Plastics Pipe Institute
BUILDING & CONSTRUCTION

Plastic Piping Materials for Ground Source Geothermal Systems

A presentation by The Plastics Pipe Institute

ASPE CEU PROVIDER
American Society of Plumbing Engineers

Contact

Lance MacNevin, P.Eng.

PPI Director of Engineering - Building & Construction Division

lmacnevin@plasticpipe.org Tel (469) 499-1057

The Plastics Pipe Institute

PPI Represents the Plastic Pipe Industry

- PPI was 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

Members: Over 170 member firms involved with the plastic pipe industry

PPI Website: www.plasticpipe.org

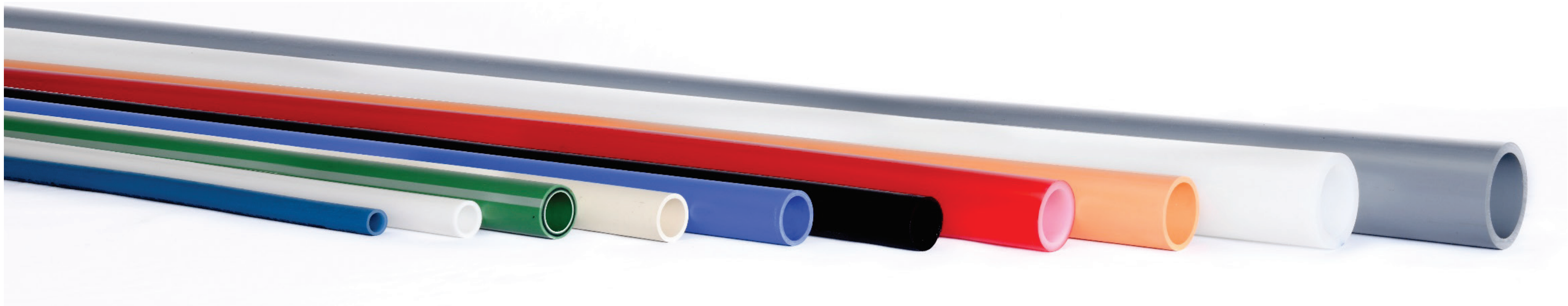
The Plastics Pipe Institute

PPI Building & Construction Division (BCD)

- BCD is focused on plastic pressure pipe and tubing systems used within buildings and on building premises for applications such as plumbing, water service, fire protection, hydronic heating & cooling, snow & ice melting, district energy heating & cooling, and ground source geothermal piping systems.

BCD Materials: CPVC, HDPE (Geothermal), PEX, PE-RT, PEX-AL-PEX, and PP (PP-R & PP-RCT)

BCD homepage: https://plasticpipe.org/BuildingConstruction



Ground Source Geothermal Systems

Ground Source Geothermal

- Ground source heat pumps are the **most efficient** source of heating and cooling energy for buildings
- The **Ground Loop Pipe** is the heat exchanger with the Earth (a.k.a. the “ground-coupled heat exchanger”)
- There are multiple methods of installing ground loop pipes, depending on sight location, hydrology, etc.

Horizontal ground loops

Vertical pipes in boreholes

Submerged pipes in water

Images Courtesy IGSHPA

Ground Source Geothermal Systems

Relevance: Two recent **PPI BCD Project of the Year** winners have been Geothermal projects

- **2018: Whisper Valley** Net-Zero Capable Community (Phase I) in Austin, TX
    - 237 homes with PEX double U-bends in a community geo system (313,000 feet of pipe)

Ground Source Geothermal Systems

Relevance: Two recent **PPI BCD Project of the Year** winners have been Geothermal projects

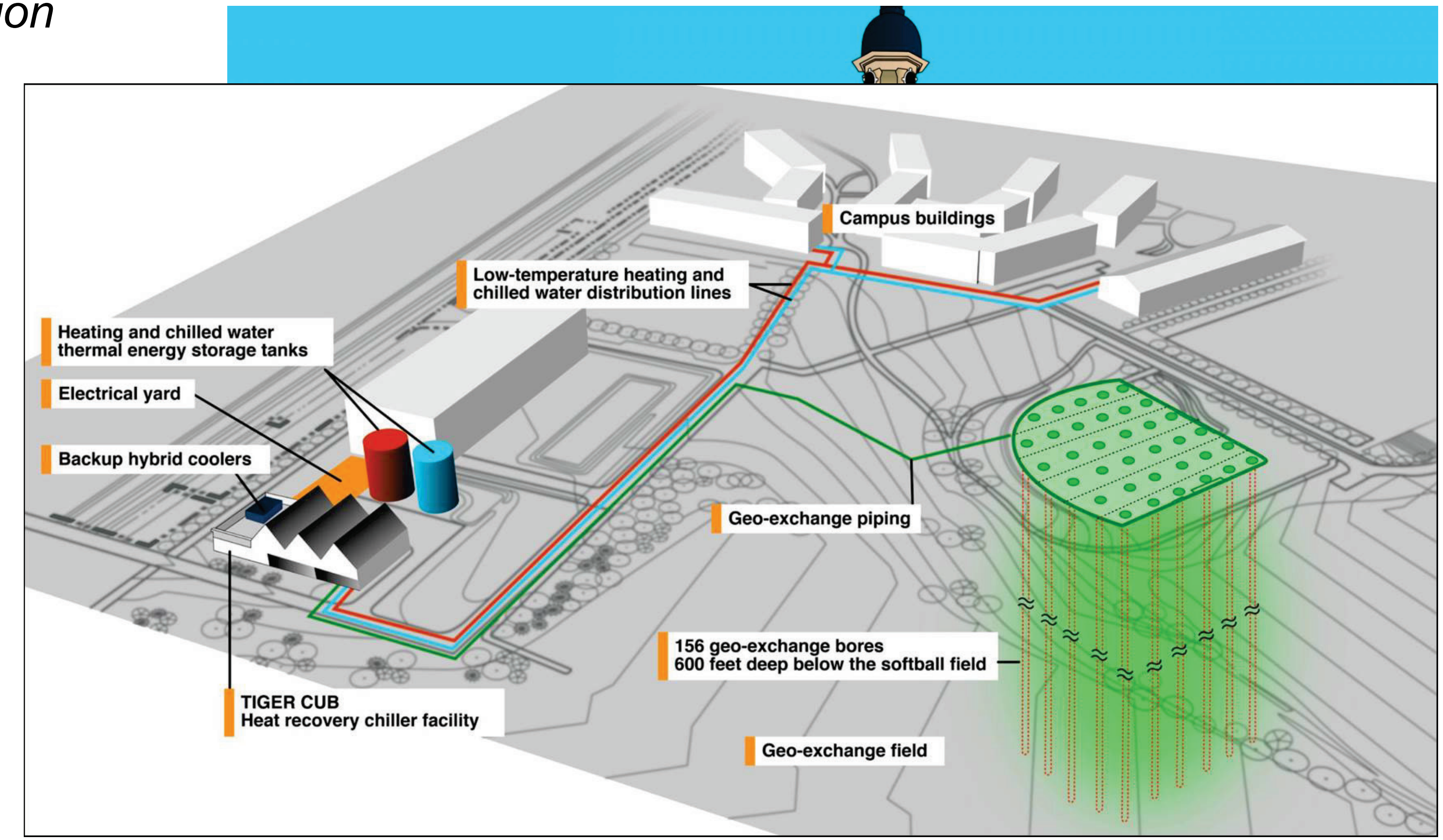
- **2019: YVR Airport** Geoexchange System in Vancouver, BC
    - 841 boreholes 500 ft deep with PE4710 loops plus headers (841,000+ feet of pipe)

Ground Source Geothermal Systems

Relevance

Princeton University (NJ) Geothermal conversion

- *"Princeton is phasing out steam generation for heating and instead implementing a new low-temperature heating water energy system driven by electric heat pumps, thermal storage and geo-exchange, which captures heat from inside campus buildings in the summer and stores that energy in the ground until it is needed again in the winter."*



Presentation Outline

This presentation will:

1. Describe the **four types** of plastic piping materials used for ground source geothermal systems
   - **HDPE** *high density polyethylene*
   - **PEX** *crosslinked polyethylene*
   - **PE-RT** *polyethylene of raised temperature resistance*
   - **PP** *polypropylene (PP-R and PP-RCT)*

2. Discuss geothermal industry **standards** and **codes**

3. Demonstrate various **manifold** and **header** techniques

4. Introduce **PPI resources** of piping information

Prologue: Plastic Piping Materials - General

Drinking Water Safety

- All plastic tubing, pipes, and fittings intended for potable (drinking) water must meet the requirements of **NSF/ANSI/CAN Standard 61** *Toxicological Evaluation for Materials in Contact with Drinking Water (“Health Effects”)*

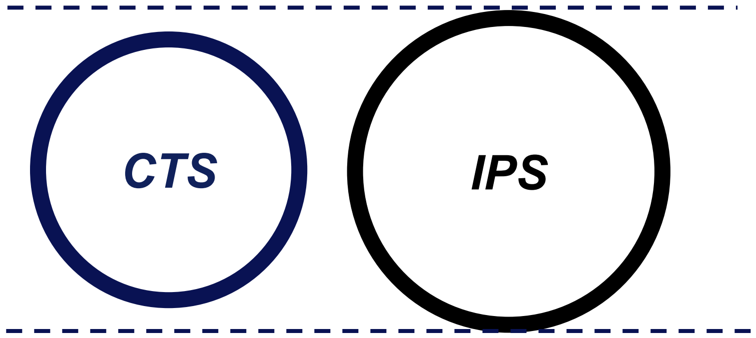
1.1 Purpose “This Standard establishes minimum health effects requirements for the chemical contaminants and impurities that are indirectly imparted to drinking water from products, components, and materials used in drinking water systems.”

Prologue: Plastic Piping Materials - General

“Tubing vs. Pipe”

- “**Tubing**” means the actual Outside Diameter is 1/8 inch larger than the nominal size
- “**Pipe**” means the actual Outside Diameter matches that of iron/steel pipe of the same nominal size, or products where the actual Outside Diameter matches the nominal size
- Tubing uses nominal sizes such as ‘**NTS 3/4**’; also known as **Copper Tube Size** (CTS)
- Pipe uses nominal sizes such as ‘**NPS 3/4**’; also known as **Iron Pipe Size** (IPS)

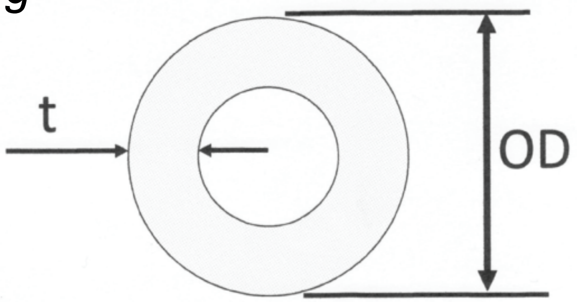
- **IPS** pipes are typically larger than **CTS** pipes, and are more commonly used in geothermal
- Example: 1 inch CTS Tubing OD = 1.125” (28.6 mm)
  1 inch IPS Pipe OD = 1.315” (33.4 mm) 15% larger



Prologue: Plastic Piping Materials - General

Dimension Ratios

- Most* plastic pipe and tubing 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

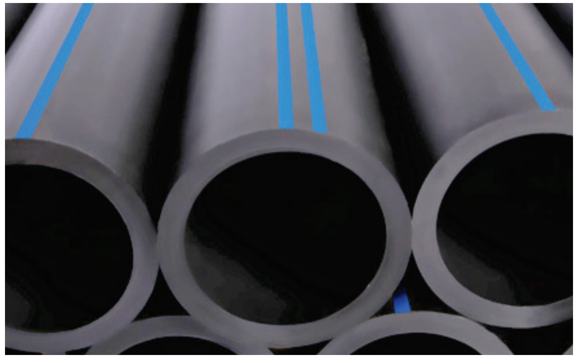


- Examples:
    - **PEX tubing** is **SDR 9** (wall thickness is 1/9 of the OD)
    - **HDPE pipe** may be **SDR 9, SDR 11, SDR 13.5**, etc.
    - E.g., For SDR 11 pipe, wall thickness is 1 / 11 of the OD

- For the same *SDR*, each diameter of the pipe type (e.g., ¾, 1, 2) has the same pressure capability & rating

Exception: Pipes that follow* ***Schedule 40/80* *dimension schemes do not use SDRs*

Prologue: Plastic Piping Materials - General



Pipe Design Factor / Safety Factor

- All plastic tubing and pipes have inherent safety factors for the intended applications, based on prescribed **Design Factors** within product standards

- Mandatory **Design Factors** reduce the listed operating pressures by up to 50%*
  **Most PE4710 materials utilize a 0.63 design factor*

- Pressure-Temperature ratings are based on an extrapolated time-to-failure prediction using a **Design Factor**
- The actual burst pressure capability is above the listed long-term pressure rating

- Plastic systems demonstrate Long-term Hydrostatic Strength (LTHS) through established test methods such as **ASTM D2837** and listings according to *PPI TR-3 Policies and Procedures for Developing Hydrostatic Design Basis (HDB) and Hydrostatic Design Stresses (HDS) for Thermoplastic Piping Materials*

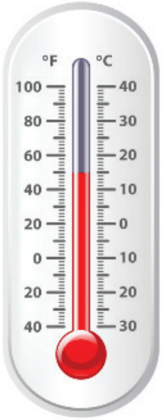
1. Plastic Piping Materials for Geo Systems

The piping material is critical to the success of the ground loop system

- Piping must provide corrosion resistance, chemical resistance, flexibility, impact resistance, toughness, resistance to slow crack growth (SCG), long-term hydrostatic strength (i.e., pressure capability), and temperature resistance

- Piping systems may experience changes in pressure up to 60 psig (415 kPa) due to thermal expansion/contraction of heat transfer fluid and the pipe itself

- Piping systems may experience changes in temperature from <30ºF to 110ºF> (-1°C to 43°C)



- Geothermal piping materials must also provide suitable heat transfer capabilities

- The ground loop piping must be a multi-talented top performer!

Plastic Piping Materials for Geo Systems

Four types of plastic piping materials are used for ground source geothermal systems:

- **HDPE** *high density polyethylene*
- **PEX** *crosslinked polyethylene*
- **PE-RT** *polyethylene of raised temperature resistance*
- **PP** *polypropylene (PP-R and PP-RCT) for indoor piping*

Plastic Piping Materials for Geo Systems

HDPE: High Density Polyethylene

- High density polyethylene (HDPE) is the most common type of piping material used for ground heat exchangers, with decades of proven service for this application

- HDPE is recognized in virtually all codes and standards as an approved material for ground loops

- Strong and tough material, suitable for applications up to 140°F (60°C)
  - Pressure ratings of pipes are reduced above 80°F (27°C)

Common types:

- PE3608, PE4710 (thermoplastic material designation codes)

Coil of HDPE piping with molded U-bend already fused to pipe ends

Plastic Piping Materials for Geo Systems

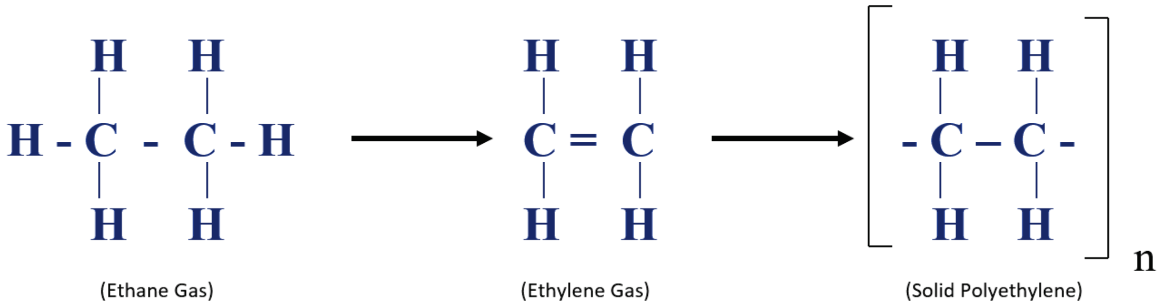
What is PE?

- **Polyethylene** (PE): A thermoplastic produced from polymerization of ethylene
- **Ethylene** is a derivative of ethane, a constituent within natural gas or derived from oil
- **Ethane** is a very clean molecule, energy efficient in production

- PE is non-polar, making it slippery (low surface polarity)

- Saturated bonds resist most chemical attack

- **PE is an environmentally-friendly polymer**

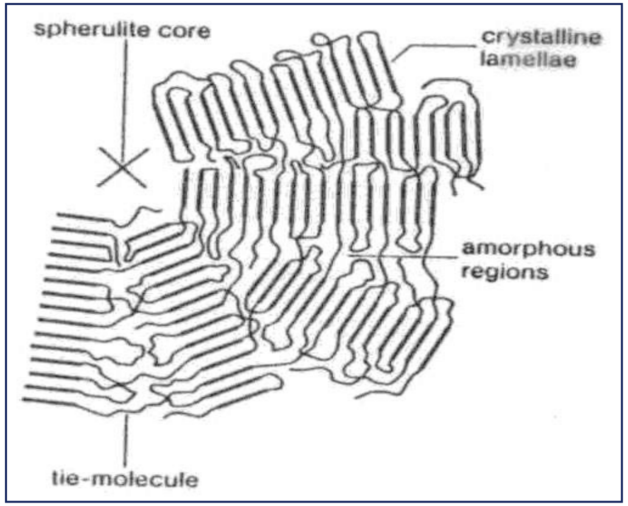


Plastic Piping Materials for Geo Systems

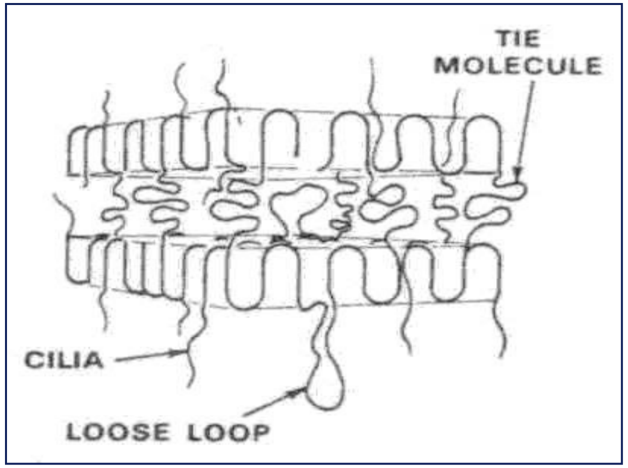
What is HDPE?

- **High Density** Polyethylene (PE) is a grade of PE
- **Density** greater than 0.940 g/cm^3 (pure water = 1.0 g/cm^3)

- **Crystalline structures** consist of folded chains, providing stiffness and tensile strength



- **Amorphous phase** consists of tie molecules, providing flexibility, impact resistance, stress crack resistance and abrasion resistance



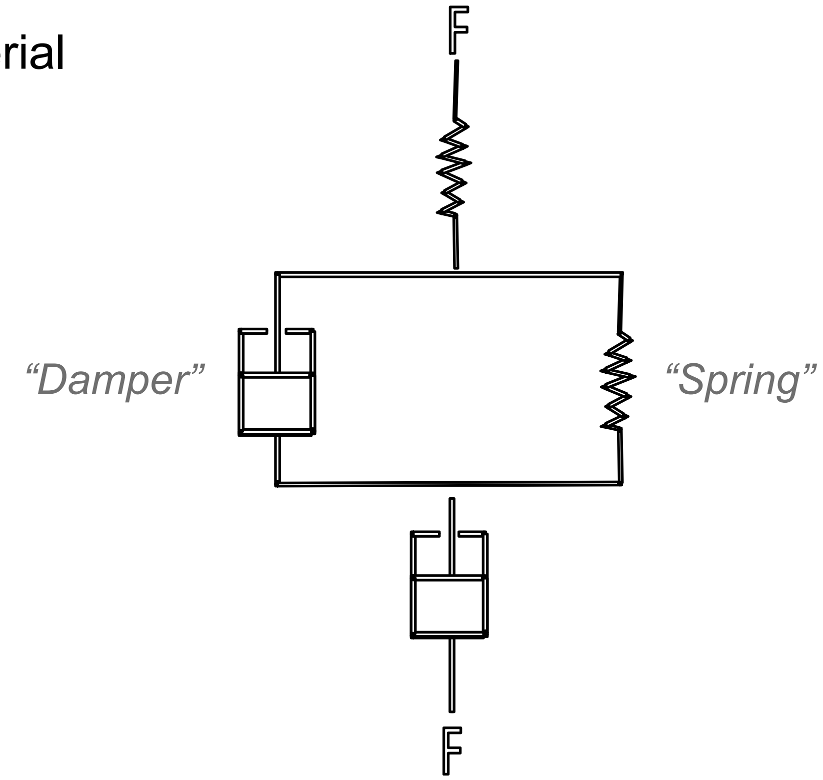
- HDPE pipe materials are blends of these phases

Plastic Piping Materials for Geo Systems

What is HDPE?

- This unique polymeric structure of HDPE yields a **Visco-Elastic** material
  - **Viscous:** Requires time to deform and to recover deformation
  - **Elastic**: Immediate recoverable deformation

- HDPE materials are **blended** or “tuned” for ideal combinations of material properties



Plastic Piping Materials for Geo Systems

What do “PE3408”, “PE3608”, and “PE4710” mean?

- Thermoplastic pipe material designation codes (e.g., PE3608, PE4710) are defined in **ASTM F412**
- Specific properties make up the PE Pipe Material Designation Code (defined in **ASTM D3350):**
  - 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)
  - Much higher slow crack growth resistance
  - Higher hydrostatic design stress (1,000 psi vs. 800 psi)
  - Higher Design Factor (0.63 vs. 0.50)
  - Higher pressure ratings

Plastic Piping Materials for Geo Systems

HDPE with higher Slow Crack Growth (SCG) resistance

- **PE3408: Minimum 10 hours** SGC Resistance using PENT test (ASTM F1473)
- **PE4710: Minimum 500 hours** SGC Resistance using PENT test (ASTM F1473)
- At least 50 times improvement (10 hours x 50 = 500)

- Many of today's commercially-available PE4710 pipe materials exceed **2,500 hours** PENT testing

- PE4710 pipe materials provide:
  - Excellent slow crack growth resistance
  - Resistance to abrasion, scratches, gouges, notches
  - Long-term hydrostatic strength and stability

Plastic Piping Materials for Geo Systems

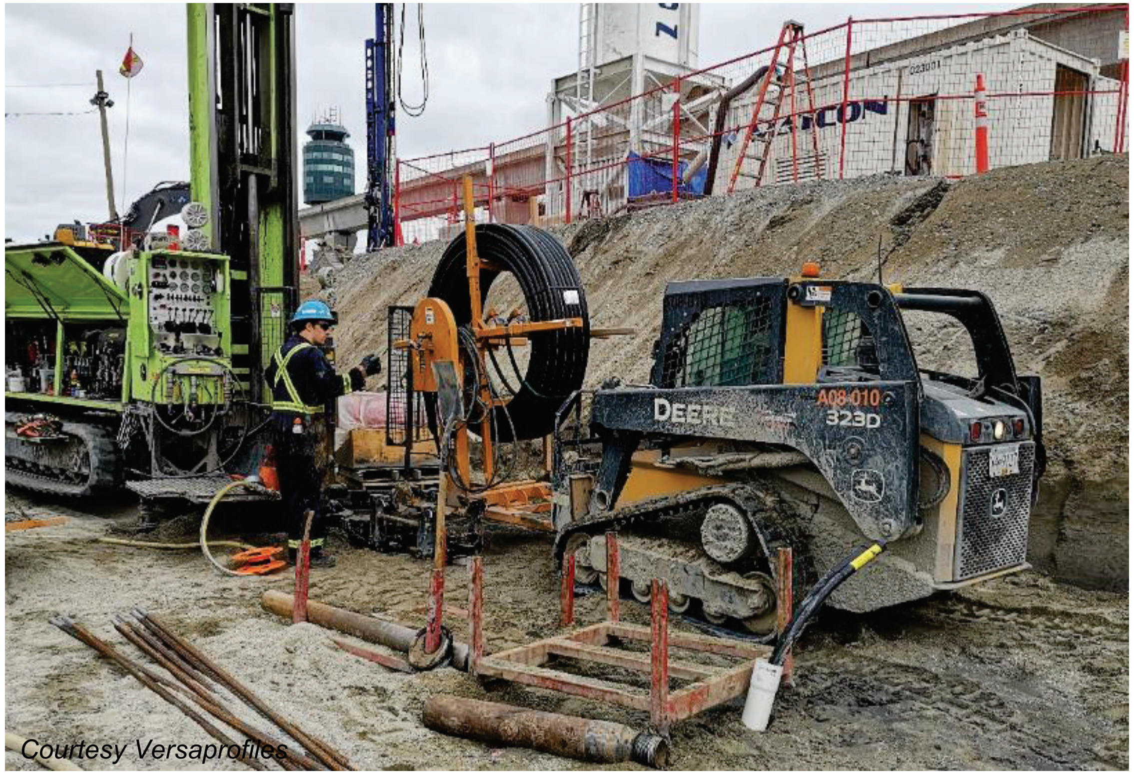
HDPE: On the job


Courtesy Versaprofiles


Courtesy Versaprofiles

Plastic Piping Materials for Geo Systems

HDPE: On the job



Courtesy Versaprofiles

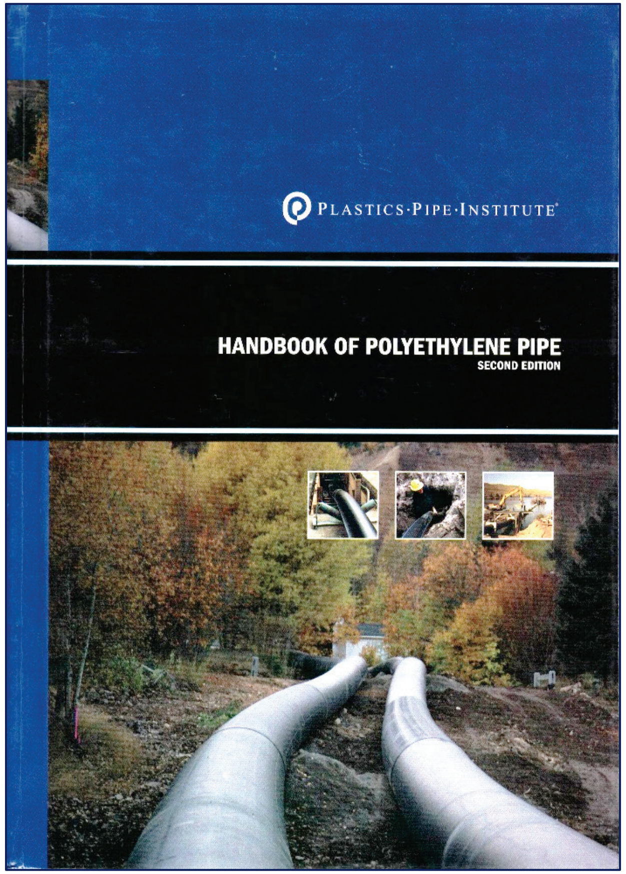
Plastic Piping Materials for Geo Systems

HDPE: Thermal Properties

- See PPI Handbook of Polyethylene Pipe 2nd Edition, **Table E.1**
- Specific Heat: **0.46 BTU / lb - °F**
- Thermal Conductivity: **3.1 BTU-in/ft^2-hr-°F** for PE4710

TABLE E.1
Approximate Value of Thermal Property for Temperature Range Between 32 and 120°F (0 and 49°C)

Thermal Property	PE Pipe Material Designation Code [1]		
	PE2XXX	PE3XXX	PE4XXX
Coefficient of Thermal Expansion/Contraction [2] (in/in ·°F)	10 x 10^{-5}	9.0 x 10^{-5}	8.0 x 10^{-5}
Specific Heat BTU / LB - °F		0.46	
Thermal Conductivity (BTU · in /hr · sq. ft ·°F)	2.6	3.0	3.1



Plastic Piping Materials for Geo Systems

HDPE: Connections

- HDPE connections are typically via heat fusion, one of three types:
  1. Butt fusion (pipe-to-pipe or fitting-to-fitting) joints are produced according to **ASTM Standard D3261**
  2. Socket fusion (pipe-to-fitting) fittings are produced according to **ASTM Standard D2683**
  3. Electrofusion (pipe-to-fitting) fittings are produced according to **ASTM Standard F1055**
- Fusion joints shall be installed in accordance with **ASTM Standard Practice F2620**
- Electrofusion joints shall be installed in accordance with **ASTM Standard Practice F1290**

Butt fusion joint

Electrofusion fitting

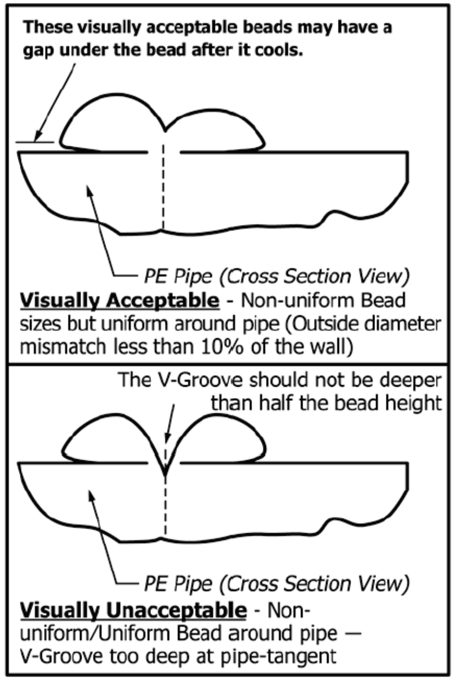
Socket fusion caps on pipes for testing

Plastic Piping Materials for Geo Systems

HDPE: Connections

- **ASTM F2620** ***Standard Practice for Heat Fusion Joining of Polyethylene Pipe and Fittings*** is the industry's practice for heat fusion (based somewhat on **PPI TR-33**)
- First published in 2006, latest edition **2020**

- Examples of content



F2620 – 19

Acceptable Visual Appearance

FIG. X2.1 Socket Fusion

Unacceptable Visual Appearance

FIG. X2.2 Socket Fusion

Generic Butt Fusion Joining Procedure for Field Joining of Polyethylene Pipe

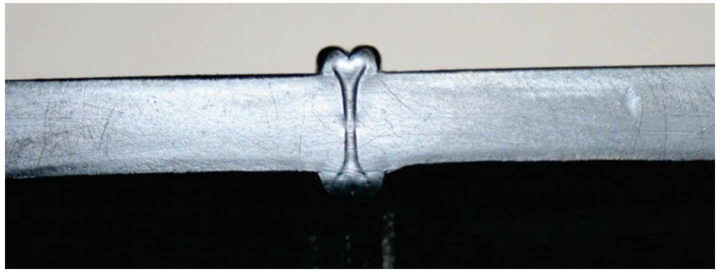
TR-33

2012

PLASTICS·PIPE·INSTITUTE®

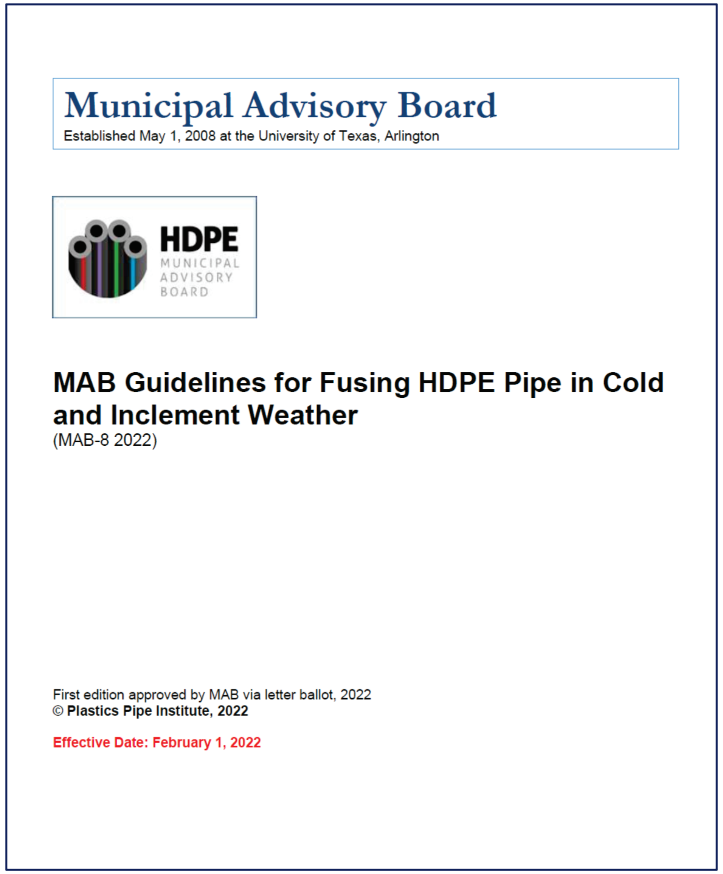
105 Decker Court, Suite 825, Irving, TX 75062 Phone: 469-499-1044 Fax: 469-499-1063 www.plasticpipe.org

Plastic Piping Materials for Geo Systems



HDPE: Connections

- **PPI MAB-08** ***Guidelines for Fusing HDPE in Cold and Inclement Weather***
- First published in 2022



Municipal Advisory Board
Established May 1, 2008 at the University of Texas, Arlington

HDPE MUNICIPAL ADVISORY BOARD

MAB Guidelines for Fusing HDPE Pipe in Cold and Inclement Weather
(MAB-8 2022)

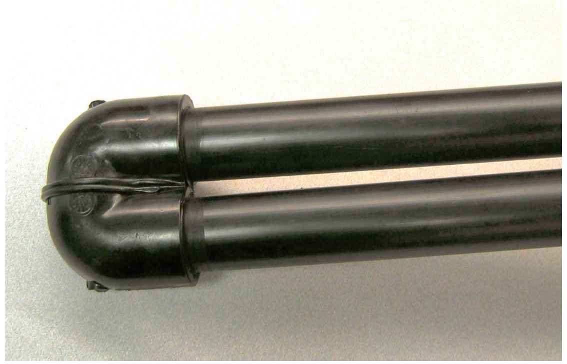
First edition approved by MAB via letter ballot, 2022
© **Plastics Pipe Institute, 2022**

Effective Date: February 1, 2022

Plastic Piping Materials for Geo Systems

HDPE: U-bends

- HDPE U-bends can be fabricated from elbows, or molded from the same polymer as the pipe material
- Factory-fabricated U-bend assemblies are recommended



U-bend fabricated with butt-fused elbows

Molded HDPE U-bend already fused to pipe ends

Image Courtesy Versaprofiles

Coil of HDPE pipe with U-bend

Plastic Piping Materials for Geo Systems

HDPE: U-bends

- HDPE U-bends can be fabricated from elbows, or molded from the same polymer as the pipe material
- Examples of Molded U-bends in three diameters, factory-fused to HDPE pipes

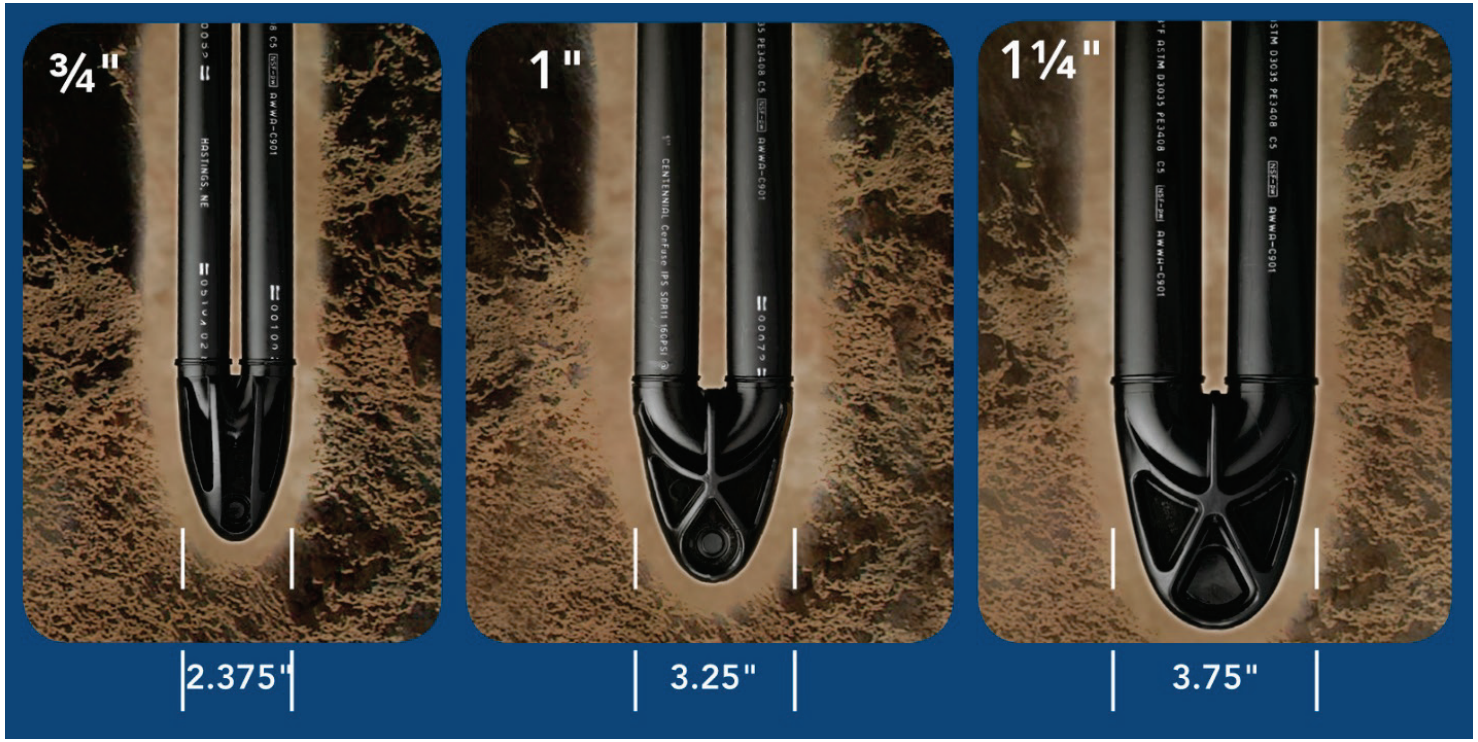


Image Courtesy Centennial Plastics

Plastic Piping Materials for Geo Systems

HDPE: Summary

- Tough, durable, flexible, strong material

- Proven over 40+ years in ground loop applications

- Wide range of diameters and wall types

- Many domestic sources

- Material does have temperature limitations

- Heat fusion joining requires equipment, training, and skill for guaranteed success

Plastic Piping Materials for Geo Systems

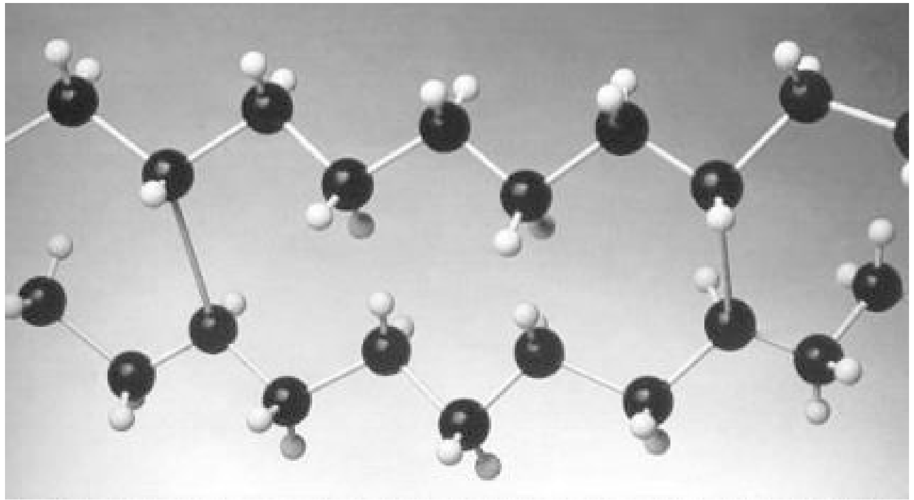
PEX: Crosslinked (X) Polyethylene

- Crosslinked polyethylene (PEX) is actually modified HDPE with enhanced capabilities for temperature
- Crosslinking creates a three-dimensional matrix of connected molecules
- PEX is a high-temperature, flexible pressure pipe with 50 years of global usage in pressure applications

- PEX is widely used for plumbing, water service, fire protection, hydronic heating and cooling, snow and ice melting, and **ground source geothermal piping systems**

- Approved for geo ground loops in North America since **2008**

Illustration of PEX "molecule"



Plastic Piping Materials for Geo Systems

PEX: Crosslinked (X) Polyethylene

- PEX density is slightly lower than HDPE, which lead to slightly lower tensile strength
- Lower tensile strength, Less stiff, More flexible, Lower pressure rating for the same wall thickness
- Strong and tough material, suitable for applications up to **180°F** (82°C) and beyond (when approved)
- Currently only available as a Tubing (CTS) for geothermal applications
- Available in diameters up to 3 inch nominal, SDR9 wall thickness
- Produced according to ASTM F876 and/or CSA B137.5
- Pressure rated for 160 psig @ 73°F, 100 psig @ 180°F

Common types:

- PEX 1206, PEX 3306 (PEX tubing material designation codes)

- *Note: PEX "code" is Not Comparable to the PE material designation code*

Plastic Piping Materials for Geo Systems

PEX: On the job

Plastic Piping Materials for Geo Systems

PEX: On the job

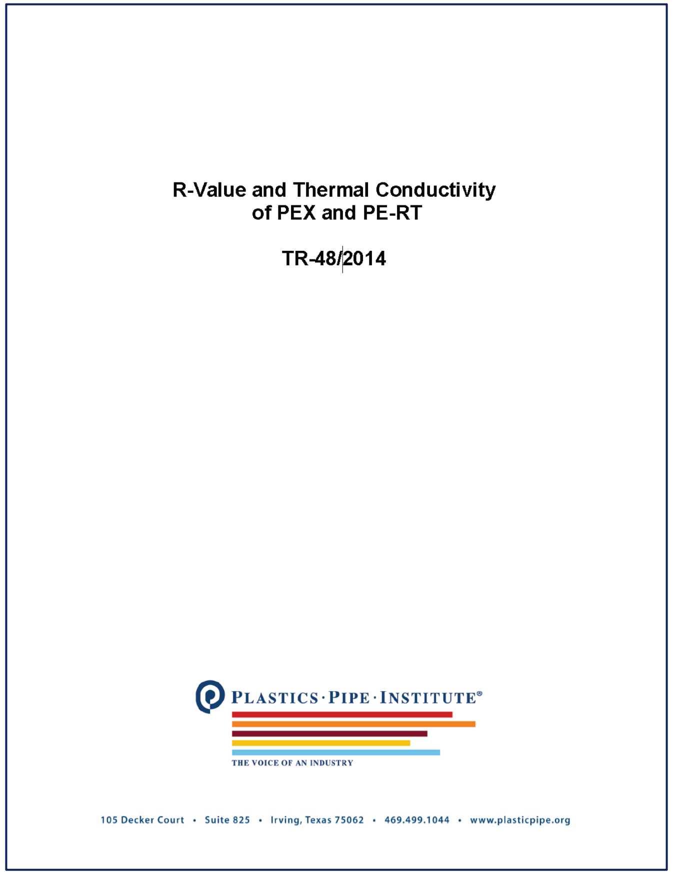
Plastic Piping Materials for Geo Systems

PEX: Thermal Properties

- See PPI TR-48/2014 *R-Value and Thermal Conductivity of PEX and PE-RT*

- PE4710 Thermal Conductivity = **3.1**
- PEX Thermal Conductivity = **2.86** (92% of HDPE)
- PE-RT Thermal Conductivity = **3.15** (101% of HDPE)

Material	Thermal Conductivity BTU•in/(ft^2•hr•°F)	Thermal Conductivity W/(m•°K)
PEX	2.86	0.41
PE-RT	3.15	0.46


R-Value and Thermal Conductivity
of PEX and PE-RT

TR-48/2014

105 Decker Court • Suite 825 • Irving, Texas 75062 • 469.499.1044 • www.plasticpipe.org

Plastic Piping Materials for Geo Systems

PEX: Connections

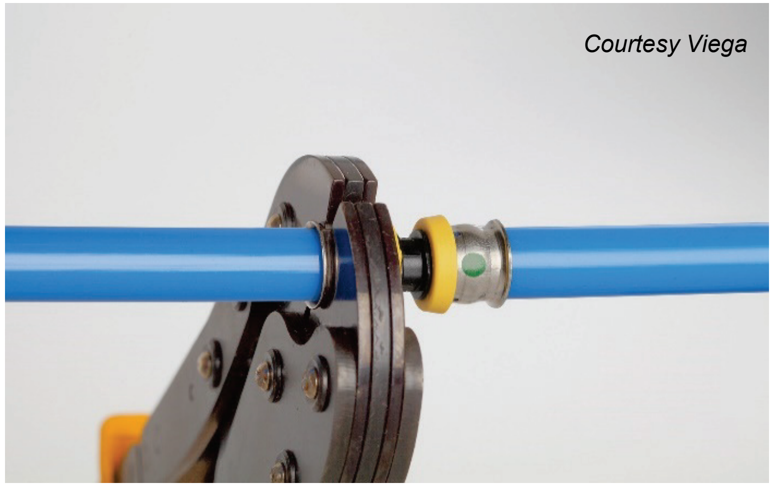
- PEX fittings work on principle of **compression** (tubing is compressed over fitting ribs)
- PEX fittings are produced from **lead-free brass alloys** and **engineered polymers**
- Butt fusion or socket fusion fittings do not work well with PEX

Collection of PEX fittings from multiple manufacturers

Plastic Piping Materials for Geo Systems

PEX: Connections

- Connections are typically via **compression fittings** or **electrofusion**
- Butt fusion or socket fusion fittings do not work well with PEX



Press-sleeve PEX fitting as per ASTM F3347

Cold-expansion PEX fitting as per ASTM F1960

Plastic Piping Materials for Geo Systems

PEX: Connections

- Connections are typically via **compression fittings** or **electrofusion**
- Butt fusion or socket fusion fittings do not work well with PEX

Courtesy REHAU

Cold-expansion compression-sleeve PEX fitting as per ASTM F2080

HDPE electrofusion fitting as per ASTM F1055

Plastic Piping Materials for Geo Systems

PEX: U-bends

- PEX U-bends may be factory-formed from continuous pipe using heat, or
- Fabricated using special s/s fittings approved for direct burial

Courtesy REHAU

Examples of Double U-bends

PEX U-bend encased in resin tip (two)

PEX U-bend with compression-sleeve fittings
Double U-bend configuration

Plastic Piping Materials for Geo Systems

PEX: Summary

- Tough, durable, flexible, strong material with high temperature capabilities (**180°F** or higher)

- Ideal when solar thermal generation is combined with ground loop thermal storage

- Approved for geo ground loops in North America since 2008 (in use in Europe before that)

- Compression fittings install without fusion using basic hand tools or battery-electric tools

- Slightly lower density and tensile strength than PE4710

- More expensive than PE4710

Plastic Piping Materials for Geo Systems

PE-RT: Polyethylene of Raised Temperature Resistance

- PE-RT is modified HDPE material with enhanced capabilities to withstand higher temperatures
- Strong and tough material suitable for applications up to **180°F** (82°C)
- Same dimensions as PEX tubing; predominantly only available as Tubing
- PE-RT tubing can be joined via **heat fusion** or using most PEX **compression fittings**
- Produced according to ASTM F2729 and/or CSA B137.18
- Recognized in most model codes for ground loop piping

Common types:

- PE4710 (PE material designation code)

Courtesy Legend Valve

Plastic Piping Materials for Geo Systems

PE-RT: Thermal Properties

- See PPI TR-48/2014 *R-Value and Thermal Conductivity of PEX and PE-RT*

- PE4710 Thermal Conductivity = **3.1**
- PEX Thermal Conductivity = **2.86** (92% of HDPE)
- PE-RT Thermal Conductivity = **3.15** (101% of HDPE)

Material	Thermal Conductivity BTU•in/(ft^2•hr•°F)	Thermal Conductivity W/(m•°K)
PEX	2.86	0.41
PE-RT	3.15	0.46

R-Value and Thermal Conductivity
of PEX and PE-RT

TR-48/2014

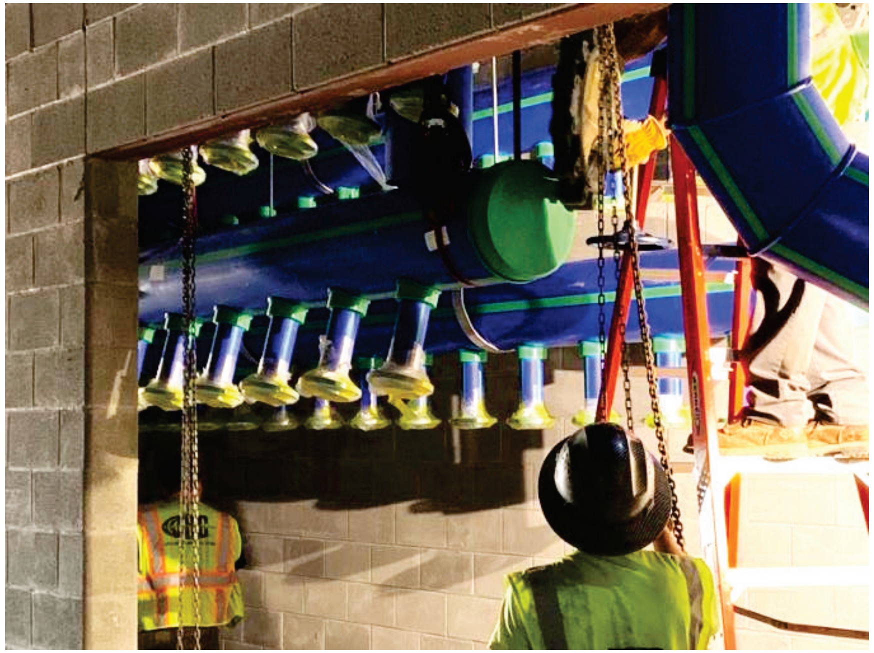
PLASTICS·PIPE·INSTITUTE®
THE VOICE OF AN INDUSTRY

105 Decker Court • Suite 825 • Irving, Texas 75062 • 469.499.1044 • www.plasticpipe.org

Plastic Piping Materials for Geo Systems

PP-R & PP-RCT: Polypropylene

- PP-R & PP-RCT are high-temperature plastic pressure piping materials first used for plumbing and hydronic heating in the 1980s in Europe and introduced to North America in the 2000s
- Provided in straight pipes lengths in DN (metric) diameters (e.g., 25 mm, 50 mm, 75 mm, etc.)
- Produced according to ASTM F2389 and/or CSA B137.11
- Recommended for geothermal manifolds and indoor piping

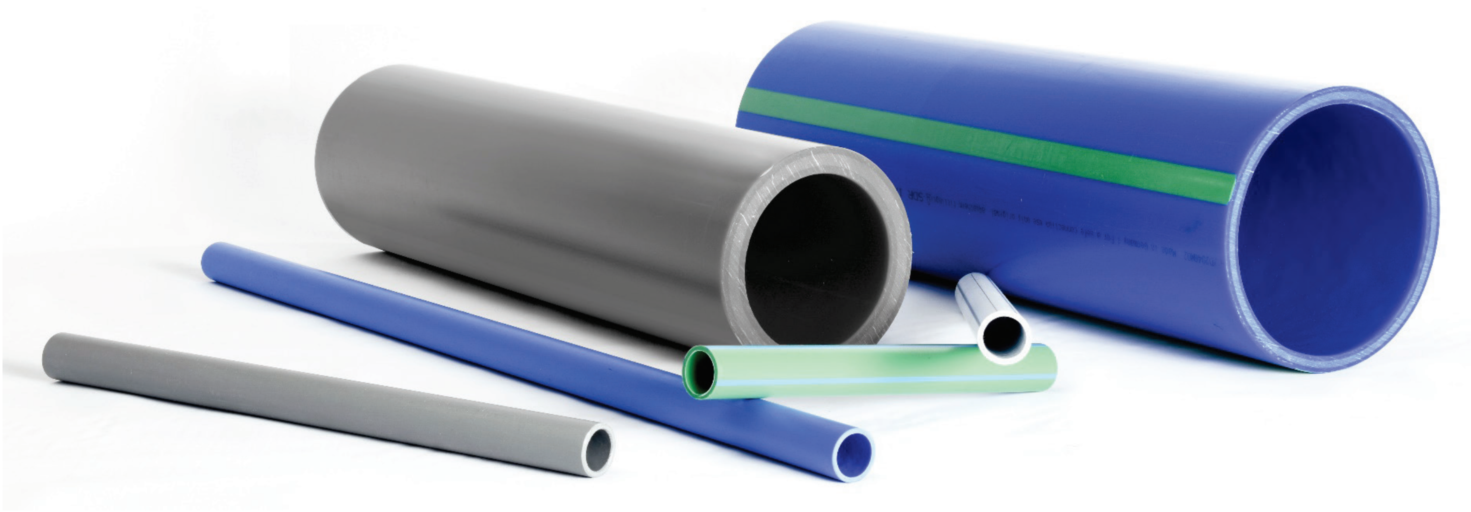


Plastic Piping Materials for Geo Systems

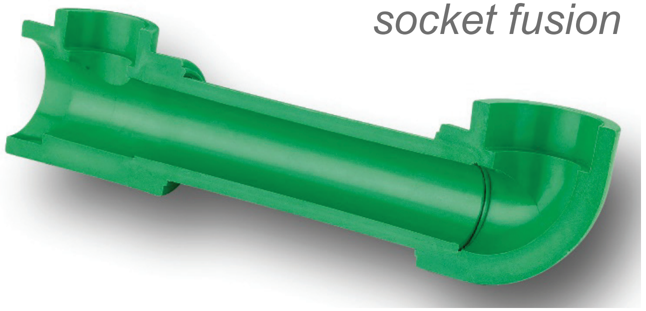
PP-R & PP-RCT: Two types of polypropylene pressure pipe materials

- *Random copolymerized polypropylene* (**PP-R**) is a high-temperature plastic pressure piping system first used for plumbing and hydronics, now for geothermal headers, indoor piping

- *Polypropylene random copolymer with modified crystallinity & temperature resistance* (**PP-RCT**) is a stronger grade of PP material, higher tensile strength, higher pressure rating



Plastic Piping Materials for Geo Systems



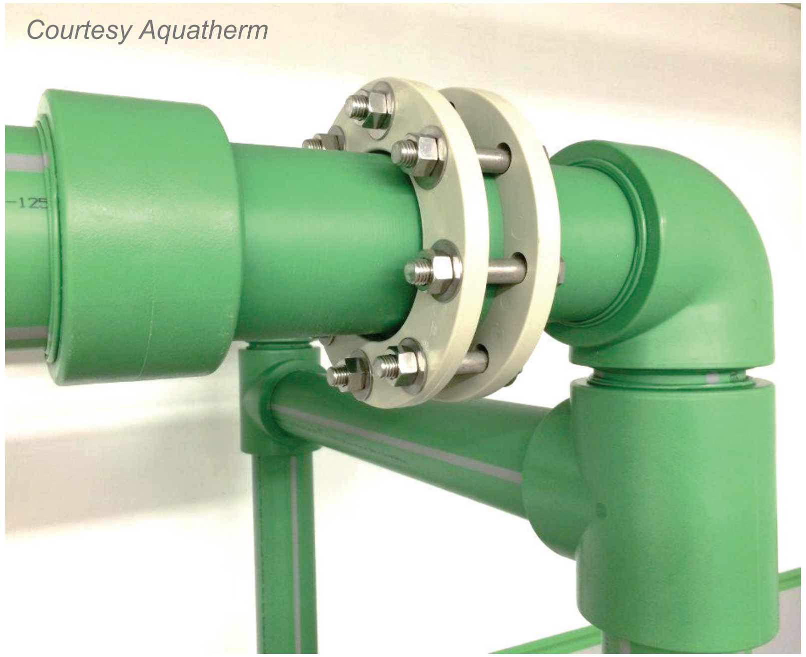
Cutaway showing socket fusion

PP-R & PP-RCT: Connections

- Connections are typically via **heat fusion** (butt, socket, electrofusion)
- Various mechanical fittings (e.g., grooved adapters) are also available

Basic fusion steps

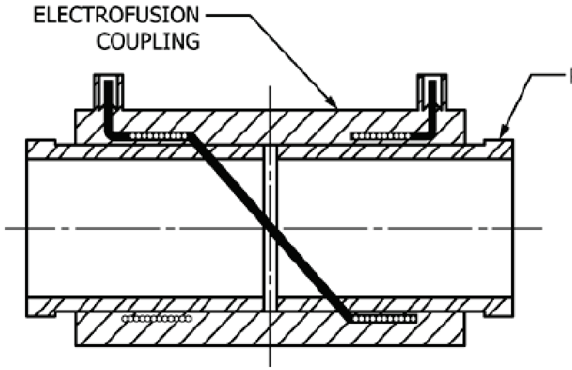
Courtesy Aquatherm

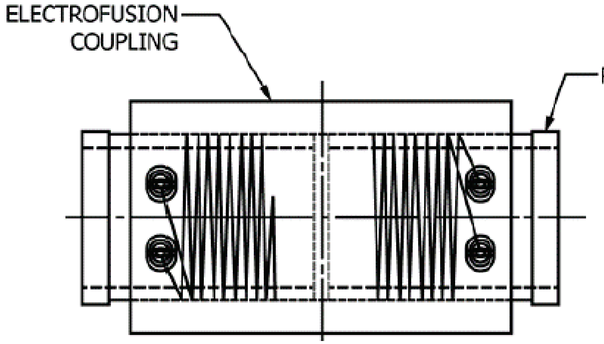


Plastic Piping Materials for Geo Systems

PP-R & PP-RCT: Connections

- **Electrofusion** joints have embedded copper wires that heat the fitting, welding it to pipe ends
- A computerized machine controls the process

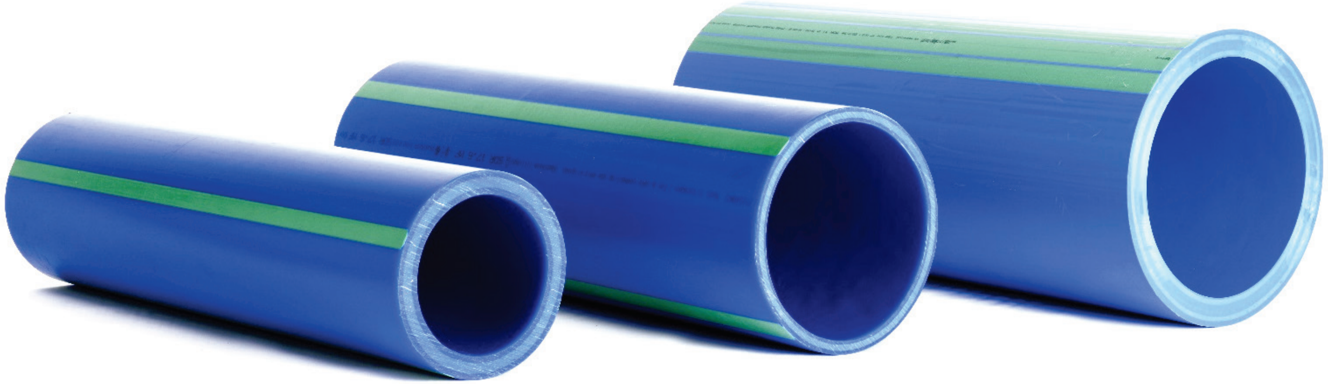




Plastic Piping Materials for Geo Systems

PP-R & PP-RCT: Summary

- Strong rigid piping material with high temperature capabilities (typically rated for **176°F**)
- Fiber-core reinforcement layers reduce longitudinal thermal expansion/contraction
- Available in diameters from 16 mm to 710 mm (soft conversions ½ inch to 28 inch)
- Available in various wall types and thicknesses (e.g., SDR 7.4, SDR 9, SDR 11, SDR 13.5, etc.), depending on the required pressure rating
- Fusion joining with a wide variety of fittings shapes and sizes
- More economical than copper
- Several domestic sources



Plastic Piping Materials for Geo Systems

Plastic Piping Material Applications

- Each of these materials may be used for geothermal ground loops and **energy piles**
- HDPE and PEX are sometimes supplied for double-U-bend configurations

PEX in rebar cage/structural pile

HDPE buried headers

HDPE Double U-bend going down the Borehole

Plastic Piping Materials for Geo Systems

Summary

- The four plastic piping materials used for geothermal ground loop systems are:

  - **HDPE** *high density polyethylene*
  - **PEX** *crosslinked polyethylene*
  - **PE-RT** *polyethylene of raised temperature resistance*
  - **PP** *polypropylene (PP-R and PP-RCT) for manifolds and indoor piping*

- Each of these materials provides corrosion resistance, chemical resistance, flexibility, impact resistance, resistance to slow crack growth, long-term hydrostatic strength (pressure capability), temperature resistance, and good thermal conductivity

2. Industry Standards for Plastic Piping and Geo Codes

Importance of proper standards

- Each of these piping materials delivers long-term reliability, proven through decades of use around the world

- Long-term pressure ratings for plastic pipes are based on **ASTM Test Method D2837**

- Piping materials are specified through rigorous product standards with detailed testing requirements for materials and performance

- The life expectancy of these plastic piping materials, when installed according to industry standards and manufacturers' guidelines, is typically well in excess of **fifty (50) years** (see PPI TN-55)

- Strict industry **certification programs** to ensure consistent quality control

Industry Standards for Plastic Piping and Geo Codes

Importance of proper standards

- The recommended piping materials are produced and third-party certified according to national and international product standards from accredited Standards Development Organizations (SDOs)
  - **HDPE**: ASTM D2737 (tubing), ASTM D3035 (pipe), ASTM F714 (pipe), CSA B137.1
  - **PEX**: ASTM F876 (tubing), ASTM F2788 (pipe), CSA B137.5
  - **PE-RT**: ASTM F2769, CSA B137.18
  - **PP-R & PP-RCT**: ASTM F2389, CSA B137.11

ASTM INTERNATIONAL Designation: D3035 – 21 An American National Standard

Standard Specification for
Polyethylene (PE) Plastic Pipe (DR-PR) Based on Controlled Outside Diameter[1]

ASTM INTERNATIONAL Designation: F876 – 20b An American National Standard

Standard Specification for
Crosslinked Polyethylene (PEX) Tubing[1]

ASTM INTERNATIONAL Designation: F2389 – 19 An American National Standard

Standard Specification for
Pressure-rated Polypropylene (PP) Piping Systems[1]

ASTM INTERNATIONAL Designation: F2769 – 18 An American National Standard

Standard Specification for
Polyethylene of Raised Temperature (PE-RT) Plastic Hot and Cold-Water Tubing and Distribution Systems[1]

Industry Standards for Plastic Piping and Geo Codes

Importance of proper standards

- Specifying an out-of-date or inappropriate standard for geothermal pipes may violate requirements of relevant mechanical **codes** while potentially increasing **costs**

- Project specifications that cite inappropriate pipe standards can cause **confusion** with manufacturers, the supply chain, and installers

- Project specifications that combine inappropriate or incompatible requirements, sometimes pulled from various sources with the best intentions, can create the need for **products that don't exist**!

- Such specifications are sometimes referred to as "**Frankenstein specs**"

Is this really what was intended?

Industry Standards for Plastic Piping and Geo Codes

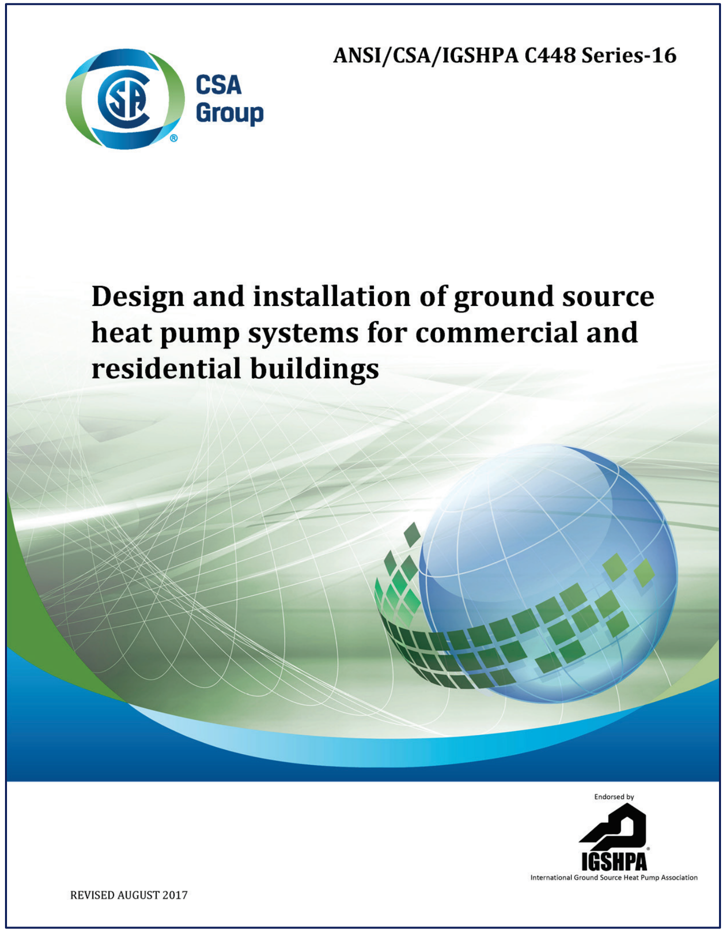
ANSI/CSA/IGSHPA C448-16

- C448 is the ANSI designated bi-national consensus standard for the design and installation of ground source heat pump systems

- First published in **February 2016** (next edition is in development)

- C448 was developed by a Bi-national Technical Committee comprised of the industry's leaders from Canada and USA

- Contains ***Piping Requirements, Equipment, Design, Installation, Testing, Heat Transfer Fluids, Decommissioning*** and much more



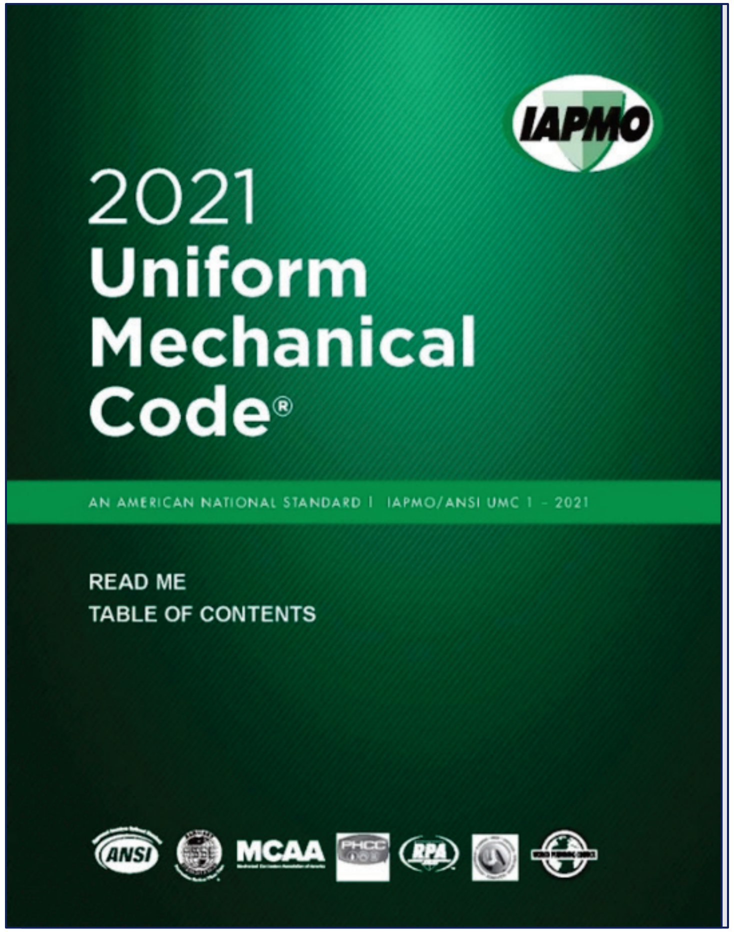
Industry Standards for Plastic Piping and Geo Codes

IAPMO Uniform Mechanical Code

- Latest 2021 edition published in March 2020

- **Appendix F** is *Geothermal Energy Systems*

- Contains ***Installation***, ***Piping Requirements***, ***Testing***, more



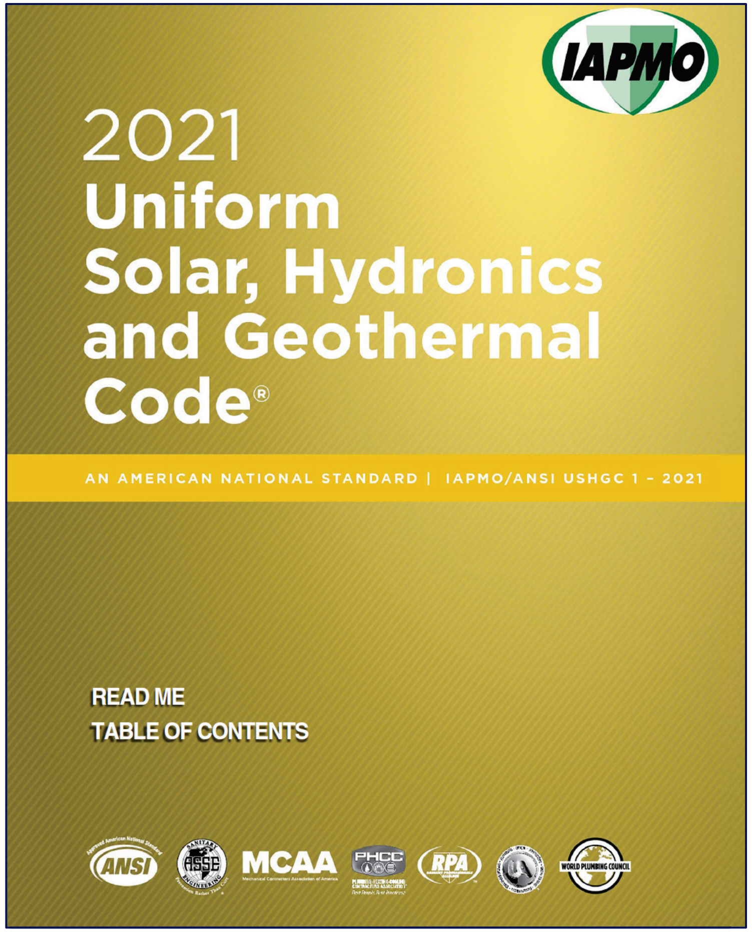
Industry Standards for Plastic Piping and Geo Codes

IAPMO Uniform Solar, Hydronics and Geothermal Code

- Latest 2021 edition published in March 2021

- **Chapter 7** is *Geothermal Energy Systems*

- Contains ***Installation***, ***Piping Requirements***, ***Testing***, more



Industry Standards for Plastic Piping and Geo Codes

ICC International Mechanical Code (IMC)

- Latest 2021 edition published in 2020

- Table 1210.4 provides the list of approved **Ground-Source Loop Pipe** materials (PEX, HDPE, PP-R, PE-RT, others)

TABLE 1210.4
GROUND-SOURCE LOOP PIPE

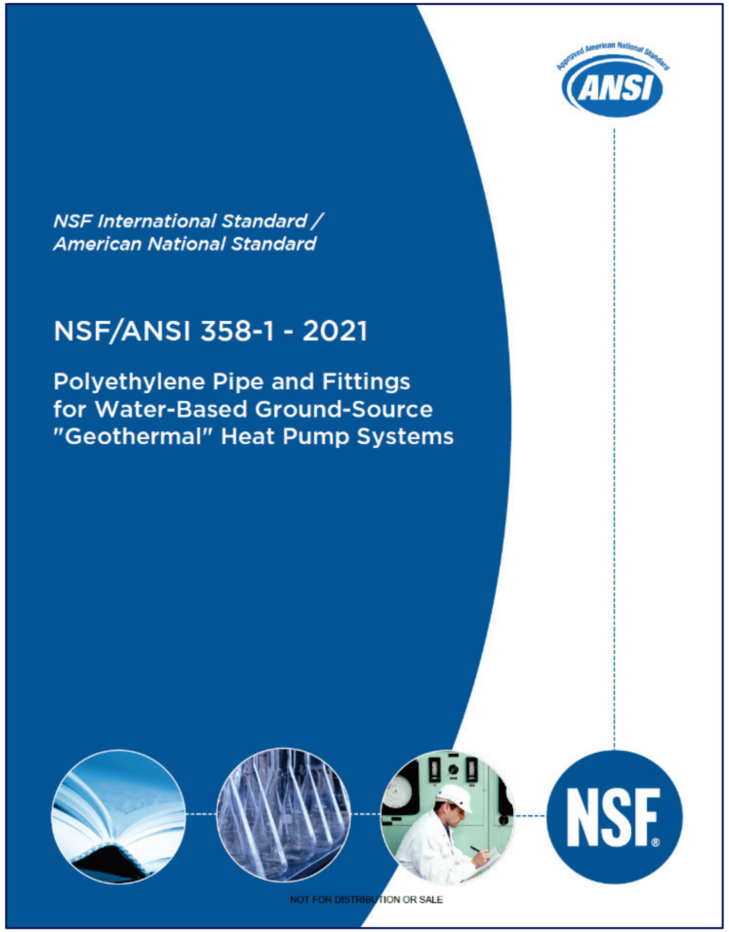
MATERIAL	STANDARD (see Chapter 15)
Chlorinated polyvinyl chloride (CPVC)	ASTM D2846; ASTM F441; ASTM F442
Cross-linked polyethylene (PEX)	ASTM F876; CSA B137.5; CSA C448; NSF 358-3
Polyethylene/aluminum/polyethylene (PE-AL-PE) pressure pipe	ASTM F1282; CSA B137.9
High-density polyethylene (HDPE)	ASTM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

Industry Standards for Plastic Piping and Geo Codes

NSF 358 Standards

- A series of standards specifically for geothermal ground loop systems
- Incudes special test requirements for pipes and fittings:
  - Compatibility with **antifreeze mixtures**
  - Tensile **pull-out tests** for connections
- Pipe manufacturers pay to have their products tested and certified to **358-x** (the appropriate version for the type of pipe)

- Four versions of **NSF 358** exist:
  - ***NSF 358-1 HDPE***
  - ***NSF 358-2 PP***
  - ***NSF 358-3 PEX***
  - ***NSF 358-4 PE-RT***



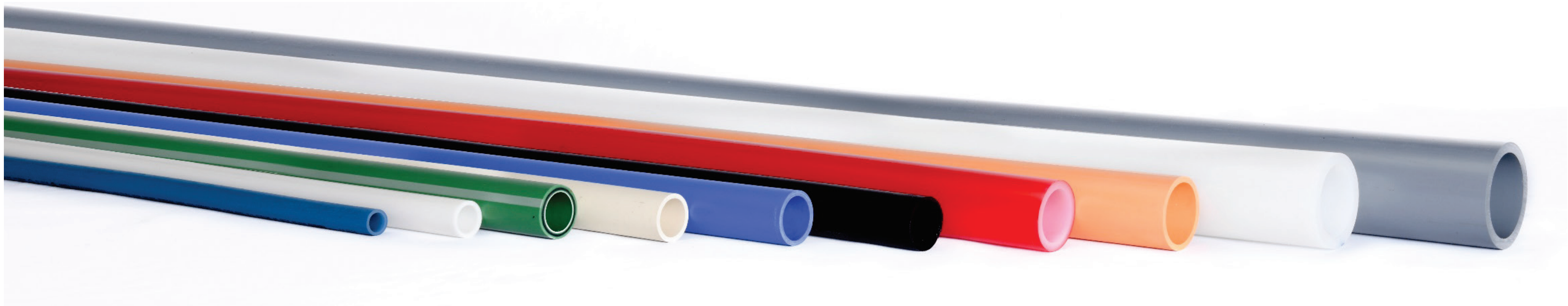
Industry Standards for Plastic Piping and Geo Codes

Summary

- Using industry standards helps to ensure proper design and installation of geothermal systems

- Each of the plastic piping materials used for ground loops can be clearly specified using standards

- It is important to properly select and specify the correct type of ground loop piping materials using current industry products and correct specific language, to avoid misunderstandings with suppliers and installers



3. Manifold and Header Techniques

Manifolds and Headers

- Most ground source geothermal projects require more than one loop of heat exchange piping for the required heat transfer capacity
- Header systems and distribution manifolds are utilized to connect multiple piping loops

Images courtesy IGSHPA

Manifold and Header Techniques

Manifold and Header systems are typically piped in one of three (3) distinct configurations:

1. **Reverse-Return:** Typically preferred for balanced flow
2. **Series:** Generally avoided due to high pressure losses
3. **Parallel or “Home run”:** Each ground loop is piped individually to a central header or manifold located in an outdoor (e.g., buried) collection vault or in the building mechanical room or interior space

Manifold and Header Techniques

In-ground Header Example: Reverse-Return

- Example of typical **Reverse-Return in-ground (buried) header system** employing several pipe diameters to connect four (4) vertical boreholes
- Pressure drop through all four pathways must be balanced to ensure that flow is equal through all four borehole loops (unequal flow = unequal heat transfer and other issues)

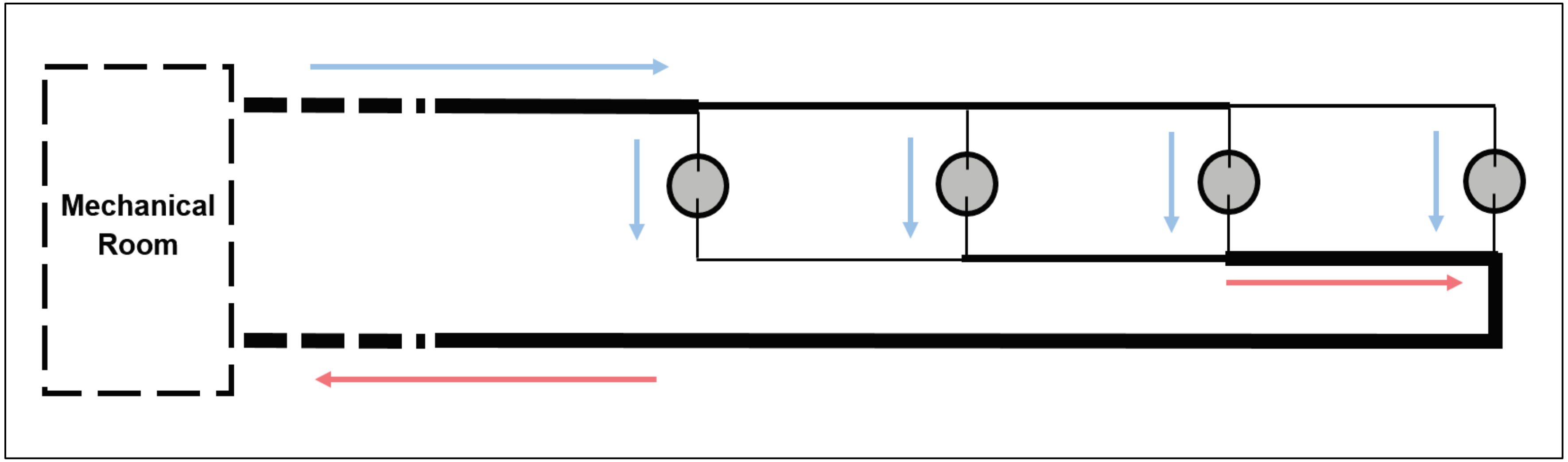
<u>Legend</u>:
Boreholes (4)

Flow direction

Line thickness indicates relative pipe diameter

Connection details at tees and elbows are not shown

Not to scale



Manifold and Header Techniques

In-ground Header Example: Reverse-Return

- Example of typical **Reverse-Return in-ground (buried) header system** employing several pipe diameters to connect four (4) vertical boreholes
- Pressure drop through all four pathways must be balanced to ensure that flow is equal through all four borehole loops (unequal flow = unequal heat transfer and other issues)

Borehole

Borehole

Borehole

Borehole

Manifold and Header Techniques

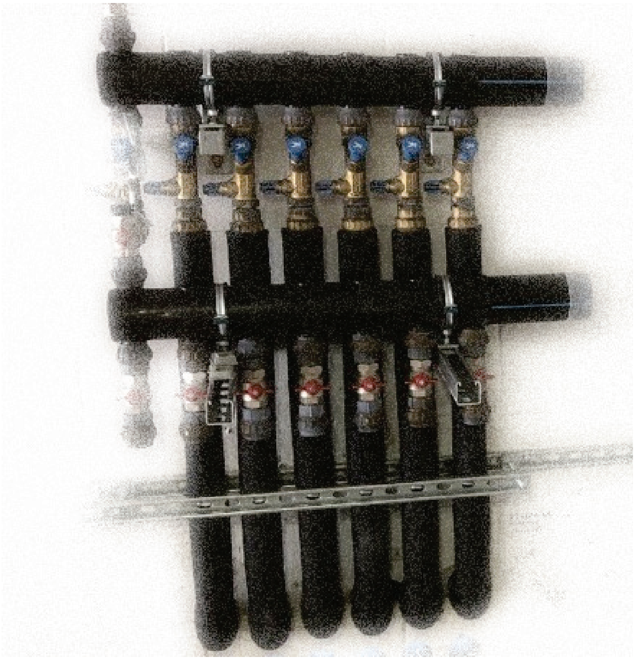
Parallel/Home-run Manifolds

- **Parallel distribution manifolds** (also called mechanical manifolds) are typically located in building mechanical spaces or in exterior collection vaults, buried in the earth

- Manifold assembly typically contains a supply and return Manifold, mounted closely together in pairs

- Manifolds may include shut-off valve (common) and/or balancing valves (rare)

- When the individual ground loops are connected to such a centralized distribution manifold, then the ground loops are in parallel, also known as **home-run**



Manifold and Header Techniques

Parallel/Home-run Manifolds

- **Parallel distribution manifolds** (also called mechanical manifolds) are typically located in building mechanical spaces or in exterior collection vaults, buried in the earth

- Examples:

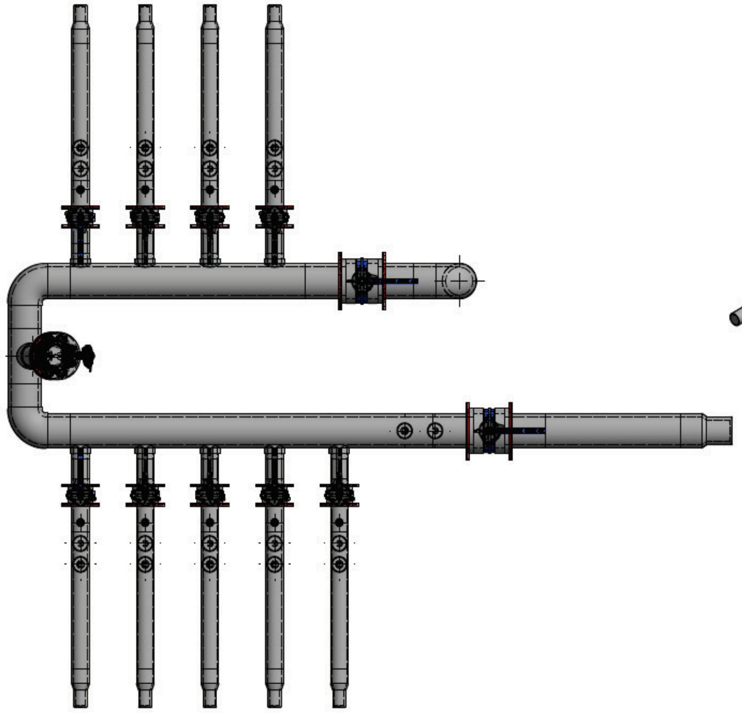
Polypropylene (PP-R) valved manifolds located in small outdoor vaults backfilled with soil

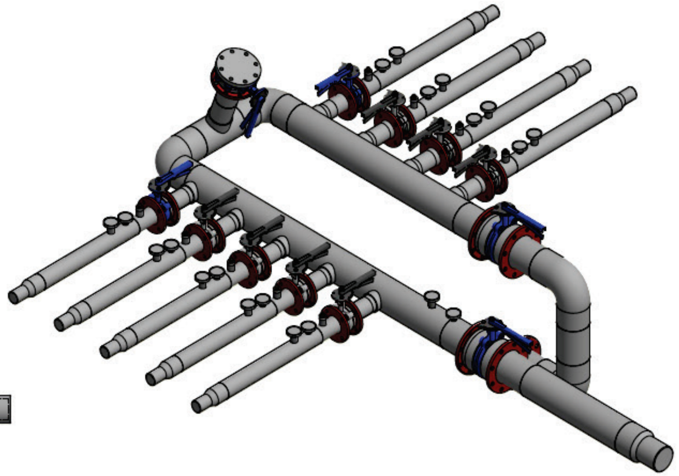
Polypropylene (PP-R) valved manifolds located in concrete vault

Manifold and Header Techniques

Parallel/Home-run Manifolds

- Example of a **distribution manifold** with shut-off valves on supply and return headers and balancing valves on supply header (two views of the same design)



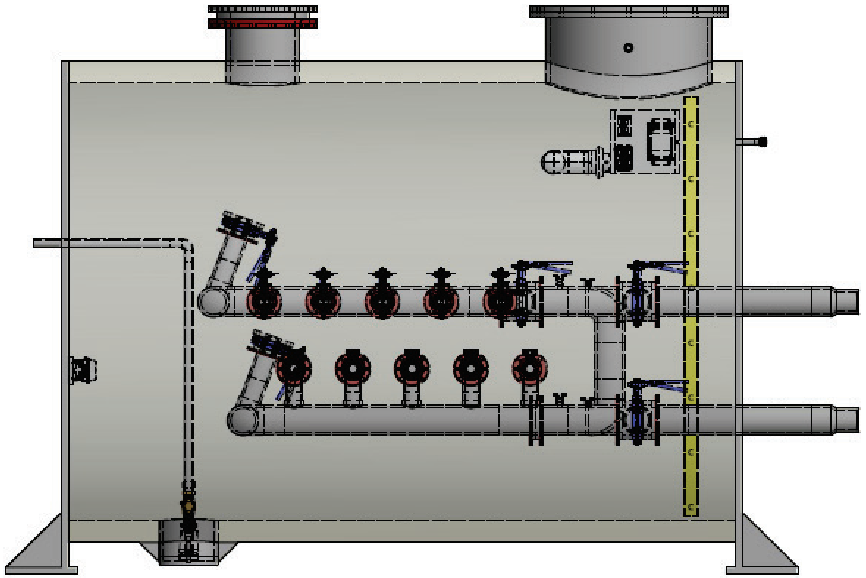


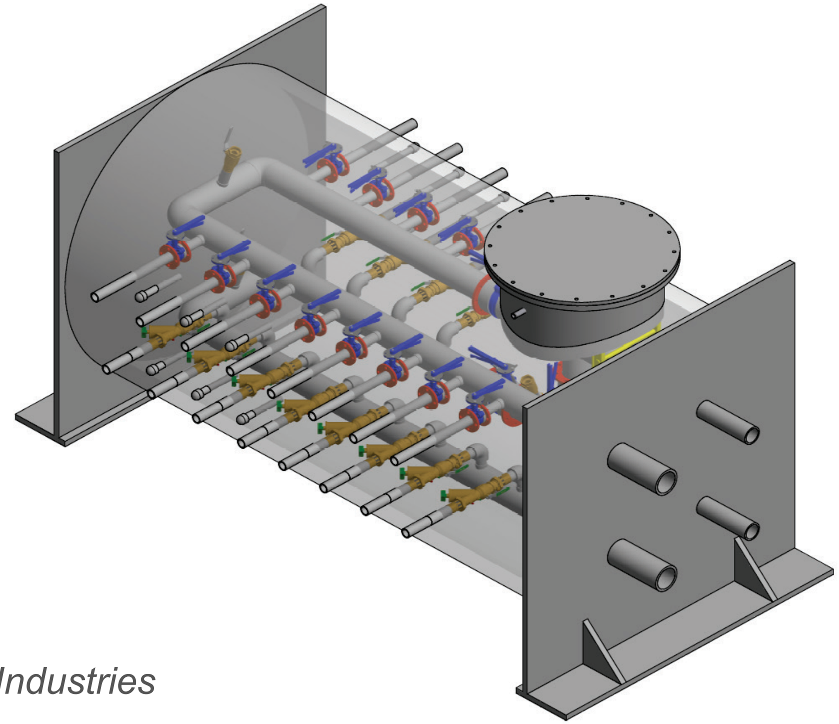
Courtesy ISCO Industries

Manifold and Header Techniques

Manifolds

- Example of HDPE **collection vaults** with integrated manifolds (two different designs)





Courtesy ISCO Industries

Manifold and Header Techniques

Manifolds

- Example of HDPE **collection vaults** with integrated manifolds (two different designs)

Courtesy
ISCO Industries

Manifold and Header Techniques

Summary

- Most ground source geothermal projects require more than one loop of heat exchange piping for the required heat transfer capacity
- Header systems and distribution manifolds are utilized to connect multiple piping loops with some control over the flow

- Manifold and header systems are typically piped in one of three (3) distinct configurations:
  1. Reverse-Return headers
  2. Series headers (generally avoided)
  3. Parallel or "Home run" manifolds

4. PPI Resources for the Geothermal Industry

PPI Resources

- As a non-profit trade association intending to support the geothermal industry, PPI members collaborate to support specifiers, designers, and installers with helpful tools

- All support tools are available at no charge on PPI website www.plasticpipe.org

PPI Resources for the Geothermal Industry

PPI TN-55

- Published in March 2018 as a piping guide to the industry
- Contains general installation information and piping details

Chapters:

1.0 Introduction
2.0 Mechanical Components
3.0 Ground Loop Heat Exchange Piping Systems
4.0 Ground Loop Heat Exchange Piping Materials
5.0 Headers and Distribution Manifolds
6.0 Heat Transfer Fluid
7.0 Standards, Codes and Regulations

Plastic Piping Materials for Ground Source Geothermal Heating and Cooling Applications

TN-55

2018

PLASTICS·PIPE·INSTITUTE®
THE VOICE OF AN INDUSTRY

105 Decker Court • Suite 825 • Irving, Texas 75062 • 469.499.1044 • www.plasticpipe.org

PPI Resources for the Geothermal Industry

PPI TN-55 Content

3.1.2 Vertical Piping Systems

For vertical systems, flexible plastic pipes can be fabricated or formed into U-bend configurations using fused joints, mechanical fittings or jointless hot-forming techniques. Pipe U-bends are lowered into vertical boreholes, and then grouted[2] from the bottom to the top of the borehole with a grouting material selected for factors such as safety for contact with water aquifers, thermal conductivity, pumpability, non-permeability, and other environmental factors.

Typical borehole depths range from 50 to 600 feet (15 m to 182 m), and even deeper in certain projects using improved drilling technology. In some cases, vertical boreholes may extend into or through water aquifers that serve as sources for residential or municipal potable water systems.

Both single U-bend and double U-bend configurations are available. Double U-bends can increase the thermal performance of a borehole. See **Figures 1a & 1b**.

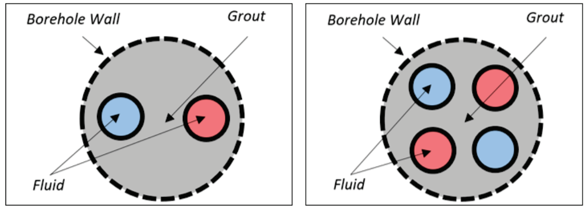


Figure 1a & 1b: Cross section of Single U-bend and Double U-bend Vertical heat exchangers

3.1.2.1 In deep vertical boreholes, ground-loop piping designers are often concerned about the static pressure of the fluid exceeding the pressure rating of the pipe itself, because substantially greater pressures can occur at the bottom of vertical piping loops. This can also occur when piping loops are connected to high-rise buildings.

[2] Grout is a bentonite material or fluid mixture, pumped into annular cavities between pipes and the earth, to seal the cavity. Grout material is usually mixed onsite and pumped into the borehole, from the bottom to the top, using an open-ended pipe known as the Tremie pipe. The functions of grout are: protection of groundwater supply; to prevent groundwater migration between aquifers; for heat transfer between pipes and borehole walls; and to prevent upward leakage from aquifers. Proper grout materials allow movement of the pipes and do not shrink or create voids. Approved grout materials and their placement are typically controlled by local/state/provincial regulations.

5

PPI Resources for the Geothermal Industry

PPI TN-55 Content

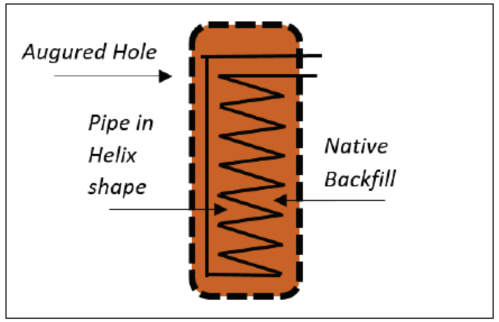


Figure 3: Side-view of a Helix piping system heat exchanger (not to scale)

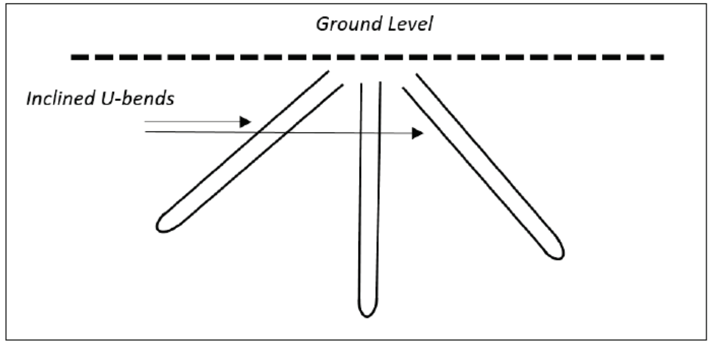


Figure 4: Side-view of an Inclined piping system heat exchanger (not to scale)

PPI Resources for the Geothermal Industry

PPI TN-55 Content

1.0 Introduction

2.0 Mechanical Components

3.0 Ground Loop Heat Exchange Piping Systems

- 3.1.1 Horizontal Piping Systems
- 3.1.2 Vertical Piping Systems
- 3.1.3 Pipe-in-Pipe Coaxial Vertical Systems
- 3.1.4 Helix Piping Systems
- 3.1.5 Inclined or Angled Configurations
- 3.1.6 Horizontal Directional Drilling (HDD)
- 3.1.7 Energy Piles
- 3.1.8 Submerged Piping Systems

4.0 Ground Loop Heat Exchange Piping Materials

4.2 PEX: Crosslinked Polyethylene

Crosslinked polyethylene (PEX) is a high-temperature, flexible pressure pipe with over 40 years of successful use in the European market, including extensive testing for durability and material performance. It was first introduced in North America in the early 1980s and is widely used for plumbing, water service, fire protection, hydronic heating and cooling, snow and ice melting and ground source geothermal piping systems.

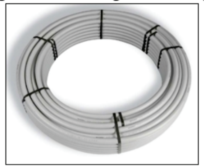


Figure 6: Coil of PEX Tubing

PPI recommends that all PEX piping components used for ground-coupled heat exchangers meet the requirements of industry standard ANSI/CSA/IGSHPA C448 and:

4.2.1 Be a crosslinked polyethylene compound with a pipe material designation code of PEX 1206[5], PEX 1306, PEX 3206, PEX 3306, PEX 5206 or PEX 5306 per ASTM F876 and CSA B137.5.

4.2.2 Be listed as such by the Plastics Pipe Institute's Hydrostatic Stress Board (HSB) in PPI TR-4 with a minimum Hydrostatic Design Stress (HDS) value of 630 psi and a minimum pressure rating of 160 psi (1,100 kPa) at 73°F (23°C).

4.2.3 Meet the requirements of ASTM F876 or CSA B137.5.

4.2.4 Meet the requirements of NSF/ANSI Standard 358-3.

4.2.5 Meet the requirements of NSF/ANSI Standard 61 for open-loop systems, or if the water aquifer or reservoir into which the piping system is installed is a water source for a potable water system.

Note 3: A PEX compound will also be listed by PPI's Hydrostatic Stress Board with a minimum Hydrostatic Design Basis (HDB) value of 800 psi at 180°F (82°C).

See also other PPI publications on PEX materials, such as PPI TN-17 "Crosslinked Polyethylene Pipe & Tubing".

[5] PEX 1206 meets the minimum requirements of ANSI/CSA/IGSHPA C448. Other PEX material designation codes listed exceed the minimum requirements.

PPI Resources for the Geothermal Industry

PPI TN-55 Content

5.2 Distribution Manifold Systems

Distribution manifolds (also called mechanical manifolds) are typically located in building mechanical spaces or in exterior collection vaults, buried in the earth. A distribution manifold typically contains a supply header and a return header, mounted closely together in pairs. When the individual ground loops are connected to such a centralized distribution manifold, then the ground loops are in parallel, also known as home-run.

Larger pipes transfer fluid to and from the supply and return headers of the distribution manifold, respectively, to the heat pump equipment in the mechanical room or space.

Distribution manifolds may be built with individual balancing valves installed on the supply or return header, depending on the type of balancing valve used.

Balancing valves can correct the unbalanced low pressure loss (or head loss) of short circuits simply by adding the correct amount of resistance in the valve itself. This can correct inherently unbalanced systems, to ensure optimal flow through each loop of the ground heat exchanger piping. See **Figure 10** as an example

Shut-off valves are typically installed at each loop or circuit, on both supply and return headers, to allow for complete isolation for purging, repair and maintenance.

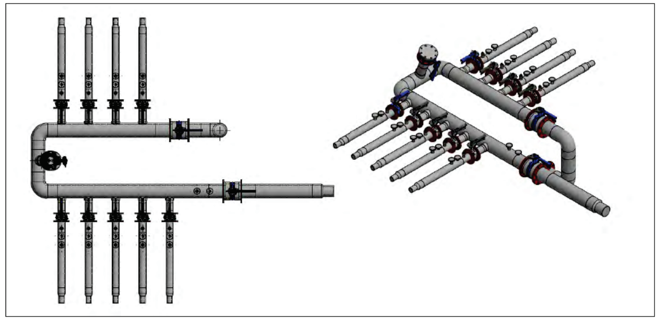


Figure 10: Example of a distribution manifold with shut-off valves on supply and return headers and balancing valves on supply header (two views of the same design)

17

PPI Resources for the Geothermal Industry

Please visit our website for:

- Application information on Geothermal Ground Loop Piping Systems, links to other tools

Geotherm
electrical
water mo
Internatio

See Also

- PPI TN-54 General Guidelines for Squeezing Off Polyethylene Pipe in Water, Oil and Gas Applications
- PPI TN-55 Plastic Piping Materials for Ground Source Geothermal Heating and Cooling Applications
- BCD Plastic Pipe Design Calculator
- PPI Presentation: Plastic Piping Materials for Ground Source Geothermal Systems
- PPI Handbook of Polyethylene Pipe (Ch. 13) HVAC Applications for PE Pipe
- ANSI/CSA/IGSHPA C448 Design and installation of ground source heat pump systems for commercial and residential buildings
- ASTM F2620 Standard Practice for Heat Fusion Joining of Polyethylene Pipe and Fittings
- ASTM F3190 Standard Practice for Heat Fusion Equipment (HFE) Operator Qualification on Polyethylene (PE) and Polyamide (PA) Pipe and Fittings
- International Ground Source Heat Pump Association IGSHPA
- The Geothermal Exchange Organization GEO
- NSF 358 Certification Programs for Geothermal Piping Systems
- Meline/Kavanaugh Paper: Geothermal Heat Pumps—Simply Efficient
- Heat Pump Basis by Professor Eugene Silberstein
- Geothermal Heat Pumps in K-12 Schools: A Case Study of the Lincoln, NE Schools

PPI Resources for the Geothermal Industry

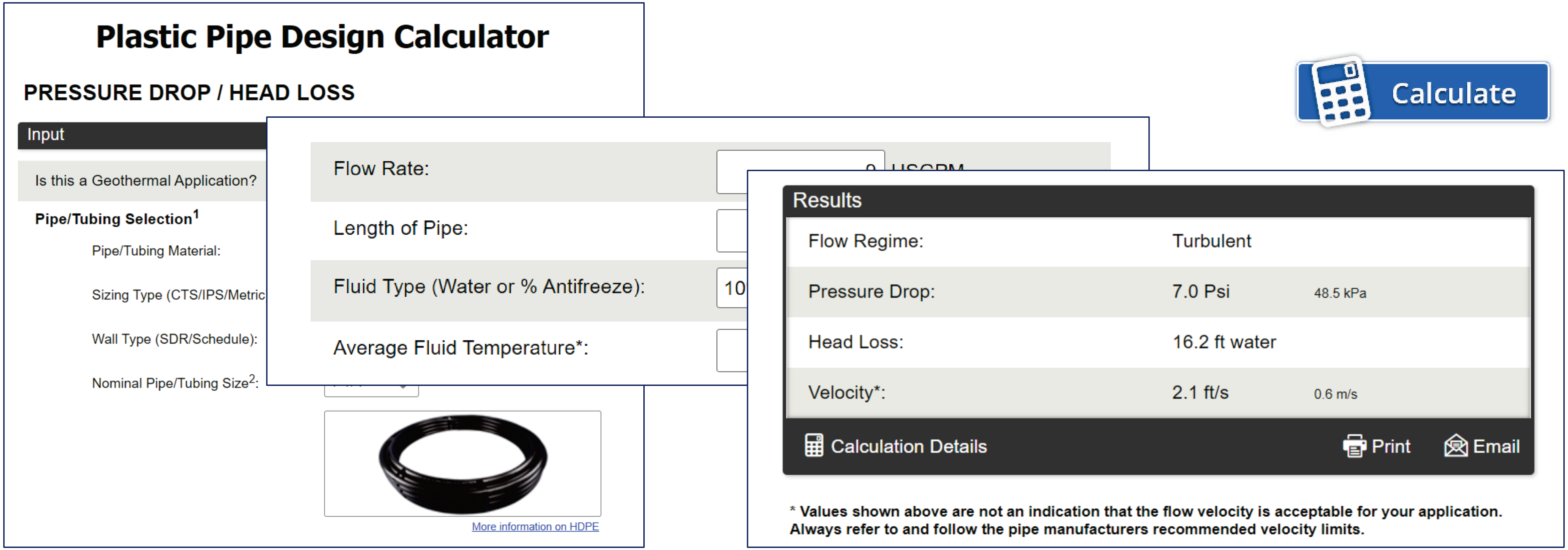
Please visit our website for:

- A specific webpage for each piping material

PPI Resources for the Geothermal Industry

Plastic Piping Design Calculator – Pressure Drop / Head Loss

- Free online sizing tool (pressure loss, volume, etc.) at www.plasticpipecalculator.com

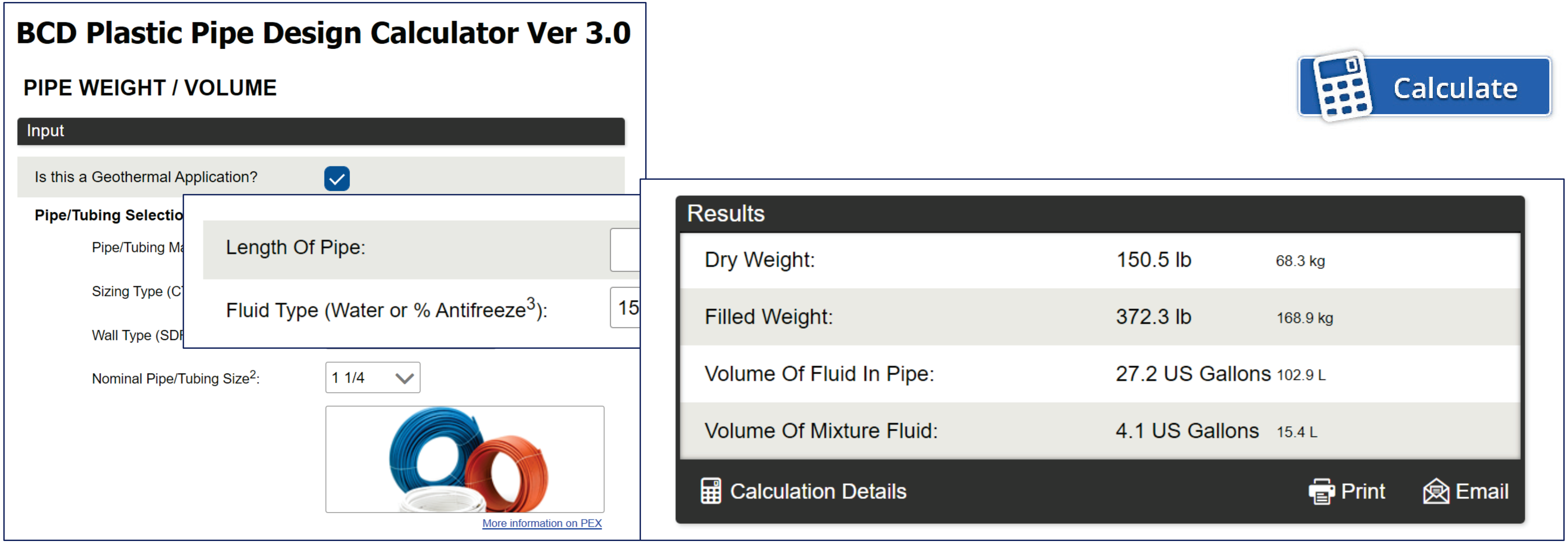


PPI Resources for the Geothermal Industry

PPI PLASTIC PIPE DESIGN CALCULATOR
PlasticPipeCalculator.com

Plastic Piping Design Calculator – Pipe Weight / Volume

- Free online sizing tool (pressure loss, volume, etc.) at www.plasticpipecalculator.com

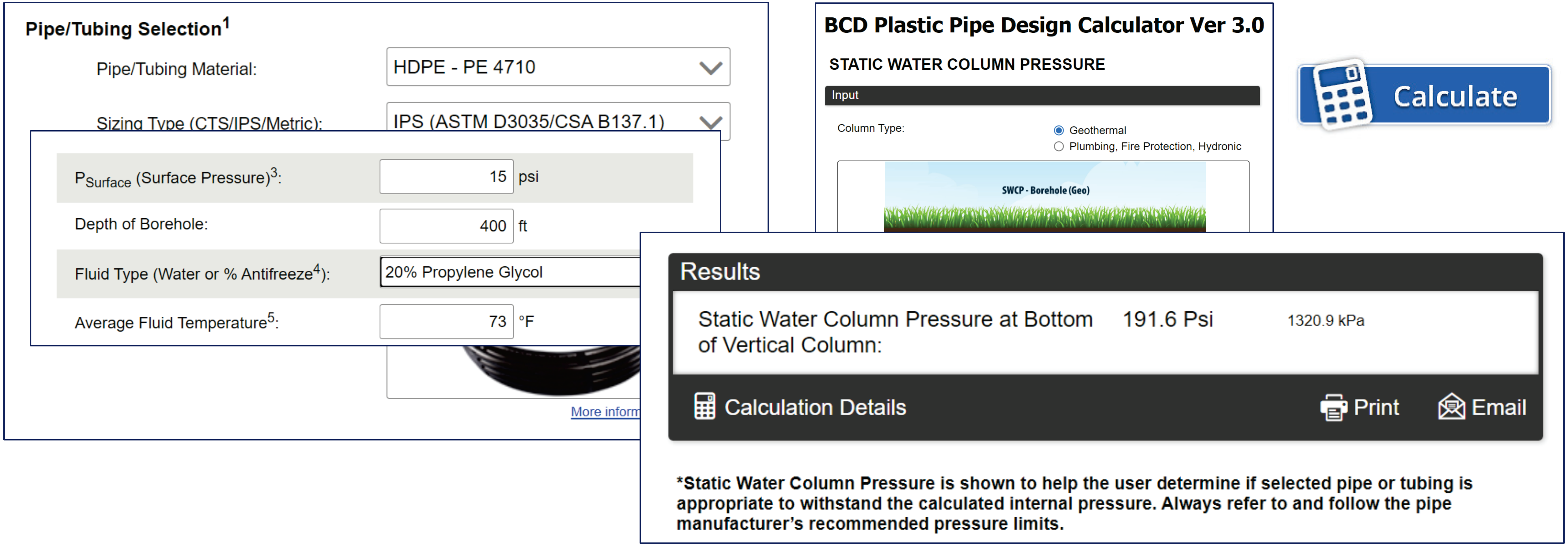


PPI PLASTIC PIPE DESIGN CALCULATOR
PlasticPipeCalculator.com

PPI Resources for the Geothermal Industry

Plastic Piping Design Calculator – Static Water Column Pressure

- Free online sizing tool (pressure loss, volume, etc.) at www.plasticpipecalculator.com



PPI Resources for the Geothermal Industry

Water Well Journal

- July 2022 edition

Figure 1. Coil of HDPE piping with molded U-bend already fused to pipe ends. Image courtesy Versaprofiles.

Figure 2. PEX tubing with factory-formed double U-bend. Im courtesy REHAU.

PIPE FOR GEO from page 20

The heat pump is connected to a network of piping installed outdoors through which fluid travels and exchanges heat with the earth or a body of water. The fluid is transferred through the pipe by circulator pumps. The majority of systems are closed loop, which means the same fluid stays within the piping network; groundwater is not extracted from the ground.

Ground source heat pump (GSHP) systems do the job of air-to-air heat pumps and fossil-fuel heating appliances with much higher efficiency and lower operating costs.

For example, most GSHP systems deliver a coefficient of performance (COP) of 4-to-1 or better, which means that for every unit of electricity purchased to operate the heat pump, four units of heat energy are delivered to the building. These systems are 400% efficient or better. Also, heat pumps usually contain a heat transfer coil for heating domestic hot water.

As the price of fossil-fuel energy and electricity are increasing unpredictably, GSHP systems can deliver significant cost savings to their owners. Geothermal systems can dramatically reduce carbon emissions and help to flatten the energy demand spike for electricity.

A critical aspect of GSHP systems is the underground network of plastic pipes and fittings that are buried in the ground or submerged in water. The network of pipe and fittings—sometimes referred to as the ground heat exchanger or simply the ground loop—is the thermal energy source during heating cycles and the thermal sink during cooling cycles.

With all these advantages, the popularity of GSHP systems is increasing fast as homeowners, governments, businesses, and universities are turning to geothermal technology. The Plastics Pipe Institute, the Texas-based nonprofit trade association, estimates growth in demand for GSHP systems of 20% per year over the next five years.

Geothermal Ground Loop Piping Materials

The piping material in the outdoor ground loop is critical to the overall success of any geothermal system. Other than direct-exchange systems, where refrigerant is piped through the earth in copper pipes, practically 100% of all GSHP systems have relied upon plastic piping materials for performance and longevity.

With pipes and fittings buried or encased directly i earth, piping materials must provide corrosion resistan chemical resistance, temperature resistance, flexibility resistance, resistance to slow crack growth, and long-t hydrostatic strength (pressure capability).

In addition, the ground loop heat exchanger materi provide suitable heat transfer capabilities, since condu heat with the earth is the primary function of the grou

Moreover, all ground loop pipes must meet the requ ments of standard NSF/ANSI/CAN 61 for drinking wa safety to ensure that any aquifer or water reservoir int the piping system is installed is not contaminated by t itself.

Considering all these challenges, the three types of piping materials which are approved for geothermal g loops are HDPE, PEX, and PE-RT. Each of these pipi rials delivers long-term reliability proven over decade around the world.

Geothermal specifiers and installers need to be awa only certain sub-types of each of these piping materia recommended and approved for geothermal ground lo

High-Density Polyethylene (HDPE)

HDPE is the predominant piping material used for heat exchangers and is approved in all modern codes f ground loops. It is joined primarily by heat fusion to p leak-free connections.

HDPE pipes (Figure 1) have improved significantly the past 20 years, thanks to new bimodal resins that de higher strength with greater toughness and resistance crack growth. The highest performing grade, known a 4710, is flexible, tough, and strong.

For horizontal piping systems, HDPE is typically s in long coils as needed for the specific project. Some be more than 1000 feet long, depending on the pipe di Larger diameter pipes (e.g., 3-inch), which are often u headers, are typically supplied as 40-foot straight leng

For vertical boreholes, pipes can be provided with molded U-bend fused to two parallel pipes. For examp 400-foot-deep borehole, the piping manufacturer can two 405-foot pipes which are fused in the factory to a U-bend fitting.

Become a Certified Vertical Closed Loop Driller by NGWA

Advances in geothermal technologies and their usage created the need for a specific voluntary certification designation for geothermal drillers. The National Ground Water Association responded to this need with the designation of Certified Vertical Closed Loop Driller (CVCLD).

The CVCLD is considered an independent designation from the CWD or CWD/PI. The designation reflects an individual who has passed a written exam administered by NGWA that evaluates an individual's knowledge of the skills and competencies associated with constructing a loop well.

To learn more, visit *www.ngwa.org/advance-your-career/certification/Geothermal-driller-CVCLD.*

This allows the drilling contractor to drop the U-bend assembly down the borehole without having to first fuse pipes to the U-bend fitting. About 5 feet of pipe length from each pipe will remain outside the 400-foot borehole for connection to horizontal headers, in this example.

Ground loops are one of the most demanding applications for pipes, so there are specific recommendations for HDPE piping components. For example, HDPE ground loop piping should have a minimum pipe material designation code of PE 3608 (higher numbers are even better) and be certified to industry standard NSF/ANSI Standard 358-1.

HDPE pipes and fittings are joined using various heat fusion methods: butt fusion, socket fusion, or electrofusion. One bad joint buried underground could create a leak that is expensive and difficult to find, access, and repair. With that, fusion contractors should strictly follow the guidance provided in ASTM F2620 "Standard Practice for Heat Fusion Joining of Polyethylene Pipe and Fittings" that describes proper fusion procedures for butt and socket fusion.

Once installed, ground loops should be tested according to ASTM F2164 "Standard Practice for Field Leak Testing of PE and PEX Pressure Piping Systems Using Hydrostatic Pressure."

Crosslinked Polyethylene (PEX)

PEX is HDPE that is modified during manufacturing to crosslink the majority of molecular chains. It is a high-temperature, flexible pressure pipe material first developed in the early 1970s. The primary benefit is capability of continuous operation at temperatures of 180°F (82°C) or above.

This higher temperature capability may be necessary in borehole thermal energy storage (BTES) systems where thermal solar energy is pumped into the earth to raise the ground temperature during summer, for example.

PEX tubing (Figure 2) has greater resistance to chemical contact, and it is slightly more flexible than HDPE. It is also more expensive.

PEX tubing cannot be joined using butt fusion or socket fusion. Instead, several types of mechanical compression fittings are approved for underground use with PEX tubing, as are electrofusion fittings.

PEX ground loop piping should have a minimum material designation code of PEX 1206 and be certified to ASTM F876 or CSA B137.5, as well as NSF/ANSI Standard 358-3.

In North America, PEX is available up to 3 inches in diameter and can be supplied as coils, straight lengths, or as prefabricated U-bends for boreholes.

Polyethylene of Raised Temperature (PE-RT)

PE-RT is high-density polyethylene material with enhanced capabilities to withstand higher temperatures up to 180°F. PE-RT may be joined using heat fusion processes, just like HDPE, or using mechanical compression fittings, just like PEX.

PE-RT ground loop piping should have a minimum pipe material designation code of PE 3608 and be certified to ASTM F2623, ASTM F2769, or CSA B137.18, as well as NSF/ANSI Standard 358-4.

Summary

Geo piping materials are produced according to rigorous product standards with strict industry certification programs to ensure consistent quality control.

The life expectancy of these plastic piping materials, when specified correctly and installed according to industry and manufacturers' guidelines, is typically well in excess of 50 years. In fact, many of the earliest geo ground loops installed in the 1970s using earlier generations of plastic piping are still in service today 50 years later.

All ground loop pipes must meet the requirements of standard NSF/ANSI/CAN 61 to ensure that any aquifer into which the piping system is installed is not contaminated by the pipe itself.

Several industry tools are available to assist geothermal designers, specifiers, and installers. For example, PPI document TN-55 "Plastic Piping Materials for Ground Source Geothermal Heating and Cooling Applications" provides even more details about the piping loops.

Designers can also use the free online Plastic Pressure Pipe Design Calculator at *www.plasticpipecalculator.com* to assist with calculations.

Design and installation training is available through IGSHPA, and CSA/ANSI/IGSHPA C448 is the ultimate code for geothermal design and installation. More information is accessible on Plastics Pipe Institute's geothermal webpage at *www.plasticpipe.org/buildingconstruction.* WWJ

Lance MacNevin, P.Eng., is the director of engineering for the Building & Construction Division at the Plastics Pipe Institute (PPI). He has been in the plastic pipe industry since 1993, involved with applications such as hydronic heating and cooling, geothermal, plumbing, and fire protection systems. MacNevin earned his IGSHPA installer accreditation in 2008 and has been closely involved with the geothermal industry ever since.

22 ■ July 2022 WWJ   waterwelljou   facebook.com/WaterWellJournal   WWJ July 2022 ■ 23

Other Resources for the Geothermal Industry

International Ground Source Heat Pump Association (IGSHPA) www.igshhpa.org

- Non-profit trade association focused on supporting the geothermal industry
- Training, certifications, design tools

International Ground Source Heat Pump Association

EXPERTS IN OUR FIELD

For more than three decades, the International Ground Source Heat Pump Association (IGSHPA) has worked to advance ground source heat pump (GSHP) technology on local, state, national, and international levels.

Welcome to the new IGSHPA!

Your past support of the International Ground Source Heat Pump Association has been central to the advancement of our industry. Thank you. Together, we are authoring a new chapter in the evolution of the organization and of the geothermal heat pump industry.

Last year OSU dissolved the IGSHPA Board and in June approved the transfer of IGSHPA, its intellectual property, and assets to the control of the Geothermal Exchange Organization. The new IGSHPA will be functionally and operationally independent, with GEO providing limited oversight of governance and financial solvency.

Other Resources for the Geothermal Industry

Geothermal Exchange Organization (GEO) www.geoexchange.org

- Non-profit trade association focused on supporting the geothermal industry
- Advocacy, tax incentive programs, promotions

About GEO

GEOEXCHANGE®

The Geothermal Exchange Organization

The Geothermal Exchange Organization (GEO) is The Voice of the Geothermal Heat Pump Industry in the United States. As a non-profit trade association, we promote the manufacture, design and installation of GeoExchange® systems—the most energy efficient and environmentally friendly heating and cooling technology in the world.

Government affairs and public outreach strategies pursued by GEO are more important than ever to knocking down barriers to industry growth, maintaining progress already won, and securing new opportunities. GEO advocacy successfully increased tax credits for residential geothermal heat pump installations from $300 to 30% of system costs. And through our efforts, geothermal heat pumps are increasingly recognized as a renewable energy technology alongside wind and solar, ensuring an integral role in meeting future government energy and environmental goals.

Presentation Summary

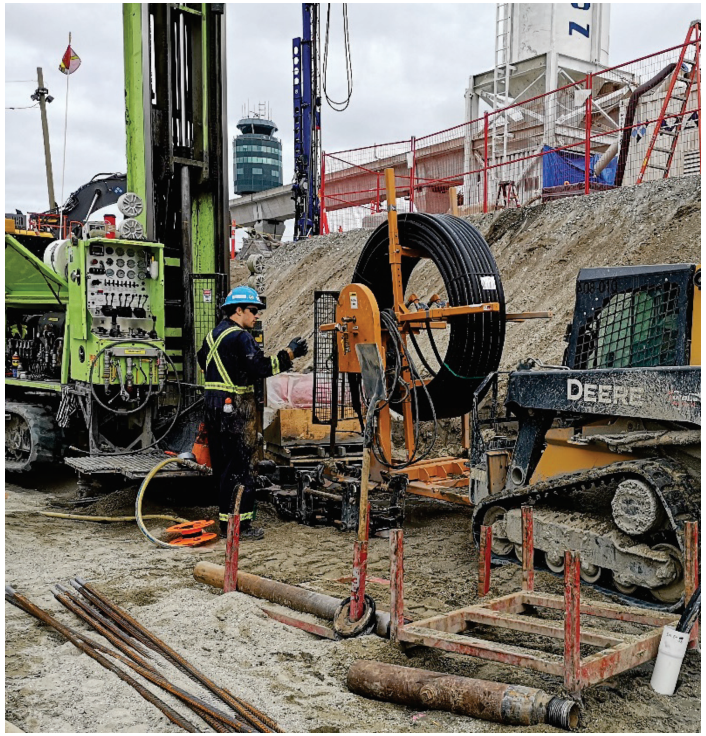
This presentation did:

1. Describe the **four types** of plastic piping materials used for ground source geothermal systems
   - **HDPE** *high density polyethylene*
   - **PEX** *crosslinked polyethylene*
   - **PE-RT** *polyethylene of raised temperature resistance*
   - **PP** *polypropylene (PP-R and PP-RCT)*

2. Discuss geothermal industry **standards** and **codes**

3. Demonstrate various **manifold** and **header** techniques

4. Introduce **PPI resources** of piping information



Plastics Pipe Institute

BUILDING & CONSTRUCTION

Plastic Piping Materials for Ground Source Geothermal Systems

Courtesy Centennial Plastics

Thank you!