Annual testing performed by a third-party certifier shall satisfy the requirement of annual quality control testing.

7.2 Start-up and qualification of molds

7.2.1 Start-up

In each case, with the exception of annual and semi-annual tests, the frequency of testing indicated in 7.8 shall be interpreted as follows: the indicated tests shall be performed at the start-up of any production operation, on each extruder or injection molder, and continued until a steady-state operation that meets the test requirement is obtained. The test shall be repeated at the required frequency until there is a change in the steady-state operation. When there is a change in operation, testing shall be conducted continuously until a new steady-state operation is achieved. After a steady-state operation is attained, the applicable testing frequencies shown in 7.8 shall resume.

7.3 Qualification of molds

The test frequency indicated for fittings shall be used only after the mold has been qualified. In order for a new or retooled mold to be considered “qualified,” all products from all cavities in the mold shall attain compliance with all of the appropriate dimensions and tests. This does not include annual or semiannual tests. After qualification, the indicated test frequencies shall apply to one cavity per mold, rotating cavities within the mold, including start-ups. If any physical change is made to the mold itself, all cavities within the mold must be re-qualified.

7.4 The calibration of all equipment used to check critical dimensions shall be verified weekly. Verification shall consist of checking the zero point, if applicable, and the critical dimension or a point near the upper limit of the instrument. Where applicable, references used for verification shall be traceable to the National Institute of Standards and Technology (NIST).

7.5 Other equipment, including equipment used for measuring ingredients in in-plant blending operations, shall be verified at a minimum of once annually. Records of equipment verification shall include the following:

− date that the verification was performed;
− identity of the equipment verified (description and serial number);
− verification data;
− description of any corrective actions taken, if applicable; and
− identity of the person who performed the verification.
7.6 Quality assurance records

The manufacturer shall maintain records of quality assurance testing at each production location for at least three years.

7.7 Production code identification

In instances where code identification of products is required, the manufacturer shall maintain records necessary to confirm identification of all products.

7.8 Number of test specimens

Unless otherwise specified by an applicable standard as referenced in 2 of this Standard, the minimum number of test specimens for a sample of one size, style, configuration, and material shall be as indicated in Table 4 and 5.

Product-specific quality assurance requirements for cross-linked polyethylene pipe and fittings are contained within Table 4 and 5.

<table>
<thead>
<tr>
<th>Test</th>
<th>Minimum number of specimens</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bent tube hydrostatic sustained pressure</td>
<td>annual</td>
</tr>
<tr>
<td>Burst pressure</td>
<td>6</td>
</tr>
<tr>
<td>Degree of cross linking</td>
<td>weekly</td>
</tr>
<tr>
<td>Dimensions, (inner diameter or outer diameter)</td>
<td>2 hours</td>
</tr>
<tr>
<td>Dimensions, minimum and maximum wall thickness</td>
<td>2 hours</td>
</tr>
<tr>
<td>Environmental stress crack corrosion</td>
<td>annually</td>
</tr>
<tr>
<td>Excessive temperature and pressure capability</td>
<td>annually</td>
</tr>
<tr>
<td>Sustained pressure</td>
<td>annually</td>
</tr>
</tbody>
</table>

1 If one material is continuously used in several machines or sizes, then when a steady-state operation is obtained on each machine, sample selection shall be from a different extruder each day and rotated in sequence among all machines or sizes.

<table>
<thead>
<tr>
<th>Test</th>
<th>Minimum number of specimens</th>
</tr>
</thead>
<tbody>
<tr>
<td>Burst pressure</td>
<td>weekly</td>
</tr>
<tr>
<td>Insert outer diameter</td>
<td>weekly</td>
</tr>
<tr>
<td>Body wall thickness</td>
<td>weekly</td>
</tr>
<tr>
<td>Insert length</td>
<td>weekly</td>
</tr>
<tr>
<td>Excessive temperature and pressure capability</td>
<td>annually</td>
</tr>
<tr>
<td>Sustained pressure</td>
<td>annually</td>
</tr>
<tr>
<td>Thermocycling</td>
<td>annually</td>
</tr>
</tbody>
</table>

1 Metal fittings, Polysulfone, Polyphenylsulfone or Polysulfone/Polyphenylsulfone blends need only be tested annually for burst pressure.