New Model Spec for Piping Materials

Avoiding confusion and costly mistakes when specifying piping materials

Geothermal: The Genius Renewable

Live at Groundwater Week in partnership with NGWA

Las Vegas, NV
December 5-7, 2023
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Speaker Introduction

Lance MacNevin, P.Eng.
- Director of Engineering, Plastics Pipe Institute Building & Construction Division
- Staff engineer to coordinate research, publications, education, advocacy, industry outreach
- Active in the piping industry since 1993
- Serves on Technical Committees within ASHRAE, ASTM, ASPE, AWWA, CIPH, CSA, HIA-C, IAPMO, ICC, IGSHPA, NSF, RPA

PPI Represents the Plastic Pipe Industry www.plasticpipe.org
- Formed in 1950 to research and develop test methods for plastic pressure pipes
- Today: Non-profit trade association serving North America, based in Irving, TX

PPI Mission: To advance the acceptance and use of plastic pipe systems through research, education, technical expertise, and advocacy
New Model Specification for Geo Piping Materials

Introduction
- In May 2023, PPI published the “Model Specification for Plastic Piping Materials for Ground Source Geothermal Applications”

- **PPI MS-7** includes detailed specifications for four plastic piping materials which have been proven for use in ground source heat exchange systems: HDPE, PE-RT, PEX, and PP (for indoor)

- This presentation will explain how to utilize PPI MS-7 to specify ground source piping systems quickly and accurately
New Model Specification for Geo Piping Materials

Presentation Outline

1. Explain HDPE pipe, tubing, and fittings using industry standards and code requirements

2. Introduce product standards from ASTM, AWWA, CSA, and NSF

3. Examples of “inappropriate” or out-of-date piping specifications

4. Share new Model Specification PPI MS-7 and how to utilize it
1. HDPE Piping Systems According to Codes & Standards

Start with Applicable Codes

- A code is a legally adopted document by a jurisdiction for the purpose of regulating a portion of the design and construction industry

- Most jurisdictions don’t have the capacity to develop their own codes, so they adopt Model Codes

- Model Codes for construction are developed by Code Development Bodies or Code Agencies (e.g., ICC, IAPMO, NRC)

- When adopted through the appropriate legislative process, standards and model codes become the “law of the land” for jurisdictions

- Therefore, a “Standard” (e.g., CSA/ANSI/IGSHPA C448) can become a “Code”
HDPE Piping Systems According to Codes & Standards

Model Codes for Mechanical & Geothermal Systems
- ANSI/CSA/IGSHPA C448-2016
- 2021 ICC International Mechanical Code (IMC)
- 2021 IAPMO Uniform Mechanical Code (UMC)
- 2021 IAPMO Uniform Solar, Hydronics and Geothermal Code (USHGC)
5.4.2 Polyethylene (PE) pipe and fittings

5.4.2.1 PE pipe and tubing

5.4.2.1.1

PE pipe and tubing shall

- a) comply with CSA B137.1, ASTM D2737, ASTM D3035, ASTM F714, or AWWA C901;
- b) be manufactured from a PE compound that has a pipe material designation code of PE 3608, PE 3708, PE 3710, PE 4608, PE 4708, or PE 4710 as defined in the applicable standards in Item a), with a cell classification as per ASTM D3350 appropriate for the material designation code, and a colour and ultraviolet stabilizer code of C or E. Code E compounds shall be stabilized against deterioration from unprotected exposure to ultraviolet rays for not less than 3 years, as evidenced by meeting the test criteria specified in ASTM D2513; and
- c) meet the requirements specified in Table 1.

Note: Nominal dimensions are provided. The specific product dimensions (outside diameter and inside diameter) are based on referenced product standards. See the applicable product standard or manufacturer’s published information for specific dimensions and availability.
HDPE Piping Systems According to Codes & Standards

2021 ICC International Mechanical Code (IMC)

<table>
<thead>
<tr>
<th>MATERIAL</th>
<th>STANDARD (see Chapter 15)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chlorinated polyvinyl chloride (CPVC)</td>
<td>ASTM D2846; ASTM F441; ASTM F442</td>
</tr>
<tr>
<td>Cross-linked polyethylene (PEX)</td>
<td>ASTM F876; CSA B137.5; CSA C448; NSF 358-3</td>
</tr>
<tr>
<td>Polyethylene/aluminum/polyethylene (PE-AL-PE) pressure pipe</td>
<td>ASTM F1282; CSA B137.9</td>
</tr>
<tr>
<td>High-density polyethylene (HDPE)</td>
<td>ASTM D2737; ASTM D3035; ASTM F714; AWWA C901; CSA B137.1; CSA C448; NSF 358-1</td>
</tr>
<tr>
<td>Polypropylene (PP-R)</td>
<td>ASTM F2389; CSA B137.11; NSF 358-2</td>
</tr>
<tr>
<td>Polyvinyl chloride (PVC)</td>
<td>ASTM D1785; ASTM D2241</td>
</tr>
<tr>
<td>Raised temperature polyethylene (PE-RT)</td>
<td>ASTM F2623; ASTM F2769; CSA B137.18; CSA C448; NSF 358-4</td>
</tr>
</tbody>
</table>

- Chapter 12 is **Hydronic Piping**
- **Table 1210.4** provides the list of approved **Ground-Source Loop Pipe** materials
HDPE Piping Systems According to Codes & Standards

2021 ICC International Mechanical Code (IMC)

**TABLE 1210.5**

<table>
<thead>
<tr>
<th>PIPE MATERIAL</th>
<th>STANDARD (see Chapter 15)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chlorinated polyvinyl chloride (CPVC)</td>
<td>ASTM D2846; ASTM F437; ASTM F438; ASTM F439; CSA B137.6</td>
</tr>
<tr>
<td>Cross-linked polyethylene (PEX)</td>
<td>ASTM F877; ASTM F1807; ASTM F1960; ASTM F2080; ASTM F2159; ASTM F2434; CSA B137.5; CSA C448; NSF 358-3</td>
</tr>
<tr>
<td>Polyethylene/aluminum/polyethylene (PE-AL-PE)</td>
<td>ASTM F1282; ASTM F2434; CSA B137.9</td>
</tr>
<tr>
<td>High-density polyethylene (HDPE)</td>
<td><strong>ASTM D2683; ASTM D3261; ASTM F1055; CSA B137.1; CSA C448; NSF 358-1</strong></td>
</tr>
<tr>
<td>Polypropylene (PP-R)</td>
<td>ASTM F2389; CSA B137.11; NSF 358-2</td>
</tr>
<tr>
<td>Polyvinyl chloride (PVC)</td>
<td>ASTM D2464; ASTM D2466; ASTM D2467; CSA B137.2; CSA B137.3</td>
</tr>
<tr>
<td>Raised temperature polyethylene (PE-RT)</td>
<td>ASTM D3261; ASTM F1807; ASTM F2098; ASTM F2159; ASTM F2735; ASTM F2769; CSA B137.1; CSA B137.18; CSA C448; NSF 358-4</td>
</tr>
</tbody>
</table>

- Chapter 12 is **Hydronic Piping**
- **Table 1210.5** provides the list of approved **Ground-Source Loop Fitting** materials
HDPE Piping Systems According to Codes & Standards

2021 IAPMO Uniform Mechanical Code (UMC)
- Appendix F covers Geothermal Energy Systems
- Table F 104.2 provides the list of approved Plastic Ground Source Loop Piping

<table>
<thead>
<tr>
<th>MATERIAL</th>
<th>STANDARD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cross-linked polyethylene (PEX)</td>
<td>ASTM F876, CSA B137.5, CSA C448, NSF 358-3</td>
</tr>
<tr>
<td>High Density Polyethylene (HDPE)</td>
<td>ASTM D2737, ASTM D3033, ASTM F714, AWWAC901, CSA B137.1, CSA C448, NSF 358:1</td>
</tr>
<tr>
<td>Polypropylene (PP)</td>
<td>ASTM F2389, CSA B137.11, NSF 358-2</td>
</tr>
<tr>
<td>Polyethylene Raised Temperature (PE-RT)</td>
<td>ASTM F2623, ASTM F2769, CSA B137.18, CSA C448, NSF 358-4</td>
</tr>
</tbody>
</table>
HDPE Piping Systems According to Codes & Standards

2021 IAPMO Uniform Mechanical Code (UMC)
- Appendix F covers Geothermal Energy Systems
- Table F 104.3 provides the list of approved Plastic Ground Source Loop Pipe Fittings

| TABLE F 104.3  
GROUND SOURCE LOOP PIPE FITTINGS | MATERIAL | STANDARD |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>High Density Polyethylene (HDPE)</td>
<td>ASTM D2683, ASTM D3261, ASTM F1055, CSA B137.1, CSA C448, NSF 358-1</td>
<td></td>
</tr>
<tr>
<td>Polypropylene (PP)</td>
<td>ASTM F2389, CSA B137.11, NSF 358-2</td>
<td></td>
</tr>
<tr>
<td>Polyethylene Raised Temperature (PE-RT)</td>
<td>ASTM D3261, ASTM F1055, ASTM F1807, ASTM F2080, ASTM F2159, ASTM F2769, CSA B137.18, CSA C448; NSF 358-4</td>
<td></td>
</tr>
</tbody>
</table>
HDPE Piping Systems According to Codes & Standards

2021 IAPMO Uniform Solar, Hydronics and Geothermal Code (USHGC)
- Chapter 7 covers Geothermal Energy Systems
- Table 703.2 provides the list of approved Plastic Ground Source Loop Piping
HDPE Piping Systems According to Codes & Standards

Summary

- Model Codes (and other codes) are very specific about approved products and procedures
- Codes approve products by reference to accredited products standards by SDOs
- It is important to understand the standards to use them correctly
- There are defined process for revising codes; most US codes follow 3-year cycles
- 2024 codes are already published, 2027 codes are in development
- Canada’s National Building Code is on a 5-year cycle (2025 code being developed now)
2. Product Standards from ASTM, AWWA, CSA, and NSF

Where do Product Standards come from?
- Standards for products such as pipes are developed by Standards Development Organizations (SDOs)
- Examples of SDOs include AHRI, ASHRAE, AWWA, ASTM, CSA, IAPMO, ICC, and NSF
- SDOs can be accredited by ANSI (USA) or SCC (Canada) to ensure they develop useful standards in a correct and transparent manner, open to the public

Purpose of Standards:
- A Standard is defined as a set of technical definitions and requirements for product design, manufacturing, testing, and certification
- Standards exist to protect consumers (i.e., the public); typically based on sets of minimum requirements
- Requirements within standards are typically driven by consumer expectations and industry knowledge
- Product manufacturers are responsible to determine which standards apply to their products and for conformance
Product Standards from ASTM, AWWA, CSA, and NSF

Listed standards for HDPE pipes and tubing

- **ASTM D2737** Standard Specification for Polyethylene (PE) Plastic Tubing
- **ASTM D3035** Standard Specification for Polyethylene (PE) Plastic Pipe (DR-PR) Based on Controlled Outside Diameter
- **ASTM F714** Standard Specification for Polyethylene (PE) Plastic Pipe (DR-PR) Based on Outside Diameter
- **AWWA C901** Polyethylene (PE) Pressure Pipe and Tubing, 3/4 in. through 3 in. for Water Service
- **CSA B137.1** Polyethylene Pipe, Tubing, and Fittings for Cold Water Pressure Services
- **NSF/ANSI 14** Plastics Piping System Components and Related Materials
- **NSF/ANSI 358-1** Polyethylene Pipe and Fittings for Water-Based Ground-Source “Geothermal” Heat Pumps Systems
Product Standards from ASTM, AWWA, CSA, and NSF

Listed standards for HDPE fittings, joining practices, and drinking water safety

- ASTM D2683 Standard Specification for Socket-Type Polyethylene Fittings for Outside Diameter-Controlled Polyethylene Pipe and Tubing
- 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 F2620 Standard Practice for Heat Fusion Joining of Polyethylene Pipe and Fittings

- NSF/ANSI/CAN 61 Drinking Water System Components – Health Effects
Who writes Product Standards related to piping systems?
- Standards are developed and maintained by relevant **Technical Committees** within each SDO

Example: **ASTM D3035** is the responsibility of **ASTM TC F17**, Subcommittee **F17.26 “Olefin Based Pipe”**
- **F17.26 Scope**: To develop and maintain ASTM standards for pipe and pipe appurtenances made from an olefin-based polymer or any combination of olefin-based polymers.

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1 This specification is under the jurisdiction of ASTM Committee F17 on Plastic Piping Systems and is the direct responsibility of Subcommittee F17.26 on Olefin Based Pipe.

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As listed in the footer of **ASTM D3035**
Product Standards from ASTM, AWWA, CSA, and NSF

Standards related to GSHP HDPE piping systems
- HDPE geothermal pipes: AWWA C901, ASTM D2737, ASTM D3035, CSA B137.1, NSF 358-1, NSF 61
Product Standards from ASTM, AWWA, CSA, and NSF

Standards related to GSHP HDPE piping systems – Relevance and Value

- Product standards contain extremely detailed lists of requirements. Example: ASTM D3035-21

| TABLE 1 Polyethylene Compound Requirements |
|-----------------------------|-----------------|-----------------|-----------------|-----------------|
|                            | PE1404          | PE2708          | PE6068          | PE4608          |
| Requirement                | Required Value  |
| HDB at 140°F (60°C), psi  |
| (MPa), in accordance with ASTM D3035 and PPI TR-3 |
| 4                           | 800 (5.5)       | 800 (5.5)       | 800 (5.5)       |
| HDS for water at 73°F (23°C) psi (MPa), |
| In accordance with ASTM D2988 and PPI TR-3 |
| 400 (2.76)                  | 800 (5.5)       | 800 (5.5)       | 800 (5.5)       |
| Melt flow rate in accordance with ASTM D1238 |
| 1.0 to 0.4 g/dl min Cond.  |
| 1902/16 or ≥20 g/dl min Cond. |
| ≤0.15 g/dl min Cond.  |
| 1902/16 or ≥20 g/dl min Cond. |
| ≤0.15 g/dl min Cond.  |
| 1902/16 or ≥20 g/dl min Cond. |
| Specification D3380 Cell Classification Property |
| Density (natural base resin) |
| 1                           | 2               | 3               | 4               |
| SCG Resistance              |
| 4                           | 7               | 6               | 6               |
| Color and UV Stabilizer Code |
| C                           | C, D, or E      | C, D, or E      | C, D, or E      |

three specimen test sample in accordance with Test Method D1598 using water as the internal test medium.

7.6 Hydraulic Burst Pressure—The test equipment, procedures, and failure definitions shall be as specified in Test Method D1599.

8. Retest and Rejection

8.1 Except as specified in 6.4, 6.5, 6.5.1 and 6.5.2, if the results of any test(s) do not meet the requirements of this specification, the test(s) may be conducted again in accordance with an agreement between the purchaser and the seller. There shall be no agreement to lower the minimum requirements of the specification by such means as omitting tests that are a part of the specification, substituting or modifying a test method, or by changing the specification limits. In retesting, the product requirements of this specification shall be met, and the test methods specified in the specification shall be followed. If, upon retest, failure occurs, the quantity of product represented by the test(s) does not meet the requirements of this specification.

9. Marking

9.1 Marking on the pipe shall include the following, spaced at intervals of not more than 5 ft (1.5 m):

9.1.1 Nominal pipe size (for example, IPS 2),
9.1.2 Type of plastic pipe material in accordance with the materials designation code given in accordance with 5.1 (for example, PE 3056 or PE4710),
9.1.3 Thermoplastic pipe dimension ratio in accordance with 4.2 (for example, DR 11),
9.1.4 The pressure rating (PR) in pounds-force per square inch for water at 73°F (23°C) shown as either the number preceded by PR, the number followed by psi (kPa), for example, 100 psi or 690 kPa,
9.1.5 “ASTM D3035,”
9.1.6 Manufacturer’s name (or trademark) and code,
9.1.7 Oxidative resistance classification of the pipe in accordance with 5.3,
9.1.8 Pipe intended for transporting potable water shall also include the seal of an accredited laboratory.

Note 5—Earlier editions of Specification D3035 included PE materials designations that are no longer used. Changes to Specification D3035 and PPI TR-3 led to changes in thermoplastic materials designations, resulting in older materials designations being superseded by new materials designations. Recognizing that a period of time is necessary for the dissemination of information and to update specifications and literature, during the transitional period, product markings that include both older and newer materials designations, may occur.

Note 6—Manufacturers using the seal of approval of an accredited laboratory must obtain prior authorization from the laboratory concerned.

9.2 Markings that identify gas, communications or electrical use are prohibited.

10. Quality Assurance

10.1 When the product is marked with this designation, D3035, the manufacturer affirms that the product was manufactured, inspected, sampled, and tested in accordance with this specification and has been found to meet the requirements of this specification.

11. Keywords

11.1 DR; OD; controlled; PE pipe; plastic pipe; potable water pipe; polyethylene pipe; service pipe; SDR; water pipe; water service pipe
Product Standards from ASTM, AWWA, CSA, and NSF

Standards related to GSHP HDPE piping systems – Relevance and Value
- Product standards contain extremely detailed lists of requirements. Example: NSF 358-1

4.4.4 Test the specimens for tensile strength in accordance with ASTM D2290, Procedure B, using 0.5 in/min testing speed within ½ h after weighing for ring tensile specimens, and per ASTM D638 using 2 in/min testing speed within ½ h after weighing for tensile bar specimens. 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>
Product Standards from ASTM, AWWA, CSA, and NSF

HDPE Properties – Cell Classification According to ASTM D3350

- **ASTM D3350** *Standard Specification for Polyethylene Plastics Pipe and Fitting Materials* defines the “Primary” pipe material properties

1. Density
2. Melt Index
3. Flexural Modulus
4. Tensile Strength
5. Slow Crack Growth Resistance
6. Hydrostatic Design Basis (HDB)
7. UV Stabilization

<table>
<thead>
<tr>
<th>Property</th>
<th>Test Method</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Density, g/cm³</td>
<td>D1505</td>
<td>0.925 or lower</td>
<td>&gt;0.925–0.940</td>
<td>&gt;0.940–0.947</td>
<td>&gt;0.947–0.955</td>
<td>&gt;0.955</td>
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<tr>
<td>Melt Index</td>
<td>D1238</td>
<td>&gt;1.0</td>
<td>1.0 to 0.4</td>
<td>&lt;0.4 to 0.15</td>
<td>&lt;0.15</td>
<td>c</td>
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</tr>
<tr>
<td>Flexural Modulus, MPa (psi)</td>
<td>D790</td>
<td>&lt;138</td>
<td>138–276</td>
<td>276–552</td>
<td>552–758</td>
<td>&gt;758</td>
<td>&gt;1103 (110 000 to &gt;160 000)</td>
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</tr>
<tr>
<td>Tensile Strength at Yield, MPa (psi)</td>
<td>D638</td>
<td>&gt;15</td>
<td>15–18</td>
<td>18–21</td>
<td>21–24</td>
<td>24–28</td>
<td>&gt;28</td>
<td>&gt;4000</td>
<td>Specify Value</td>
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<tr>
<td>Slow Crack Growth Resistance</td>
<td>D1693</td>
<td>A</td>
<td>B</td>
<td>C</td>
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<td>Hydrostatic Strength Certification</td>
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<td>NPRF</td>
<td>5.52</td>
<td>6.89</td>
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<td></td>
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<td>...</td>
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<td>8</td>
<td>10</td>
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<td>Specify Value</td>
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</tbody>
</table>
### HDPE Properties – Cell Classification According to ASTM D3350

<table>
<thead>
<tr>
<th>Property</th>
<th>PE3408</th>
<th>PE3608</th>
<th>PE4710</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Density</td>
<td>3</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>2. Melt Index</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>3. Flexural Modulus</td>
<td>5</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>4. Tensile Strength</td>
<td>4</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>5. Slow Crack Growth Resistance</td>
<td>4</td>
<td>6</td>
<td>7</td>
</tr>
<tr>
<td>6. Hydrostatic Design Basis (HDB)</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>7. UV Stabilization</td>
<td>C or E</td>
<td>C or E</td>
<td>C or E</td>
</tr>
</tbody>
</table>

**Pressure Pipe Cell Classifications:**
- PE3408: 345444C or E
- PE3608: 345464C or E
- PE4710: 445574C or E
Pipe Material Designation Codes: “PE3408”, “PE3608”, and “PE4710”

- Thermoplastic pipe material designation codes are defined in ASTM F412
- Specific properties make up the PE Pipe Material Designation Code
  - First digit: “the cell classification number value for density”
  - Second digit: “the cell classification number value for slow crack growth resistance”
  - Third & Fourth digits: “the hydrostatic design stress when tested with water at 73°F, in units of 100 psi”

- **PE4710** is the new generation, state-of-the-art, PE pressure pipe material with:
  - Higher density/stiffness (compared with PE3408 and PE3608)
  - Much higher slow crack growth resistance
  - Higher hydrostatic design stress (1,000 psi vs. 800 psi) = Higher pressure ratings
Product Standards from ASTM, AWWA, CSA, and NSF

Summary
- Listing the right standards for the right items is the best way to ensure that customers will receive what was expected (i.e., the right products, the right systems)

- Specifying products via standard designations is the clearest way to communicate requirements

- Fulfilling specifications (i.e., supplying products and systems) with products meeting the listed standards provides safety, performance, and customer satisfaction

- Understanding material codes is important for selecting the right pipe

- Being aware of piping standards helps to ensure compliance with codes
3. Examples of “Inappropriate” Piping Specifications

Problems of Inappropriate or out-of-date piping specifications (“bad specs”)
- “Bad specs” might cite inappropriate product standards, causing confusion with manufacturers, the supply chain, and installers (the wrong products might get supplied and installed)

- “Old specs” might list obsolete piping materials that are no longer in production (everyone is guessing)

- “Custom specs” may combine inappropriate or incompatible requirements, sometimes pulled from various sources with the best intentions, lacking thoroughness and up-to-date requirements (no product complies!)

- Sometimes referred to as “Frankenstein Specs” (specification monsters)

Is this really what Dr. Frankenstein intended?
Examples of “Inappropriate” Piping Specifications

Problems of Inappropriate or out-of-date piping specifications - Example 1
- Gas pipe may not be suitable for geo applications

GEOTHERMAL GROUND-LOOP PIPING

PART 1 GENERAL

1.01 REFERENCES

A. Publications listed here are part of this specification to the extent they are referenced. Where no specific edition of the standard or publication is identified, the current edition shall apply.

B. ASHRAE – American Society of Heating, Refrigerating, and Air-Conditioning Engineers

C. ASTM – American Society for Testing and Materials
   1. ASTM D2513 – Standard Specification for Thermoplastic Gas Pressure Pipe, Tubing, and Fittings
   2. ASTM F876 – Standard Specification for Crosslinked Polyethylene (PEX) Tubing
   4. ASTM F1055 – Standard Specification for Electrofusion Type Polyethylene Fittings for Outside Diameter Controlled Polyethylene Pipe and Tubing
Examples of “Inappropriate” Piping Specifications

Problems of Inappropriate or out-of-date piping specifications - Example 1
- Pipe manufacturers generally don’t make fittings and vice-versa
- IGSHPA does not “approve” products

1.04 QUALITY ASSURANCE

A. Manufacturer: Must be a company specializing in the Work of this Section with a minimum of 5 years documented experience.
B. All components shall be supplied by one manufacturer.
C. Pipe shall be manufactured in a facility whose quality management system is ISO 9001 certified.
D. Pipe and fittings shall be IGSHPA approved.
Examples of “Inappropriate” Piping Specifications

Problems of Inappropriate or out-of-date piping specifications - Example 1
- PEX is not “PE 4710”
- ASTM F876 PEX tubing is SDR9, not SDR11
- Oil Creek Plastics does not produce PEX

PART 2 PRODUCTS

2.01 ACCEPTABLE MANUFACTURER
   A. Oil Creek Plastics Geothermal Pipe or approved equal.

2.02 PIPING
   A. Ground loop heat exchange pipe shall be SDR11, PE 4710 high-density cross-linked polyethylene manufactured using the high-pressure peroxide method of crosslinking (PEXa). Pipe shall conform to (a) ASTM F876 and ASTM F877n and (b) CSA B137.5 and (c) CSA C448 or (d) ISO 15875-1:2003, 15875-2:2003 or DIN 16892 and 16893.
   B. Pipe shall be rated for continuous operation of 100 psi gauge pressure at 180°F temperature, and 160 psi gauge pressure at 73.4°F temperature.
Examples of “Inappropriate” Piping Specifications

Problems of Inappropriate or out-of-date piping specifications - Example 1
- Same spec, next page: Calls for SDR 13.5 PE4710 (not SDR 11 PEX)
- But the fittings are for “PEX carrier pipe”
- Electrofusion fittings are typically made of HDPE

2.05 UNDERGROUND CARRIER PIPING

A. SDR 13.5, PE 4710 Geothermal Pipe by Oil Creek Plastics or approved equal.

B. Markings: The outer casing shall be marked with the following information, repeated no less than every 5 feet (1.5 meters):
1. Manufacturer name or trade name
2. Carrier pipe nominal size and Standard Dimensional Ratio (SDR)
3. Temperature and pressure ratings
4. Footage markings

C. Fittings: Mechanical fittings to be suitable for the fluid application, in a size suitable for the PEX carrier pipe dimensions.
1. Electro-fusion Fittings: Electro-fusion fittings made from cross-linked polyethylene used for joining PEX-a pipes.
Examples of “Inappropriate” Piping Specifications

Problems of Inappropriate or out-of-date piping specifications - Example 2

- “Virgin” HDPE resin is required in all pressure pipe standards (Clean, rework material from the manufacturer’s own pipe production is allowed)

- Canada/US pipe standards do not list a “32 mm” pipe. Do they really want 32 mm metric pipe from Europe, or 1 ¼ inch pipe?

- 200 psi = 1378 kPa, not “1280 kPa”
Examples of “Inappropriate” Piping Specifications

Problems of Inappropriate or out-of-date piping specifications - Example 2

- Canada/US pipes standards do not list a “50 mm” or “75 mm” pipe

- “PE4710” does not have a cell class of “345564” or “345434” (PE3408), so which material should be supplied?

- PE4710 will not meet part .6
Examples of “Inappropriate” Piping Specifications

Problems of Inappropriate or out-of-date piping specifications - Example 3
- Do they really want “32 mm” metric pipe from Europe, or 1 ¼ inch pipe?

- “Virgin” HDPE resin is required in all pressure pipe standards, so this is automatic

- “PE4710” does not have a cell class of “345564” or “345434” (PE3408), so which material should be supplied?

- Stamped “certificate or origin” - strange request

- Simply require “third-party certification” for the pipe to meet CSA B137.1

Part 2- Products

2.1 LOOP PIPE

2.1.1 Vertical loop pipe shall consist of 32 mm (1.25 inch) diameter PE4710 SDR 11 polyethylene pipe.

2.1.2 The vertical loop pipe shall meet the requirements of CSA Standard B137.1.

2.1.3 The vertical loop pipe shall have permanent markings in accordance with CSA Standard B137.1, indicating the intended service as "Geothermal" or "Geo" and the CSA Standard number "C448".

2.1.4 The vertical loop piping shall not carry the word "potable" or the letters "P" or "PW" on its surface.

2.1.5 The vertical loop pipe shall be constructed of virgin high density polyethylene (HDPE) resin with a PE4710 piping formulation classification.

2.1.6 The vertical loop piping material shall have a cell classification of 345564 or 345434 as specified in ASTM Standard D3350.

2.1.7 Provide a certificate of origin of the pipe pigment and resin formulation from the pipe manufacturer. This certificate will have the CSA stamp confirming that the pipe material meets CSA B137.1.

2.1.8 Each borehole loop shall have a tail of 2 m above the surface grade of drilling, or as approved by Engineer.
Examples of “Inappropriate” Piping Specifications

Summary
- Just a few examples of specifications with unclear, inappropriate, or impossible-to-meet requirements
- There is a better way!

Courtesy Centennial Plastics
4. PPI Model Specification MS-7

Introduction

- Published May 2023 as part of a family of Model Specifications provided as a service to the industry
- A guide to support designers and specifiers of ground source geothermal heat exchange systems with ground loop piping information

- Free download, no charge
- *Word* version available upon request

- **PPI MS-7** includes detailed specifications for four plastic piping materials which have been proven for use in ground source heat exchange systems: **HDPE, PE-RT, PEX, and PP**
Table of Contents

1.0 General
2.0 Ground Loop Piping Products
3.0 Ground Loop Piping Installation
4.0 Indoor Piping Products

- Access at www.plasticpipe.org/buildingconstruction
1.2 Definitions (27)

- From “Antifreeze” to “Vertical Borehole Heat Exchanger”

**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”.
PPI Model Specification MS-7

1.3 Referenced Standards (36)
- From ASTM, AWWA, CSA, NSF, and PPI

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

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 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
2.0 Ground Loop Piping Products
- Sections for HDPE, PE-RT, and PEX
- Users can choose to select from either or all of these piping materials
PPI Model Specification MS-7

2.2.1 HDPE Pipe and Tubing

a) Pipe and tubing standards (ASTM or CSA)
b) Material – PE4710 (cell class 445574C or E)
c) PPI HSB TR-4 listing for long-term strength
d) Certification to NSF 358-1
e) Certification to NSF/ANSI/CAN 61
f) DR and pressure ratings per Table 1
PPI Model Specification MS-7

Table 1
- SDR 13.5 is allowed for vertical systems
- SDR 13.5 is allowed for horizontal systems
- SDR 17 is allowed for horizontal systems in diameters 3 inch and larger

<table>
<thead>
<tr>
<th>Nominal pipe size</th>
<th>Minimum pipe pressure rating</th>
<th>Maximum dimension ratio</th>
<th>Minimum pipe pressure rating</th>
<th>Maximum dimension ratio</th>
</tr>
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<tr>
<td>3/4</td>
<td>160 (1103)</td>
<td>SDR 13.5</td>
<td>160 (1103)</td>
<td>SDR 13.5</td>
</tr>
<tr>
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<td>125 (862)</td>
<td>SDR 13.5</td>
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<td>SDR 13.5</td>
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<td>3</td>
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<td>SDR 17</td>
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<tr>
<td>8 and larger</td>
<td>6</td>
<td>6</td>
<td>100 (690)</td>
<td>SDR 17</td>
</tr>
</tbody>
</table>
PPI Model Specification MS-7

2.2.3 HDPE Pipe and Tubing Fittings
a) Fitting standards (ASTM x 3)
b) Material – PE4710 (cell class 445574C or E)
c) Certification to NSF 358-1
d) Certification to NSF/ANSI/CAN 61
e) Pressure ratings per Table 1

2.2.4 HDPE U-Bends
- Factory-fabricated
2.2.5 Installation of HDPE Fittings

a) Follow ASTM Standard Practice F2620…
b) Follow ASTM Standard Practice F2620…
c) Follow ASTM Standard Practice F1290…

“…and the instructions of the pipe and tubing or fitting manufacturer(s).”
PPI Model Specification MS-7

2.3 PE-RT Tubing and Fittings

- Same format of requirements as for HDPE

- PE-RT is HDPE with enhanced temperature capabilities

2.3. Polyethylene of Raised Temperature Resistance (PE-RT) Tubing and Fittings

2.3.1. PE-RT Tubing

PE-RT tubing shall:

a) be certified to the requirements of CSA B137.18 or ASTM F2769;

b) be manufactured from a PE compound that has a pipe material designation code of PE3608, or PE4710 when evaluated in accordance with ASTM D3350;

c) be listed by The Plastics Pipe Institute’s Hydrostatic Stress Board (HSB) in PPI TR-4 with the minimum Hydrostatic Design Stress (HDS) value of 630 psi at 73°F (23°C);

d) be certified to the requirements of NSF Standard 358-4;

e) be certified to the requirements of NSF/ANSI/CAN 61; and

f) meet the dimension ratio and pressure rating requirements specified in Table 1.
PPI Model Specification MS-7

2.4 PEX Pipe, Tubing, and Fittings
- Same format of requirements as for HDPE
- PEX is HDPE with enhanced temperature capabilities and other advantages

2.4. Crosslinked Polyethylene (PEX) Pipe, Tubing, and Fittings
2.4.1. PEX Pipe and Tubing

PEX pipe and tubing shall:

a) be certified to the requirements of CSA B137.5, ASTM F876, or ASTM F2788;

b) have a minimum material designation code as per CSA B137.5, ASTM F876, or ASTM F2788 of “PEX1208”;

c) be listed by The Plastics Pipe Institute’s Hydrostatic Stress Board (HSB) in PPI TR-4 with the minimum Hydrostatic Design Stress (HDS) value of 630 psi at 73°F (23°C);

d) be certified to the requirements NSF 358-3;

e) be certified to the requirements of NSF/ANSI/CAN 61; and

f) meet the dimension ratio and pressure requirements specified in Table 1.

Courtesy REHAU
2.4.4 PEX Pipe and Tubing Fittings

Underground and underwater joints and fittings for PEX plastic pipe and tubing used in ground heat exchanger systems shall:

a) be certified to ASTM F1807, ASTM F1960, ASTM F2080, ASTM F2159, ASTM F3347, or ASTM F3348 for use with PEX tubing, and ASTM F2829 for PEX pipe, and shall be approved for direct burial by the manufacturer;

b) be certified to the dezincification resistance and stress corrosion cracking resistance requirements of NSF/ANSI 14;

c) be certified to the requirements of NSF/ANSI/CAN 61;

d) meet the minimum pressure requirements specified in Table 1;

e) be certified to meet the performance requirements of ASTM F877 for PEX tubing and ASTM F2829 for PEX pipe;

f) be installed in accordance with the fitting manufacturer's instructions; and

g) be marked in accordance with the relevant fitting standard specification as per Section 2.4.3.a

2.4.4.1 Electrofusion fittings with PEX pipe and tubing

Polyethylene electrofusion fittings shall be qualified for use with PEX pipe according to ASTM F3373 and shall be qualified for use with PEX tubing according to ASTM F1055.
PPI Model Specification MS-7

Table 1
- Specific requirements for pressure ratings and minimum wall thickness (via “Maximum SDR”)

- Most plastic pipe follows a **Standard Dimension Ratio (SDR)**
- SDR Definition: *the ratio of outside diameter to wall thickness, calculated by dividing the average outside diameter of the tubing by the minimum wall thickness.*
- Bigger SDR number = thinner wall and lower pressure rating
- SDR is also known as “wall type”

SDR = OD/t

<table>
<thead>
<tr>
<th>Nominal pipe size</th>
<th>Minimum pipe pressure rating</th>
<th>Maximum dimension ratio(^a) all pipe &amp; tubing</th>
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</tbody>
</table>

\(^a\) Normal pressure and temperature.
PPI Model Specification MS-7

Table 1
- Several informative notes, including:
  - So-called soft metric conversions of these nominal pipe sizes may cause confusion.
  - For instance, a specification for a “25 mm pipe” would not match any of the available HDPE, PE-RT, or PEX pipes meeting the referenced standards.
  - Designers and specifiers should specify the nominal pipe sizes as shown in Table 1.

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<td>100 (690)</td>
<td>SDR 13.5</td>
<td>100 (690)</td>
<td>SDR 17</td>
</tr>
</tbody>
</table>

1 Vertical installations also include diagonal, inclined, and angled installations.
2 Horizontal installations also include headers for use in vertical borehole heat exchanger systems, horizontal directional drilling (HDD) installations, and submersed heat exchangers.
3 Nominal pipe sizes indicate the nominal diameter by which a pipe is designated. The specific product dimensions (i.e., outside diameter and inside diameter) are based on referenced standards for HDPE, PEX, and PE-RT pipe and tubing materials. Actual outside and inside diameters are not the same as the nominal sizes. So-called soft metric conversions of these nominal pipe sizes may cause confusion. For instance, a specification for a “25 mm pipe” would not match any of the available HDPE, PE-RT, or PEX pipes meeting the referenced standards. Designers and specifiers should specify the nominal pipe sizes as shown in Table 1.
4 Pressure ratings listed in Table 1 are for water at 73°F (23°C). Pressure ratings will be reduced for operating temperatures above 80°F (27°C) according to the materials and the relevant product standards.
5 A numerically lower Standard Dimension Ratio (SDR) value indicates a thicker wall for a given diameter. For example, SDR 11 pipe has a thicker wall than SDR 13.5 pipe. Therefore, a numerically lower dimension ratio (e.g., SDR 9) complies with a maximum dimension ratio of SDR 11 as listed in Table 1.
6 The Maximum Dimension Ratios specified in Table 1 are to ensure that pipe or tubing has a sufficiently thick wall in all diameters for the purpose of resisting typical working stresses during installation, resistance to kinking and incidental mechanical damage caused by handling, uncoupling, abrasion against borehole casing, rocks, debris, etc., so that the pipe or tubing may withstand minor scratches or gouges without loss of pressure capability.
7 Using this nominal pipe size in a vertical borehole installation is considered an exception that requires evaluation by a professional engineer.
3.0 Ground Loop Piping Installation
3.1 Piping Installation – General
3.2 Bend Radius
3.3 Vertical Borehole Heat Exchanger Piping Installation
3.4 Horizontal Loop Piping Installation
3.5 Field Quality Control

3.0 GROUND LOOP PIPING INSTALLATION
3.1 Piping Installation – General
The following procedures shall be utilized for installation of high-density polyethylene (HDPE), crosslinked polyethylene (PEX), and polyethylene of raised temperature (PE-RT) pipe and tubing as ground loop piping.

a) Pipe and tubing shall be inspected before installation and any sections that have cuts, gouges, kinks, or other signs of significant damage shall be removed.
b) To avoid surface abrasion, pipe and tubing shall not be dragged over rough ground or obstructions.
c) Pipe and tubing shall not be bent to form a sharp angle or kink.
d) Where pipe or tubing is dispensed from an uncoiling device, it shall be mounted in such a way that stresses are minimized during installation. The pipe shall not be subjected to reverse curvature.
e) Pipe and tubing shall not be installed in contact with or close to hot surfaces in excess of their highest rated operated temperature.
f) Pipe and tubing shall be inserted into boreholes without significant damage.
g) The installation process shall be defined such that the internal and external hydrostatic pressures exerted on the pipe during installation can be shown not to exceed the pressure rating of the pipe (internal hydrostatic pressure) and collapse (i.e., external hydrostatic buckling) resistance of the pipe (external pressure caused by water or grout in the borehole), respectively.
h) Backfill material must be free of large stones or other dense hard objects which could damage the pipe when dropped into the trench or create concentrated pipe loading.

3.2 Bend Radius
Pipe or tubing shall not be bent to a radius less than the minimum bend radii as follows.

---

*significant damage* is defined as a scratch, dent, or gouge of a depth greater than 10% of the minimum pipe wall thickness that is required for the pipeline’s operating pressure or the minimum wall thickness required to meet structural design requirements.
PPI Model Specification MS-7

3.0 **Ground Loop Piping Installation**
3.1 Piping Installation – General
3.2 Bend Radius
3.3 Vertical Borehole Heat Exchanger Piping Installation
3.4 Horizontal Loop Piping Installation
3.5 Field Quality Control

### 3.2.1. HDPE Pipe and Tubing Bend Radius

The minimum bend radius of HDPE pipe and tubing shall be in accordance with Table 2. When a fitting or flange connection is present in the pipe bend, the minimum bend radius shall be one hundred times the pipe outside diameter (OD) for a distance of five times the pipe diameter on either side of the fitting location.

<table>
<thead>
<tr>
<th>DIMENSION RATIO (DR)</th>
<th>MINIMUM BEND RADIUS</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>20 x Pipe OD</td>
</tr>
<tr>
<td>9</td>
<td>20 x Pipe OD</td>
</tr>
<tr>
<td>11</td>
<td>25 x Pipe OD</td>
</tr>
<tr>
<td>13.5</td>
<td>25 x Pipe OD</td>
</tr>
<tr>
<td>15.5</td>
<td>27 x Pipe OD</td>
</tr>
<tr>
<td>17</td>
<td>27 x Pipe OD</td>
</tr>
<tr>
<td>Fitting/flange present in the pipe bend</td>
<td>100 x Pipe OD</td>
</tr>
</tbody>
</table>

### 3.2.2. PEX Tubing Bend Radius

The minimum bend radius of PEX pipe and tubing is six times the outside diameter (OD) of the tubing or in accordance with the manufacturer’s installation instructions.

### 3.2.3. PE-RT Tubing Bend Radius

The minimum bend radius of PE-RT tubing is six times the outside diameter (OD) of the tubing or in accordance with the manufacturer’s installation instructions.
PPI Model Specification MS-7

3.0 Ground Loop Piping Installation
3.1 Piping Installation – General
3.2 Bend Radius
3.3 Vertical Borehole Heat Exchanger Piping Installation
3.4 Horizontal Loop Piping Installation
3.5 Field Quality Control

3.3. Vertical Borehole Heat Exchanger Piping Installation
   a) Install piping in boreholes according to ASTM D2774 or ASTM F645.
   b) Clean pipe and fittings and make heat-fusion joints according to ASTM F2620, ASTM F1056 or ASTM F3373 for electrofusion fittings. Minimize the number of joints.
   c) Purge, flush, and pressure test vertical loop piping before backfilling borehole heat exchangers. See Field Quality Control in Section 3.5.
   d) Completely fill the borehole from bottom to top with grout, water, or other backfill material as specified. Grout material shall be pressure pumped through the appropriately sized tremie pipe and placed in the borehole column from the bottom to the top (or from end to end in a horizontally bored application). When required, mark borehole locations with detectable locator tape.

3.3.1. Prevention of Hydrostatic Buckling or Collapse
   When external pressure is applied to the outer wall of cylinder, there is the possibility of buckling or collapse of the cylinder. A pipe can be considered a cylinder in this regard.

   For plastic pressure pipe and tubing materials that are installed within deep vertical boreholes, there is the theoretical possibility that external pressure caused by grout or groundwater on the outside of pipes could cause unconstrained pipe buckling or collapse. The term “unconstrained” is used when pipes are not surrounded with compacted backfill, as is the case in a borehole heat exchanger.

   Extensive industry experience has provided the mathematical models to predict when such buckling could occur, allowing designers and installers to prevent such occurrences.

   The calculation methods presented in the PPI Handbook of Polyethylene Pipe (Chapter 6) or in the ASHRAE HVAC Applications Handbook (Chapter 35, Geothermal Energy) may be used to illustrate that the installation process does not exceed pipe pressure or buckle/collapse resistance ratings.
PPI Model Specification MS-7

3.0 Ground Loop Piping Installation
3.1 Piping Installation – General
3.2 Bend Radius
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3.4 Horizontal Loop Piping Installation
3.5 Field Quality Control

3.4. Horizontal Loop Piping Installation
   a) All excavations shall comply with local regulations.
   b) Install piping in trenches according to ASTM D2774 or ASTM F645. All piping shall be placed at minimum depth from grade as shown on the drawings.
   c) Pipe embedment material should be Class I, Class II, or Class III materials as defined by ASTM D2321 Section 6.
   d) Pipe bedding shall be in conformance with ASTM D2321 Section 8. Compaction rates should be as specified by ASTM D2321.
   e) Extend the horizontal piping and connect to ground-loop heat-pump piping systems at outside face of building wall in locations and pipe sizes indicated.
   f) Terminate water-service piping at the building wall or inside mechanical room of building until ground-loop heat-pump piping systems are installed. Terminate piping with caps and/or isolation valves as indicated on the contract documents. Make connections to indoor pipe of heat pump systems when those systems are installed. Fill the entire piping loop with potable water that meets the required water quality.
   g) Seal penetrations through building walls using a compressible sleeve seal or other approved product.
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3.0 **Ground Loop Piping Installation**
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3.5 **Field Quality Control**

3.5. **Field Quality Control For Ground Loop Piping**

3.5.1. **Inspection of Ground Loop Piping before Installation**

All ground loop pipe and tubing shall be physically inspected at the jobsite before installation and any sections that have cuts, gouges, kinks, or other signs of significant damage shall be removed.

Cap or tape each pipe end until the pipe is joined to other pipes to avoid contamination from trash, soil, small animals, and other foreign debris.

3.5.2. **Pressure Testing of Ground Loop Pipes before Installation**

Before installation of pipes in the ground, test pipes according to the manufacturer’s recommendations.

3.5.3. **Ground Loop Flush/Purge after Pipe Installation**

Ensure that the exterior ground loop piping has been filled with liquid and purged of air and debris, pressure tested, and filled with proper quality water and heat transfer fluid as specified.

Flushing, pigging, or other means of cleaning the system to remove dirt and debris that may damage valves, regulators, and so forth may be required before testing.

The flushing/purging flow rate shall be 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 (pressure) recommended by the pipe and fittings manufacturer to remove debris. For pipes of nominal diameter 3 inches and larger, fluid velocity higher than 2 ft per second (0.6 m/s) may be required to adequately remove dirt and rock debris.
3.0 **Ground Loop Piping Installation**

3.1 Piping Installation – General
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3.4 Horizontal Loop Piping Installation
3.5 Field Quality Control
3.5.4 **Hydrostatic Pressure Testing of Installed Pipes**

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3.5.4. **Hydrostatic Pressure Testing of Installed Pipes:**

Pressure tests shall be conducted in accordance with ASTM F2164 Standard Practice for Field Leak testing of Polyethylene (PE) and Crosslinked Polyethylene (PEX) Pressure Piping Systems Using Hydrostatic Pressure which provides information on apparatus, safety, restraints, pre-test preparation, and procedures for conducting pressure tests, and the piping manufacturer’s recommendations.
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3.0 **Ground Loop Piping Installation**

3.1 Piping Installation – General
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3.4 Horizontal Loop Piping Installation
3.5 Field Quality Control
3.5.4 Hydrostatic Pressure Testing of Installed Pipes
3.5.4.1 Supplemental Information on Hydrostatic Testing

**Supplemental Information on Hydrostatic Testing**

- a) Before testing, heat fusion joints shall be completely cooled following procedures outlined in ASTM F2620 and ASTM F1055.
- b) Leakage or failures are more likely to occur at joints than in piping sections.
- c) Mechanical connections shall be completely assembled with all necessary seals and all fasteners installed and tightened.
- d) Components that are not to be subjected to test pressure or could be damaged by test pressure shall be isolated or removed as necessary. If lower pressure-rated components cannot be removed or isolated from the test section, the maximum test pressure is the pressure rating of the lowest pressure-rated component that cannot be isolated from the test section.
- e) There is no leakage allowance for HDPE, PE-RT, or PEX piping systems.
- f) When HDPE, PE-RT, or PEX piping systems are first pressurized,
- g) The test fluid shall not be allowed to freeze during the pressure test. In freezing conditions, ensure that adequate antifreeze is used to prevent freezing.
- h) Each pipeline section to be tested shall be restrained against movement in the event of catastrophic failure. Joints may be exposed for leakage examination, provided that restraint is maintained.
- i) Leakage at any joint indicates a defective joint which could rupture or separate while under pressure. Immediately remove pressure and replace any leaking joints before a retest.
- j) Test pressure and duration shall be in accordance with ASTM F2164.
- k) Only authorized people should be in the proximity of the piping systems during the testing procedure and must be wearing the appropriate personal protective equipment (PPE).
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3.5 Field Quality Control
3.5.4 Hydrostatic Pressure Testing of Installed Pipes
3.5.4.1 Supplemental Information on Hydrostatic Testing
3.5.5 Hydrostatic Test Records

The following information about hydrostatic pressure tests shall be documented:

a) A description of the test section components (e.g., circuit number/location)
b) The test liquid
c) The target test pressure in addition to test pressures recorded during the test.
d) The type of test gauge used to measure the pressure
e) Location of test gauges through the piping system
f) The test date and duration (starting time, ending time)
g) The weather conditions and ambient temperature at the site during the test
h) Any adjustments made to test pressure for elevated temperature, pipe expansion, etc.
i) Description of any leaks or failures and the corrective actions taken
j) The identification of the party conducting the test
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4.0 Indoor Piping Products

4.1 Pipe and Fitting Materials for Indoor Piping
   a) HDPE
   b) PE-RT
   c) PEX
   d) PP

4.2 PP-R and PP-RCT Pipe and Fittings

These four materials are recommended for indoor piping.

Annual Conference, December 5 - 7, 2023 – Las Vegas, NV
PPI Model Specification MS-7

Comments on using PPI MS-7
- This is the 1st Edition; suggestions are welcome
- Codes change regularly, so this can become out-of-date
- The user/specifier has to select which pipe type/types to allow
  (e.g., HDPE, PE-RT, and/or PEX)
- For HDPE and PEX, specifier must specify pipe or tubing dimensions
- IPS pipes are typically larger than CTS pipes
- Example: CTS 1 Tubing OD = 1.125" (28.6 mm)
  IPS 1 Pipe OD = 1.315" (33.4 mm) 15% larger

- MS-7 is like a menu:
  Order your preference!
PPI Resources for the Geo Industry

Plastic Piping Design Calculator – Pressure Drop / Head Loss
- Free online sizing tool at www.plasticpipecalculator.com

Plastic Pipe Design Calculator

PRESSURE DROP / HEAD LOSS

Input
Is this a Geothermal Application? ✔

Pipe/Tubing Selection¹
- Pipe/Tubing Material: HDPE - PE 4710
- Sizing Type (CTS/IPS/Metric): IPS (ASTM D3035/CSA B137.1)
- Wall Type (SDR/Schedule): SDR 11
- Nominal Pipe/Tubing Size²: 1 1/4

Results
- Flow Regime: Turbulent
- Pressure Drop: 7.0 Psi (48.5 kPa)
- Head Loss: 16.2 ft water
- Velocity*: 2.1 ft/s (0.6 m/s)

* Values shown above are not an indication that the flow velocity is acceptable for your application. Always refer to and follow the pipe manufacturers recommended velocity limits.
New Model Specification for Geo Piping Materials

Presentation Summary

1. Explain HDPE pipe and fittings using industry standards and code requirements

2. Introduce product standards from ASTM, AWWA, CSA, and NSF

3. Examples of “inappropriate” or out-of-date piping specifications

4. Share new Model Specification PPI MS-7 and how to utilize it

Thank you!
New Model Spec for Piping Materials

Avoiding confusion and costly mistakes when specifying piping materials

Geothermal: The Genius Renewable

Live at Groundwater Week in partnership with NGWA

Las Vegas, NV
December 5-7, 2023