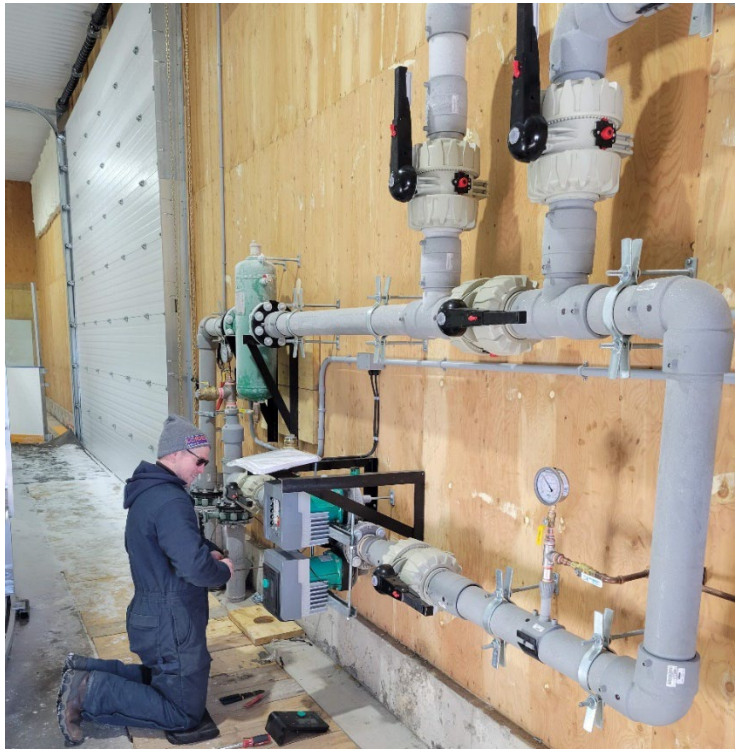
Plastics Pipe Institute
BUILDING & CONSTRUCTION

Achieving Higher Reliability and Sustainability with Plastic Pressure Piping Materials for Mechanical Applications

A presentation by The Plastics Pipe Institute



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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

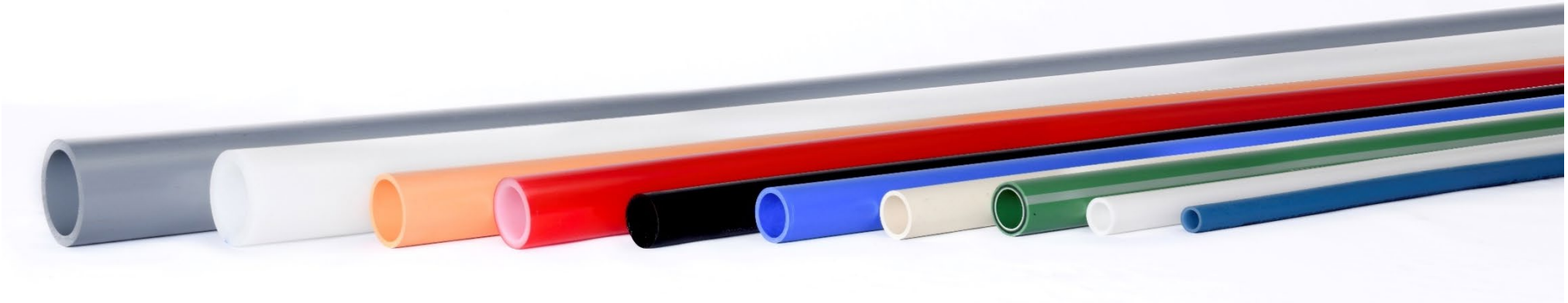
The Plastics Pipe Institute

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, and ground source geothermal piping systems.

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

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



Achieving Higher Reliability and Sustainability with Plastic Pressure Piping Materials for Mechanical Applications

Course Introduction:

- Specifiers and designers of mechanical systems have several options when selecting the optimal pipe and fitting material for each application.

- Considerations include temperature and pressure capabilities, material durability, convenience of handling, joining procedures, cost, and long-term reliability.

- Other practical selection factors include sound, vibration, and heat transfer.

- There is also the aspect of sustainability, embodied carbon, and the environmental impacts for producing various piping materials.

Achieving Higher Reliability and Sustainability with Plastic Pressure Piping Materials for Mechanical Applications

Course Description:

This course will demonstrate that plastic pressure pipe and fitting materials deliver reliable and sustainable solutions for many mechanical piping purposes and will help the audience to select which piping material or materials is best for applications such as:

- Hot- and cold-water plumbing distribution
- Hydronic heating & cooling, including radiant
- Snow and ice melting for outdoor surfaces
- Geothermal indoor piping systems
- District heating and cooling (typically buried pipelines)

Achieving Higher Reliability and Sustainability with Plastic Pressure Piping Materials for Mechanical Applications

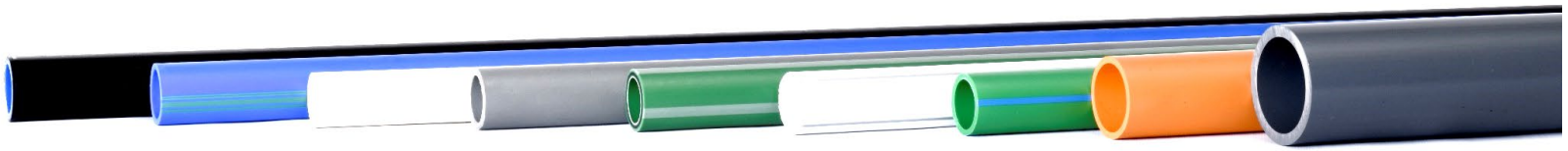
Presentation Outline:

1. Describe five plastic piping materials recommended for mechanical hydronic systems:
   - **CPVC, HDPE, PEX, PE-RT,** and **PP**
2. Indicate where and how to use these materials in applications such as plumbing, fire protection, hydronic heating and cooling, snow and ice melting, and district heating applications
3. Discuss the design of piping systems in terms of sizing for flow, pressure loss, thermal expansion and contraction, and static water column pressure etc.
4. Explain how to access industry resources for selecting mechanical piping material/s

Advantages of Plastic Pressure Piping Materials

Advantages to specifiers, contractors, and owners

- Safety of potable water and long-term reliability (when certified to NSF/ANSI/CAN 61)
- Resistant to disinfectants chlorine and chloramines (relevant for plumbing)
- No flame used for joining; fusion, solvent cement or compression joints
- Lower thermal conductivity = reduced heat transfer through pipe walls
- Resistant to corrosion, tuberculation, mineral deposits and build-up
- Clean work and ease of installation with professional appearance
- Lightweight, easier to transport on trucks and on jobsites (worker safety)
- Durability and toughness to survive commercial jobsite conditions
- Faster installation and lower installed cost than metallic pipes
- No scrap value helps to prevent jobsite theft
- **Better materials. Longer life. More Value.**

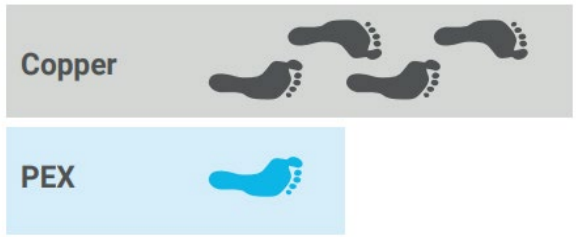


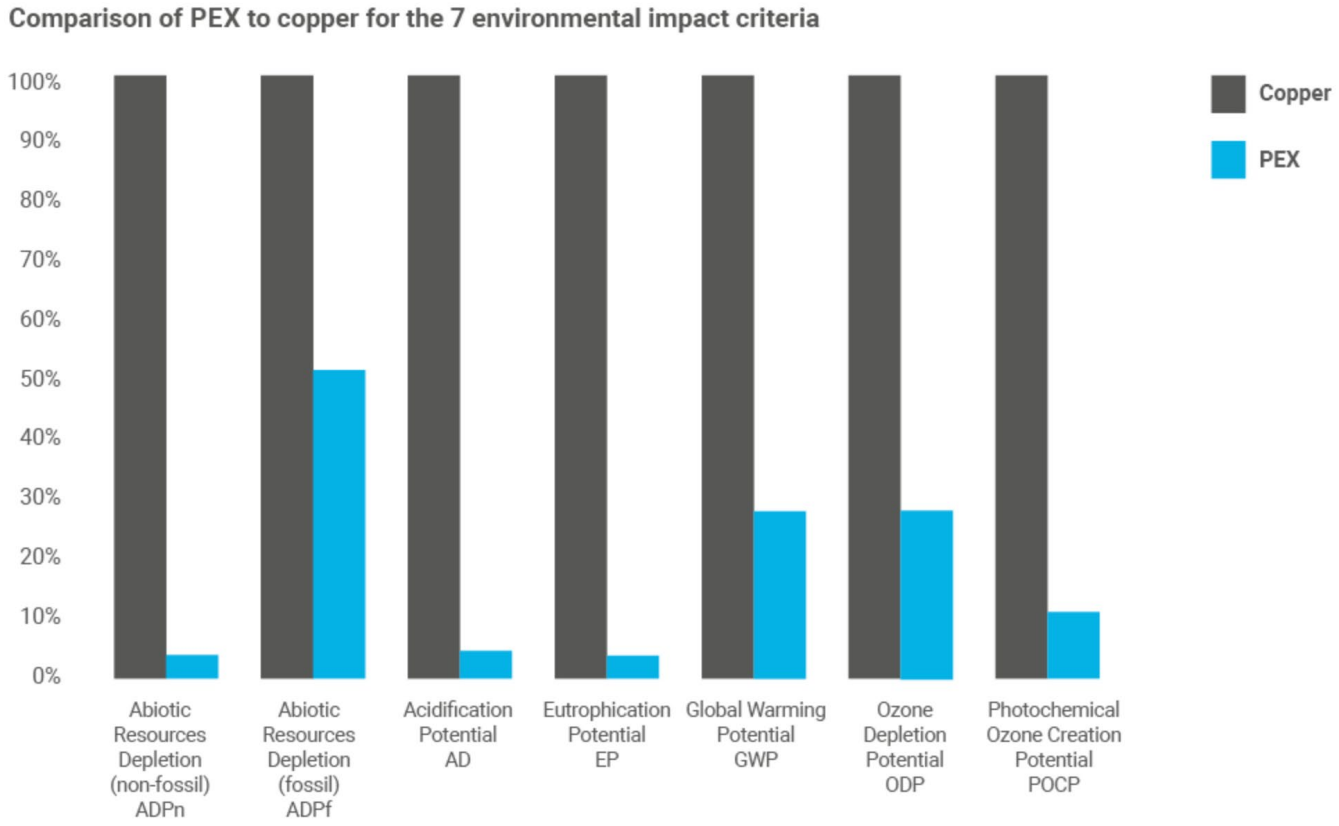
Advantages of Plastic Pressure Piping Materials

Sustainability

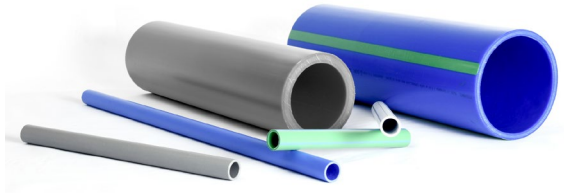
- Numerous peer-reviewed Life Cycle Analysis (LCA) reports clearly demonstrate that plastic piping systems have lower embodied carbon and require fewer resources to produce than traditional metallic piping
- Example: **PEX vs. Copper**

"An independent study following EN 15804 methodology by the world-renowned Flemish Institute for Technological Research (VITO), and validated by the Denkstatt sustainable development institute in Austria, is conclusive in its findings that plastic plastic pipe systems made from cross-linked polyethylene (PEX) for plumbing hot and cold solid wall applications have a lower environmental impact than those made from copper"





Advantages of Plastic Pressure Piping Materials



Sustainability

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- Example: **PP-R vs. Copper**

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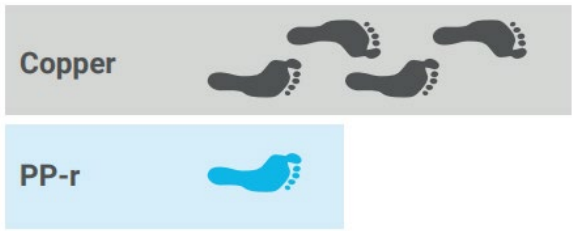
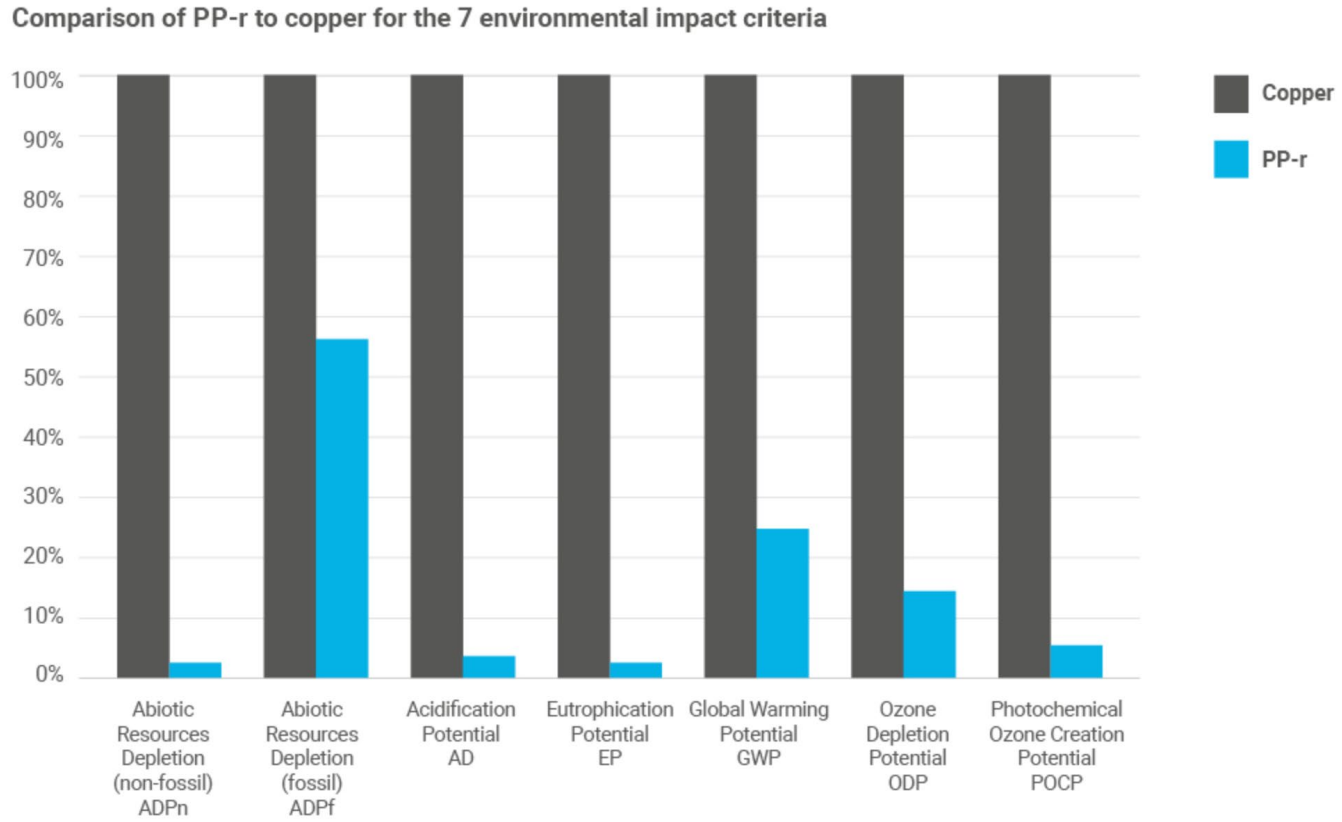
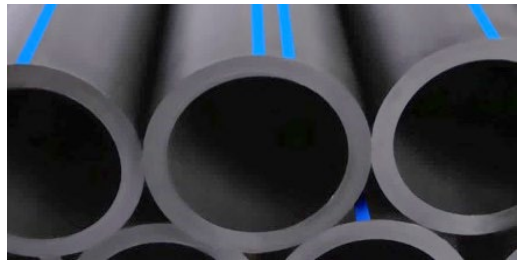




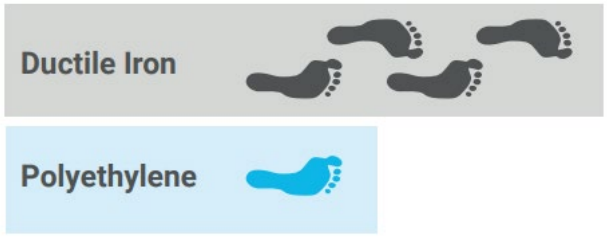
Advantages of Plastic Pressure Piping Materials

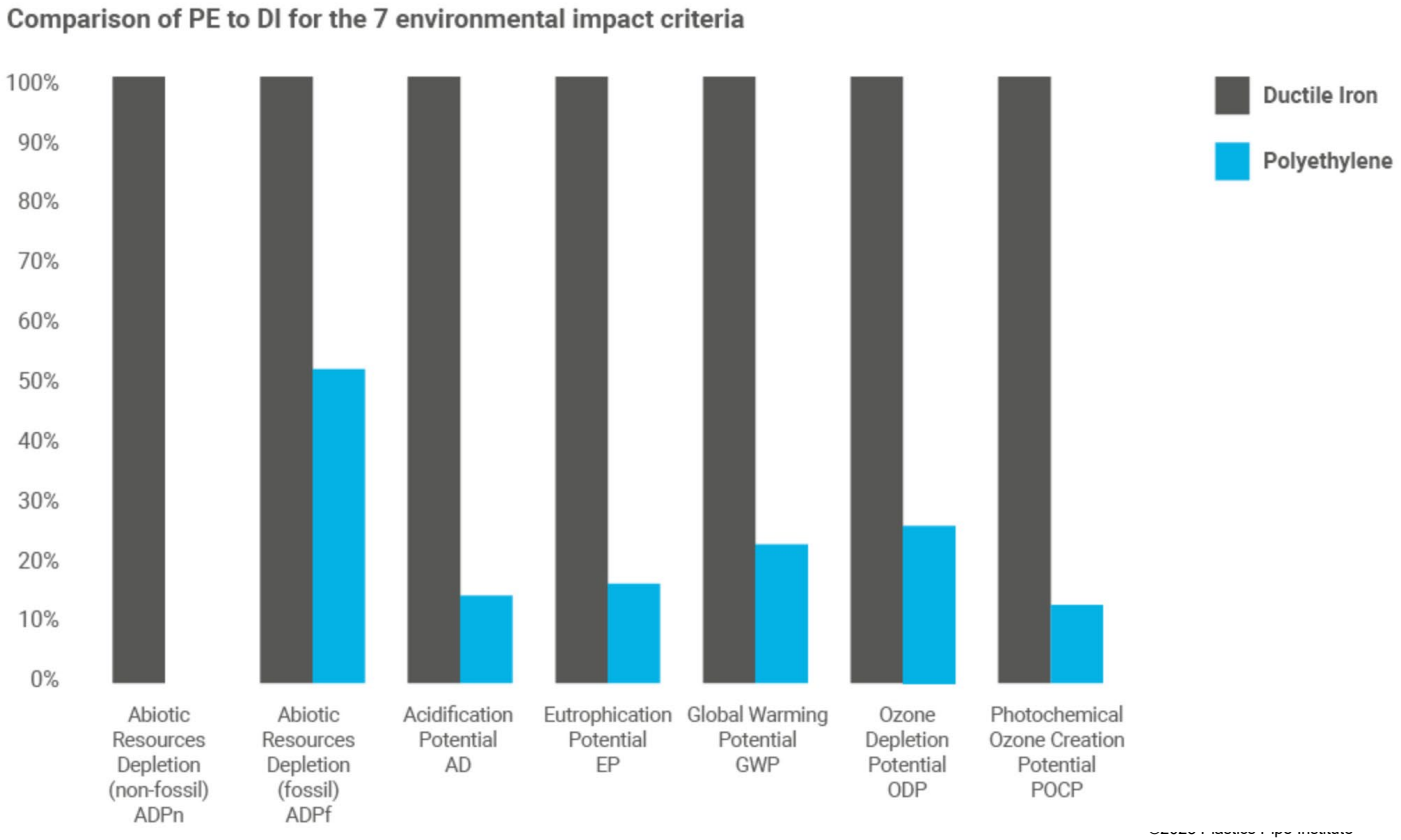


Sustainability

- Numerous peer-reviewed Life Cycle Analysis (LCA) reports clearly demonstrate that plastic piping systems have lower embodied carbon and require fewer resources to produce than traditional metallic piping
- Example: **HDPE vs. Ductile Iron**

"An independent study following EN 15804 methodology by the world-renowned Flemish Institute for Technological Research (VITO), and validated by the Denkstatt sustainable development institute in Austria, is conclusive in its findings that plastic plastic pipe systems made from cross-linked polyethylene (PEX) for plumbing hot and cold solid wall applications have a lower environmental impact than those made from copper"

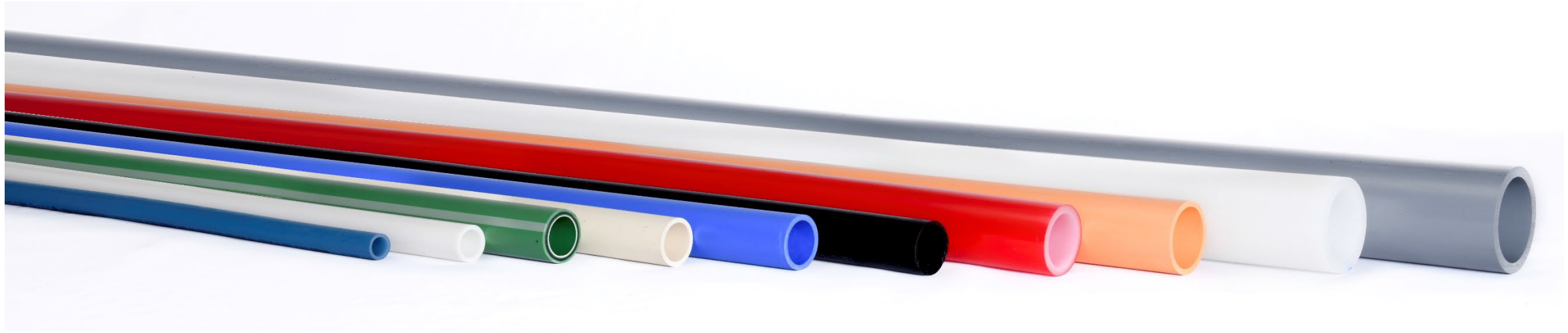




1. Piping Materials for Mechanical Applications

The five plastic piping materials recommended for mechanical piping applications are:

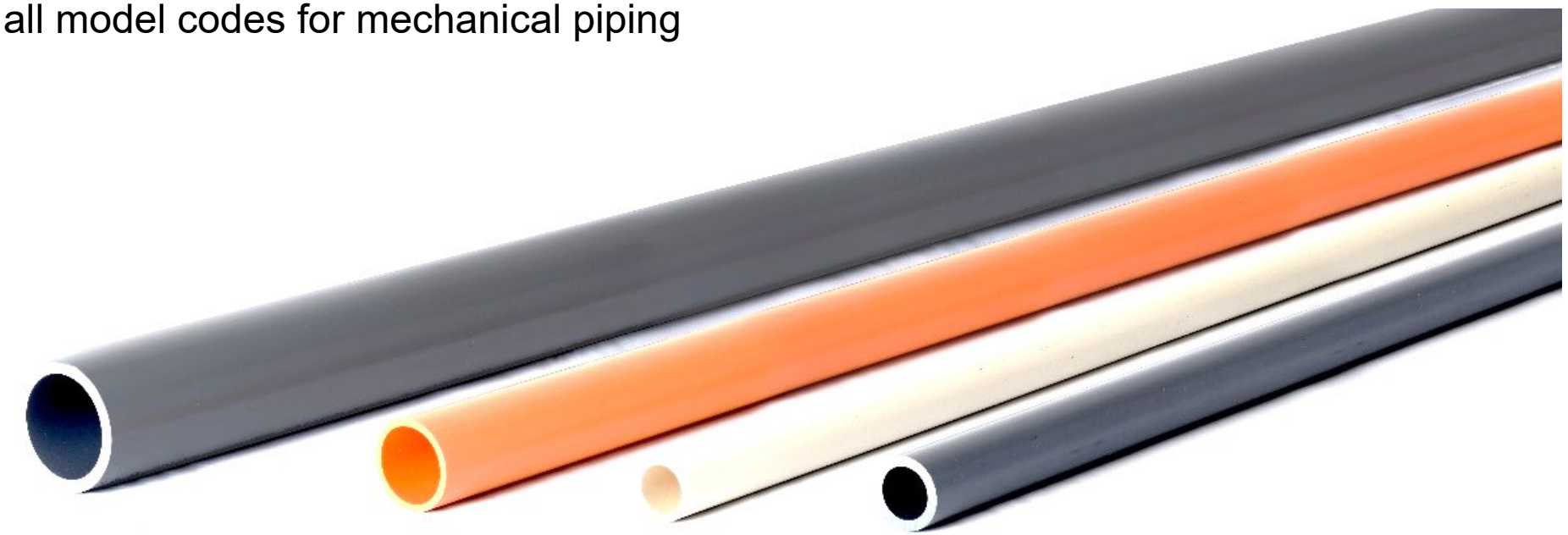
1. **CPVC** *chlorinated polyvinyl chloride*
2. **HDPE** *high density polyethylene*
3. **PEX** *crosslinked polyethylene*
4. **PE-RT** *polyethylene of raised temperature resistance*
5. **PP (PP-R, PP-RCT)** *polypropylene*



Piping Materials for Mechanical Applications

1. CPVC: What is CPVC?

- CPVC is polyvinyl chloride (PVC) that has been chlorinated via a *free radical chlorination reaction*
- CPVC material is produced by adding a chlorine molecule (C) to PVC
- Chlorine added to PVC gives CPVC higher temperature performance and improved fire and corrosion resistance
- CPVC pressure pipe is a **distinct material from PVC pressure pipe**, with additional capabilities
- CPVC is recognized in all model codes for mechanical piping



Piping Materials for Mechanical Applications

CPVC: Chlorinated Polyvinyl Chloride

- A high-temperature pressure piping system; rated for operation **up to 200°F (93°C)**
- Introduced for potable plumbing in 1959 (60+ years ago) followed by other uses
- Used for hot- and cold-water distribution, hydronic heating & cooling, industrial and process piping applications
- Provided in straight pipes lengths in both CTS sizes and IPS sizes
- Produced according to ASTM D2846, ASTM F441, ASTM F442 and/or CSA B137.6

Common types: CPVC 4120-05, CPVC 4120-06 (material designation codes)

Courtesy Lubrizol (x2)

Piping Materials for Mechanical Applications

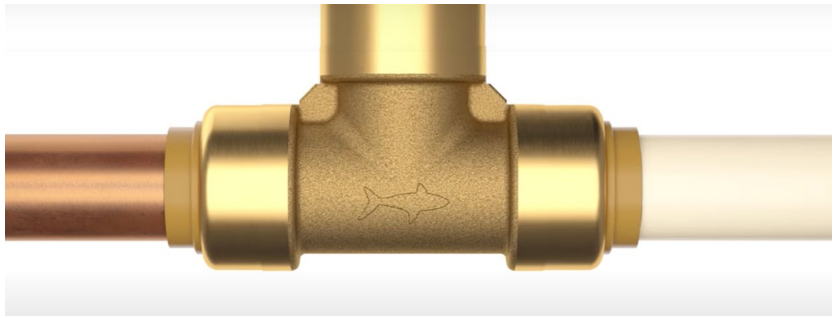
CPVC Configurations

- CPVC is provided in straight lengths
- Copper Tube Size (CTS) diameters ½ to 2 in SDR 11 wall type
- Iron Pipe Size (IPS) diameters ½ to 24 in Schedule 40/80 and several SDRs
- Fittings are molded in both CTS and IPS sizes

Piping Materials for Mechanical Applications

CPVC Joining

- CPVC pipe & fittings are joined via:
  1. Solvent Cement (most common)
  2. Push-fit fittings
  3. Grooved mechanical fittings
  4. Flanged connections



Piping Materials for Mechanical Applications

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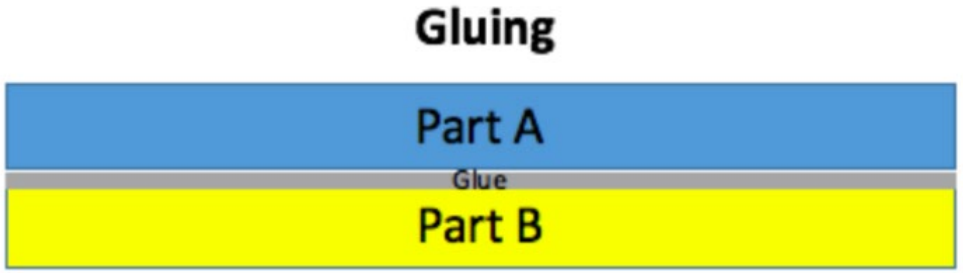
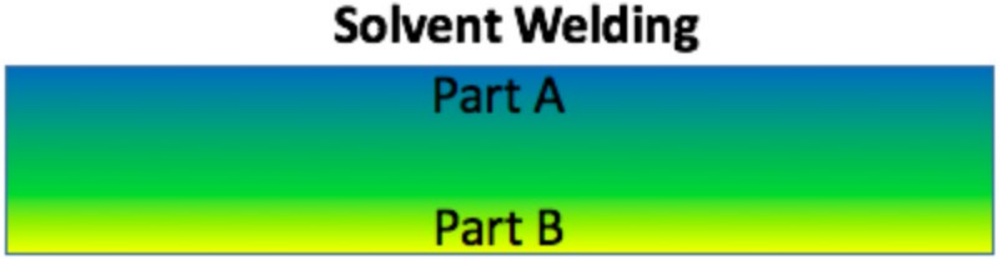
Solvent Cement is <u>Not Glue</u>

- **Glues** work by providing a sticky layer between two components to create a bond

- **Solvent welding** requires the two components to come into contact as the solvent cements allow the parts to molecularly bond with each other (i.e., welding)





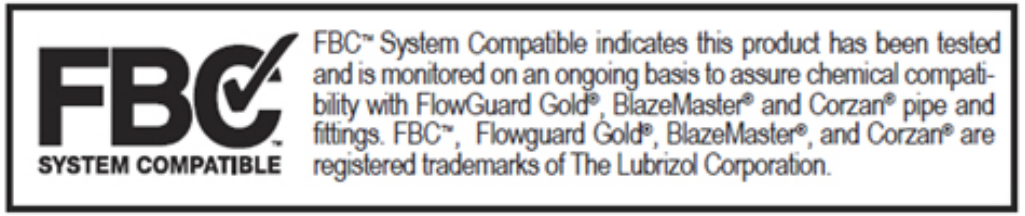
Piping Materials for Mechanical Applications

CPVC Chemical Compatibility

- CPVC materials have certain incompatibilities with some construction materials
- Each CPVC manufacturer should test for and publish chemical compatibility

Example:

- The **FBC™ System Compatible Program** is a resource made available to manufacturers of ancillary products intended to be used with CPVC to help determine whether a product is chemically compatible with Lubrizol Advanced Materials' FlowGuard®, BlazeMaster®, Corzan®, and products made with TempRite Technology
- Visit *https://www.lubrizol.com/CPVC/FBC-System-Compatible-Program -*



Piping Materials for Mechanical Applications

CPVC Summary

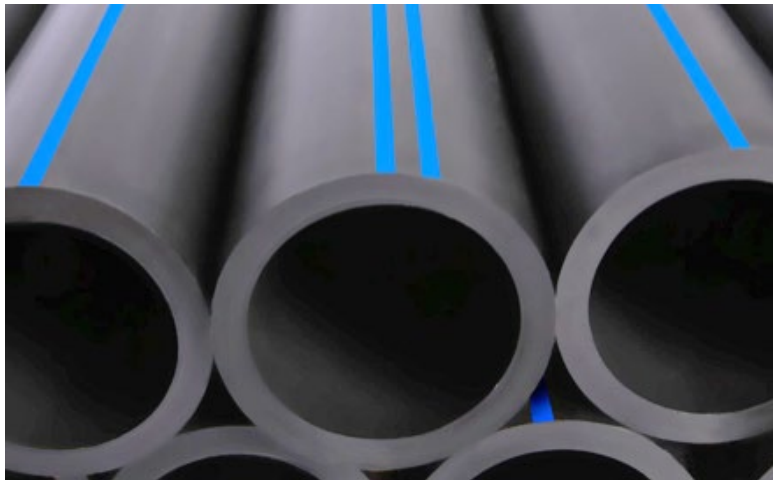
- Strong rigid piping material with high temperature capabilities (rated for **200°F**)
- Available in wide range of CTS and IPS diameters
- Available in various wall types and thicknesses (e.g., SDR 11, SDR 13.5, Schedule 40/80, etc.) depending on the required pressure rating
- Wide variety of fitting shapes and sizes available
- More economical than copper or steel
- Several domestic sources

Courtesy Lubrizol (x2)

Piping Materials for Mechanical Applications

2. 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
- Also used in several indoor piping applications
- Strong and tough material, suitable for applications up to **140°F (60°C)**
  - Pressure ratings of pipes must be de-rated above **80°F (27°C)**
- High chemical resistance, corrosion resistant, economical
- Produced according to ASTM D2239, D3035, F714 and/or CSA B137.1
- Recognized in IAPMO UMC for mechanical piping



Common types:

- PE3608, PE4710 (thermoplastic material designation codes)

Piping Materials for Mechanical Applications

HDPE Connections

- HDPE connections are typically via **heat fusion** (three types of fusion)
  1. Butt fusion (pipe-to-pipe or fitting-to-fitting) joints are produced according to **ASTM Standard D3261**
  2. Socket fusion (pipe-to-fitting) joints are produced according to **ASTM Standard D2683**
  3. Electrofusion (pipe-to-fitting) joints 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

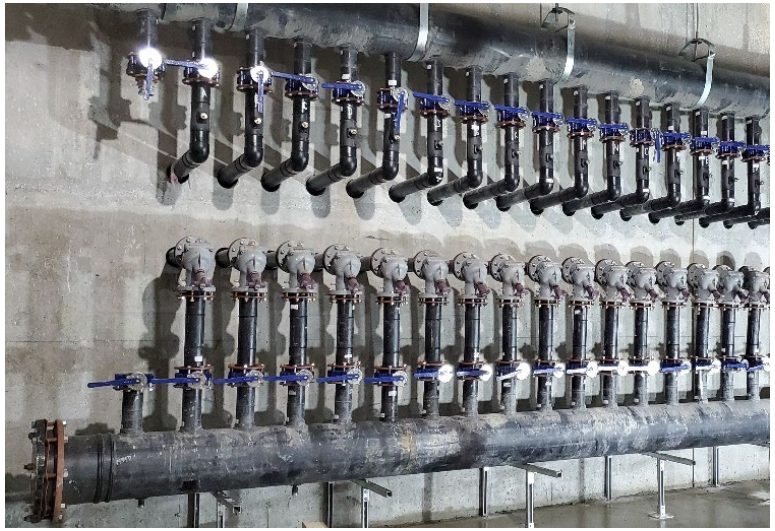
Electrofusion fitting

Socket fusion caps for testing

Piping Materials for Mechanical Applications

HDPE Summary

- Tough, durable, flexible, strong material
- Proven over 40+ years in ground loop applications
- Wide range of diameters and wall types
- Mechanical fittings (e.g., Victaulic) are options
- 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
- Material has temperature limitations (not over 140°F)
- Heat fusion requires training, equipment, and attention to detail



Piping Materials for Mechanical Applications

3. PEX: Crosslinked (X) Polyethylene

- Crosslinked polyethylene (PEX) is actually modified HDPE with enhanced capabilities for temperature
- PEX is a high-temperature, flexible pressure pipe, 50 years of global usage in pressure applications
- Crosslinking creates a three-dimensional matrix of inter-connected molecules
- Manufactured in copper tube size (CTS) sizes
- Produced according to ASTM F876 and/or CSA B137.5
- Recognized in all model codes for mechanical piping

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

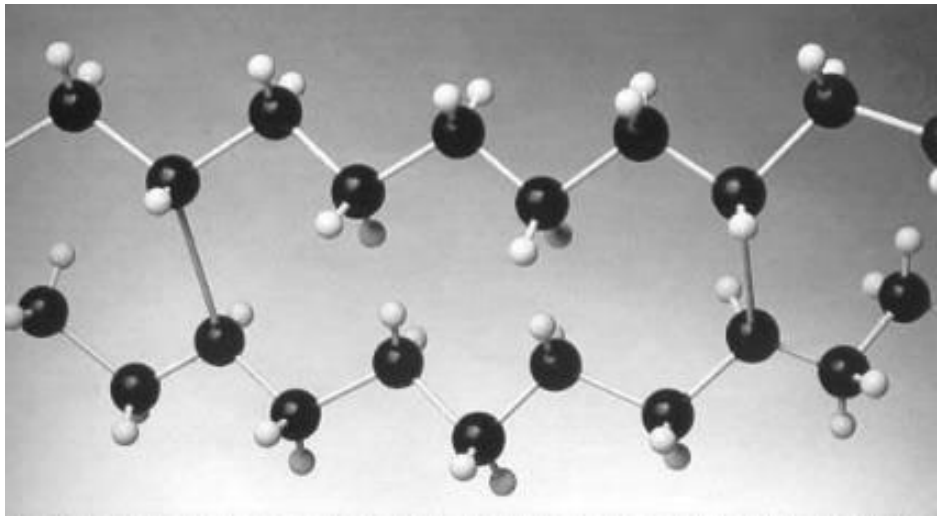


Illustration of PEX "molecule"

Piping Materials for Mechanical Applications

PEX: Crosslinked (X) Polyethylene

- PEX density is slightly lower than HDPE
- Lower tensile strength = Less stiff = More flexible than HDPE
- Strong and tough material, suitable for applications up to **180°F (82°C)** and beyond
- Many joining options available (not butt fusion or socket fusion)

Common types:

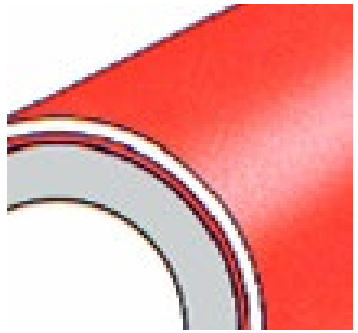
- PEX 1206, PEX 5106 (PEX tubing material designation codes)

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

Piping Materials for Mechanical Applications

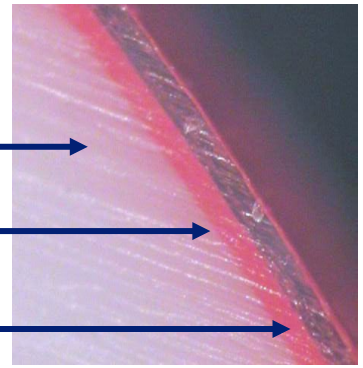
PEX with Oxygen Diffusion Barrier

- Oxygen (O_2) from the atmosphere can permeate or diffuse (pass through) the wall of certain plastic pipes (e.g., HDPE, PEX, PE-RT) and be absorbed into the heating system water
- This may cause corrosion of iron or steel components (causes no harm to the tubing itself)



Solution:

- Certain PEX tubing has an oxygen diffusion barrier (layer) to resist this permeation
- Barrier layer is a thin coating of **EVOH** (ethylene vinyl alcohol) coextruded above PEX
- This oxygen diffusion barrier is usually required when pipes are used in closed-loop hydronic systems with ferrous components
- The alternative is regular treatment of system fluid with corrosion inhibitors



Piping Materials for Mechanical Applications

PEX Joining

- 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**

Collection of PEX fittings from multiple manufacturers

Piping Materials for Mechanical Applications

PEX Joining: Crimp ring fittings

Crimp ring fitting

Copper crimp ring

(both per ASTM F1807)

Manual crimp tool

Piping Materials for Mechanical Applications

PEX Joining: Cold-expansion fittings with PEX reinforcing ring

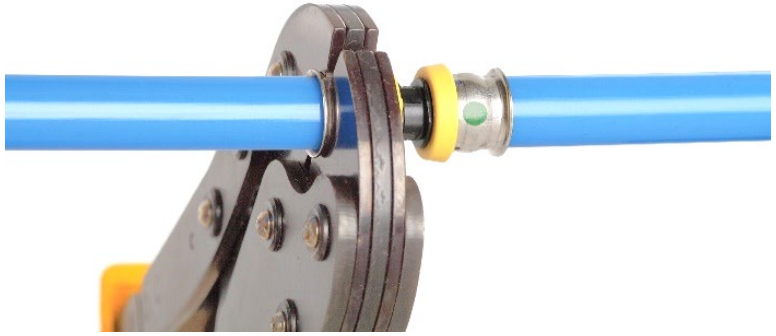
Courtesy Uponor

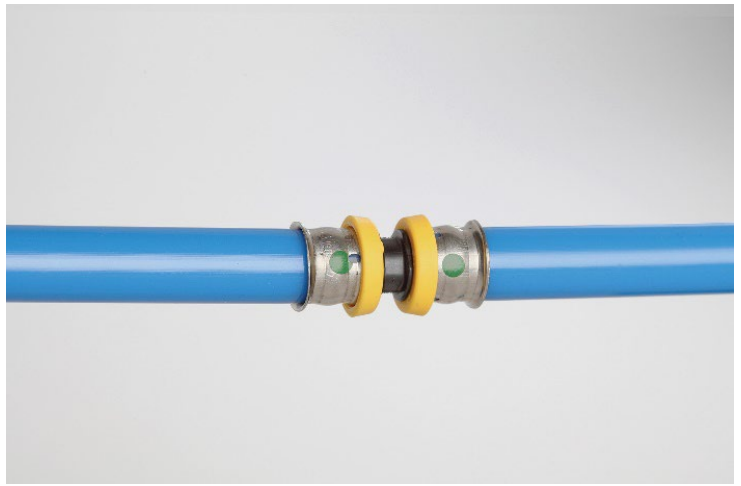
Cold-expansion PEX fittings (brass or polymer) per ASTM F1960

Piping Materials for Mechanical Applications

PEX Joining: Press sleeve fittings

Courtesy Viega LLC

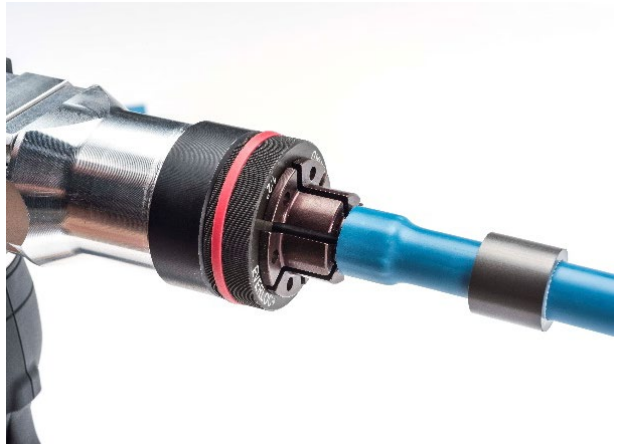


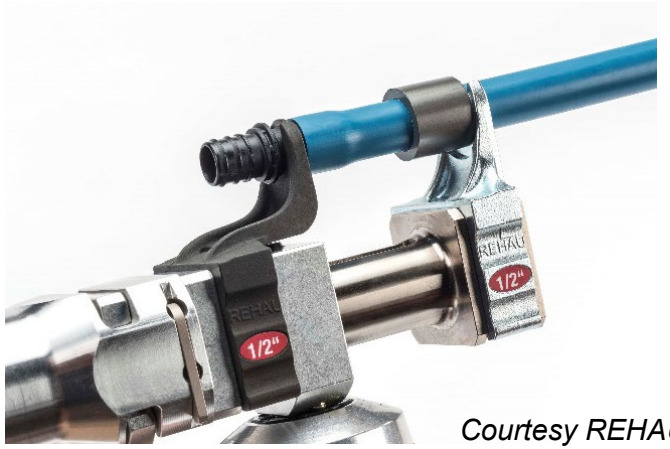


Press-sleeve PEX fitting per ASTM F3347 (bronze) or ASTM F3348 (polymer)

Piping Materials for Mechanical Applications

PEX Joining: Cold-expansion fittings with compression sleeve





Courtesy REHAU

Cold-expansion PEX fittings (brass or polymer) with PEX compression sleeve

Piping Materials for Mechanical Applications

PEX Summary

- Tough, durable, flexible, strong material with high temperature capabilities (**180°F** or higher)
- Ideal when high temperature resistance is needed (e.g., radiators)
- Available with oxygen diffusion barrier
- Available in diameters up to 3 inch nominal
- Joining systems install using basic hand tools or battery-electric tools

Courtesy Viega

Piping Materials for Mechanical Applications

4. 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 available as Tubing (CTS)
- PE-RT tubing can be joined via **heat fusion** (for PE or PE-RT fittings) or using most **PEX fittings**
- Produced according to ASTM F2729 and/or CSA B137.18
- Recognized in all model codes for mechanical piping

Common type:

- PE4710 (PE material designation code)

Courtesy Legend Valve

Piping Materials for Mechanical Applications

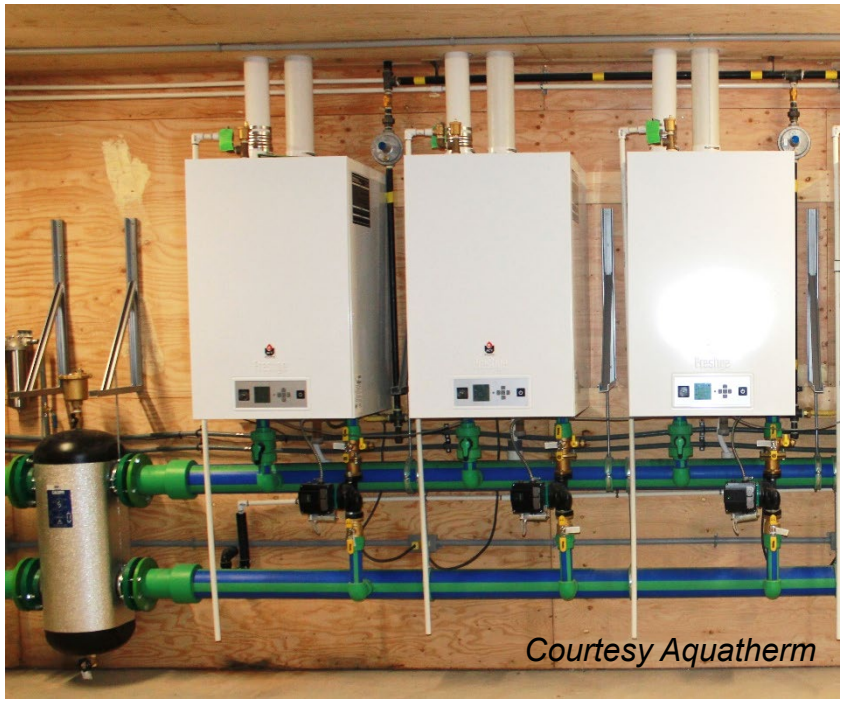
PE-RT is also available in large diameter piping

- May be used in district heating/cooling systems
- May use mechanical fittings or heat fusion

Piping Materials for Mechanical Applications

5. 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
- Recognized in all model codes for mechanical piping



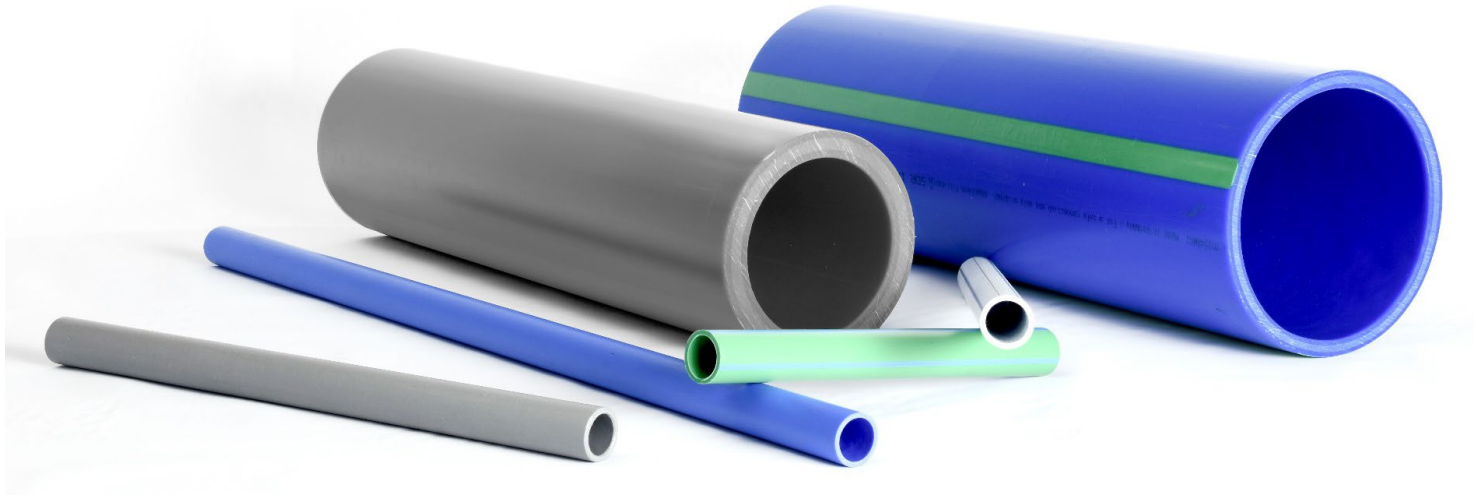
Courtesy Aquatherm

Piping Materials for Mechanical Applications

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

- *Random copolymerized polypropylene* (**PP-R**) is a high-temperature plastic pressure piping system developed used for plumbing and hydronic applications

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



Piping Materials for Mechanical Applications

PP-R & PP-RCT Connections

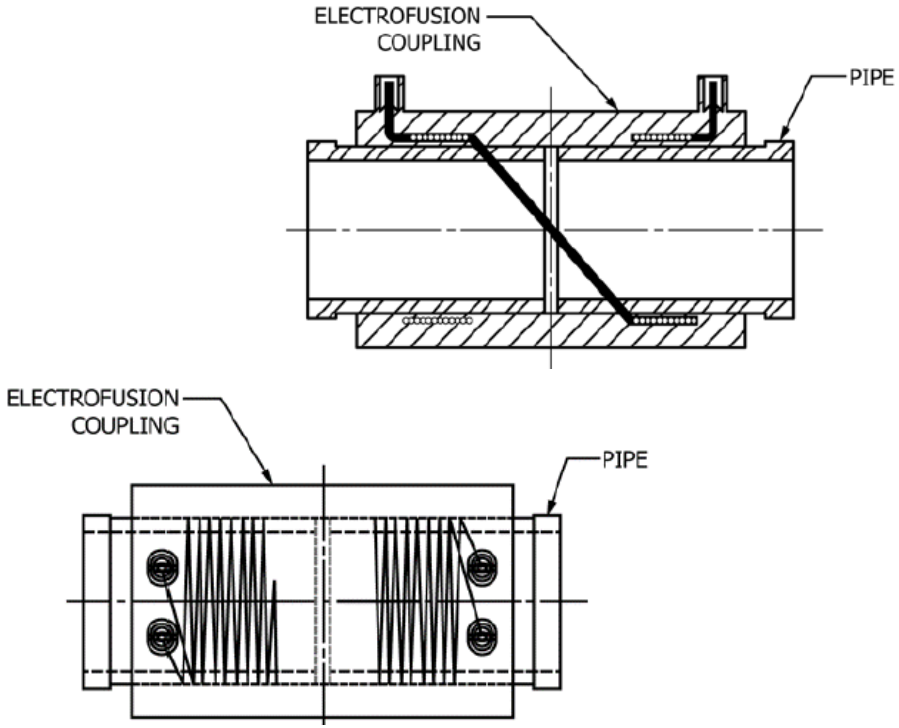
- Connections are typically via **heat fusion (socket, butt, and electrofusion)**
- Various mechanical fittings (e.g., grooved) and adapters are also available
- Prefabrication can save significant time and reduce installation costs

Basic fusion steps: 1. Heat 2. Press 3. Cool

Piping Materials for Mechanical Applications

PP-R & PP-RCT Connections

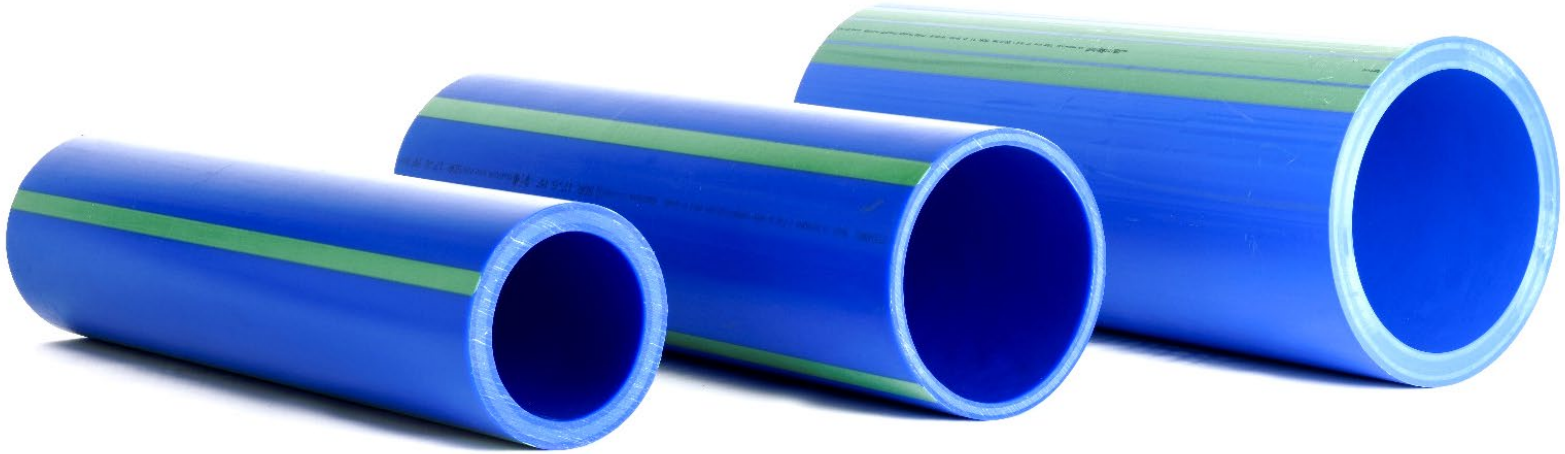
- **Electrofusion** joints have embedded copper wires that heat the fitting and the pipe, welding them
- A computerized electronic machine controls the process



Piping Materials for Mechanical Applications

PP 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
- Reliable fusion joining with a wide variety of fitting shapes and sizes



Piping Materials for Mechanical Applications

Each* of these materials is approved in model codes for plumbing & hydronics

**HDPE not permitted in IMC for hydronics*

- Example: IMC Table 1202.04

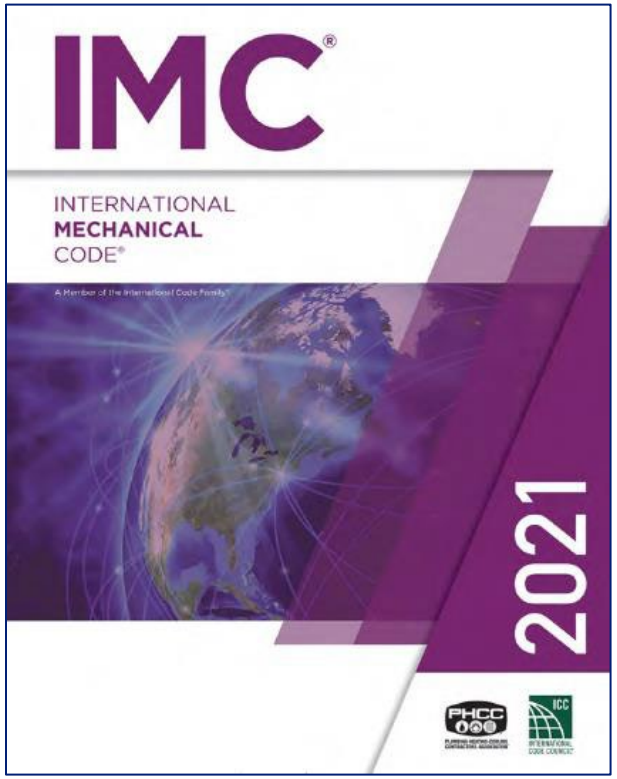


TABLE 1202.4
HYDRONIC PIPE

MATERIAL	STANDARD (see Chapter 15)
Acrylonitrile butadiene styrene (ABS) plastic pipe	ASTM D1527; ASTM F2806
Chlorinated polyvinyl chloride (CPVC) plastic pipe	ASTM D2846; ASTM F441; ASTM F442
Chlorinated polyvinyl chloride/aluminum/chlorinated polyvinyl chloride (CPVC/AL/CPVC)	ASTM F2855
Copper or copper-alloy pipe	ASTM B42; ASTM B43; ASTM B302
Copper or copper-alloy tube (Type K, L or M)	ASTM B75; ASTM B88; ASTM B135; ASTM B251
Cross-linked polyethylene/aluminum/cross-linked polyethylene (PEX-AL-PEX) pressure pipe	ASTM F1281; CSA CAN/CSA-B-137.10
Cross-linked polyethylene (PEX) tubing	ASTM F876; ASTM F3253; CSA B137.5
Ductile iron pipe	AWWA C115/A21.15; AWWA C151/A21.51
Lead pipe	FS WW-P-325B
Polyethylene/aluminum/polyethylene (PE-AL-PE) pressure pipe	ASTM F1282; CSA B137.9
Polypropylene (PP) plastic pipe	ASTM F2389
Polyvinyl chloride (PVC) plastic pipe	ASTM D1785; ASTM D2241
Raised temperature polyethylene (PE-RT)	ASTM F2623; ASTM F2769; CSA B137.18
Steel pipe	ASTM A53; ASTM A106
Steel tubing	ASTM A254

Piping Materials for Mechanical Applications

Each of these materials is approved in model codes for plumbing & hydronics

- Example: UMC Table 1210.1

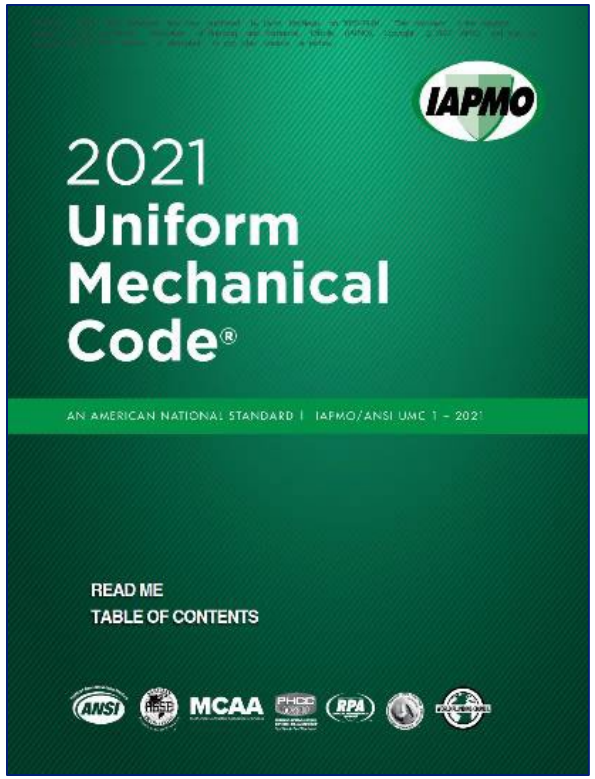


TABLE 1210.1
MATERIALS FOR HYDRONIC SYSTEM PIPING, TUBING, AND FITTINGS

MATERIAL	STANDARDS	
	PIPING/TUBING	FITTINGS
Copper/Copper Alloy	ASTM B42, ASTM B43, ASTM B75, ASTM B88, ASTM B135, ASTM B251[2], ASTM B302, ASTM B447	ASME B16.15, ASME B16.18, ASME B16.22, ASME B16.23, ASME B16.24, ASME B16.26, ASME B16.29, ASME B16.51, ASSE 1061, IAPMO PS 117
Ductile Iron	AWWA C115/A21.15, AWWA C151/A21.51	AWWA C110/A21.10[1], AWWA C153/A21.53
Steel	ASTM A53, ASTM A106, ASTM A135	ASME B16.5, ASME B16.9, ASME B16.11, ASTM A420
Stainless Steel	ASTM A269, ASTM A312, ASTM A554, ASTM A778	ASTM F1476, ASTM F1548, ASTM F3226, IAPMO PS 117
Gray Iron	—	ASTM A126
Malleable Iron	—	ASME B16.3
Chlorinated Polyvinyl Chloride (CPVC)	ASTM D2846, ASTM F441, ASTM F442, CSA B137.6	ASSE 1061, ASTM D2846, ASTM F437, ASTM F438, ASTM F439, ASTM F1970, CSA B137.6
Polyethylene (PE)	ASTM D1693, ASTM D2513, ASTM D2683, ASTM D2737, ASTM D3035, ASTM D3350, ASTM F714, AWWA C901, CSA B137.1, NSF 358-1	ASTM D2609, ASTM D2683, ASTM D3261, ASTM F1055, CSA B137.1, NSF 358-1
Cross-Linked Polyethylene (PEX)	ASTM F876, ASTM F3253, CSA B137.5, NSF 358-3	ASSE 1061, ASTM F877, ASTM F1055, ASTM F1807, ASTM F1960, ASTM F2080, ASTM F2098, ASTM F2159, ASTM F2735, ASTM F3253, CSA B137.5, NSF 358-3
Polypropylene (PP)	ASTM F2389, CSA B137.11, NSF 358-2	ASTM F2389, CSA B137.11, NSF 358-2
Polyvinyl Chloride (PVC)	ASTM D1785, ASTM D2241, CSA B137.3	ASTM D2464, ASTM D2466, ASTM D2467, ASTM F1970, CSA B137.2, CSA B137.3
Raised Temperature Polyethylene (PE-RT)	ASTM F2623, ASTM F2769, CSA B137.18	ASSE 1061, ASTM F1807, ASTM F2159, ASTM F2735, ASTM F2769, ASTM D3261, ASTM F1055, CSA B137.18
Cross-Linked Polyethylene/ Aluminum/Cross-Linked Polyethylene (PEX-AL-PEX)	ASTM F1281, CSA B137.10	ASTM F1281, ASTM F1974, ASTM F2434, CSA B137.10
Polyethylene/Aluminum/Polyethylene (PE-AL-PE)	ASTM F1282, CSA B137.9	ASTM F1282, ASTM F1974, CSA B137.9
Chlorinated Polyvinyl Chloride/Aluminum/ Chlorinated Polyvinyl Chloride (CPVC/AL/CPVC)	ASTM F2855	ASTM D2846

Piping Materials for Mechanical Applications

Each of these materials is approved in model codes for plumbing & hydronics

- Example: USHGC Table 409.1

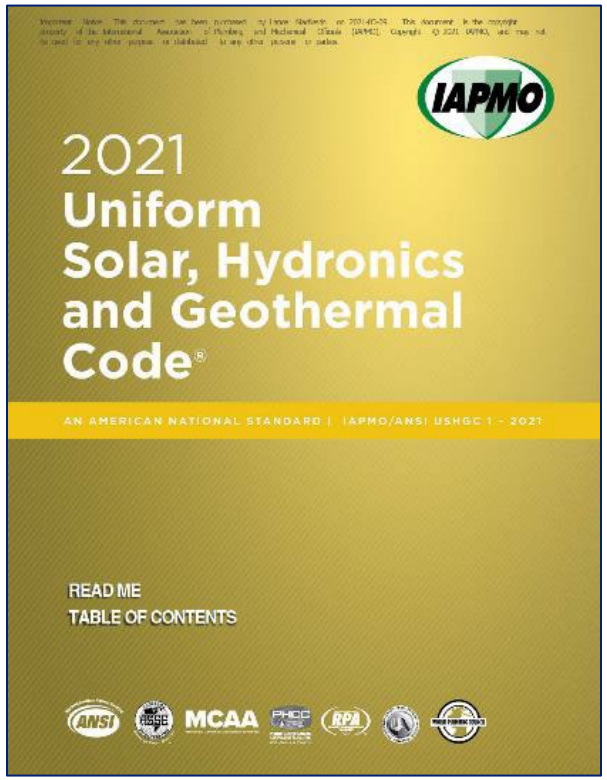


TABLE 409.1
MATERIALS FOR HYDRONIC AND SOLAR THERMAL SYSTEM, PIPING, TUBING, AND FITTINGS

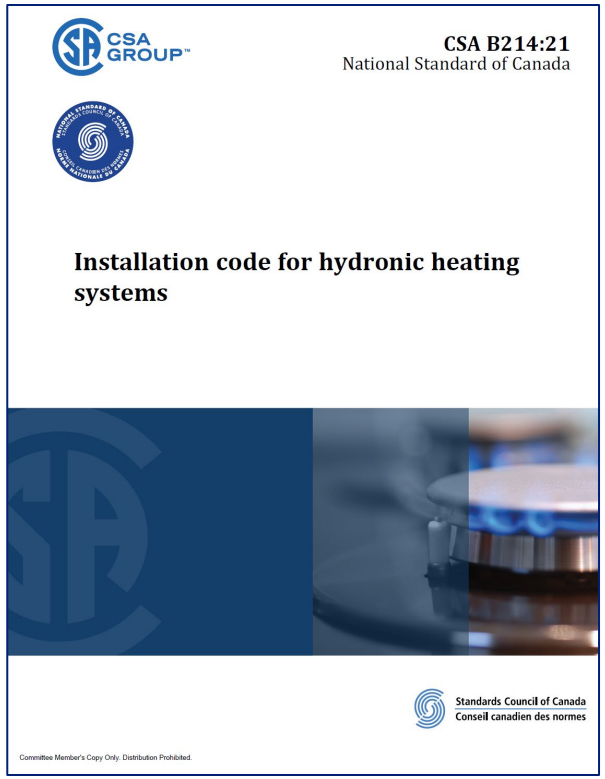
MATERIAL	STANDARDS	
	PIPING/TUBING	FITTINGS
Copper/Copper Alloy	ASTM B42, ASTM B43, ASTM B75, ASTM B88, ASTM B135, ASTM B251*, ASTM B302, ASTM B447	ASME B16.15, ASME B16.18, ASME B16.22, ASME B16.23, ASME B16.24, ASME B16.26, ASME B16.29, ASME B16.51, ASSE 1061, ASTM F3226, IAPMO PS 117
Steel	ASTM A53, ASTM A106, ASTM A254	ASME B16.5, ASME B16.9, ASME B16.11, ASTM A420, ASTM F3226, IAPMO PS 117
Gray Iron	—	ASTM A126
Malleable Iron	—	ASME B16.3
Chlorinated Polyvinyl Chloride (CPVC)	ASTM D2846, ASTM F441, ASTM F442, CSA B137.6	ASSE 1061, ASTM D2846, ASTM F437, ASTM F438, ASTM F439, ASTM F1970, CSA B137.6
Polyethylene (PE)	ASTM D1693, ASTM D2513, ASTM D2683, ASTM D2737, ASTM D3035, ASTM D3350, ASTM F714, ASTM F2165, AWWA C901, CSA B137.1, NSF 358-1	ASTM D2609, ASTM D2683, ASTM D3261, ASTM F1055, ASTM F2165, CSA B137.1, NSF 358-1
Cross-Linked Polyethylene (PEX)	ASTM F876, ASTM F2165, ASTM F3253, CSA B137.5, NSF 358-3	ASSE 1061, ASTM F877, ASTM F1055, ASTM F1807, ASTM F1960, ASTM F2080, ASTM F2098, ASTM F2159, ASTM F2165, ASTM F2735, ASTM F3253, ASTM F3347, ASTM F3348, CSA B137.5, NSF 358-3
Polypropylene (PP)	ASTM F2165, ASTM F2389, CSA B137.11, NSF 358-2	ASTM F2165, ASTM F2389, CSA B137.11, NSF 358-2
Polyvinyl Chloride (PVC)	ASTM D1785, ASTM D2241, CSA B137.3	ASTM D2464, ASTM D2466, ASTM D2467, ASTM F1970, CSA B137.2, CSA B137.3
Raised Temperature Polyethylene (PE-RT)	ASTM F2165, ASTM F2623, ASTM F2769, CSA B137.18	ASSE 1061, ASTM D3261, ASTM F1055, ASTM F1807, ASTM F2159, ASTM F2165, ASTM F2735, ASTM F2769, CSA B137.18
Cross-Linked Polyethylene/Aluminum/ Cross-Linked Polyethylene (PEX-AL-PEX)	ASTM F1281, ASTM F2165, CSA B137.10	ASTM F1281, ASTM F1974, ASTM F2165, ASTM F2434, CSA B137.10
Polyethylene/Aluminum/Polyethylene (PE-AL-PE)	ASTM F1282, ASTM F2165, CSA B137.9	ASTM F1282, ASTM F1974, ASTM F2165, CSA B137.9
Stainless Steel	ASTM A269, ASTM A312, ASTM A554, ASTM A778	ASTM F1476, ASTM F1548, ASTM F3226, IAPMO PS 117
Chlorinated Polyvinyl Chloride/Aluminum/ Chlorinated Polyvinyl Chloride (CPVC/AL/CPVC)	ASTM F2855	ASTM D2846

Piping Materials for Mechanical Applications

Each* of these materials is approved in model codes for plumbing & hydronics

**HDPE not permitted in CSA B214*

- Example from Ch. 9 of CSA B214-21



8 Distribution piping

8.1 Proximity to heat source

The proximity of a non-metallic pipe or tubing connection to the heat source shall be in accordance with the pipe or tubing manufacturer's installation instructions.

8.2 Unconditioned spaces

In cases where distribution piping is to pass through an unconditioned space, measures shall be taken to protect the piping from freezing and to allow delivery of the system design output. The pipe shall be insulated [applicable Code].

8.3 Inspection and test

The installation shall be pressure tested as specified in Clause 4.5.1 before the distribution piping is enclosed.

Note: *The authority having jurisdiction might require an inspection at this point.*

8.4 General

8.4.1 Expansion and contraction

Pipe and tubing shall not be anchored rigidly to a support but shall be allowed freedom of movement to expand and contract, except where a pipe anchor is used that is designed to force controlled expansion in both directions through pipe guides.

8.4.2 Minimizing stresses

Pipe and tubing shall be installed in such a way that prevents undue stress on the pipe, tubing, and fittings. Restraints, such as clamps, guides, or straps, may be used to support the pipe or tubing.

8.4.3 Support

Pipe and tubing shall be supported as specified in Clause 9.3 or 9.4. Additional support shall be provided for system components, such as valves, circulators, and expansion tanks.

9 Pipe, tube, and tubing

9.1 Metallic pipe and tube

Metallic pipe and tube shall comply with

a) ASTM B88 for copper tube; or
b) ASTM A53/A53M, ASTM A105/A105M, or ASTM A106/A106M for steel pipe.

Galvanized steel pipe and fittings shall not be used.

Note: *See Clause 4.2.5.3.*

9.2 Non-metallic pipe and tubing

9.2.1 Cross-linked polyethylene (PEX) tubing

Cross-linked polyethylene (PEX) tubing shall comply with CSA B137.5 or one of the following:

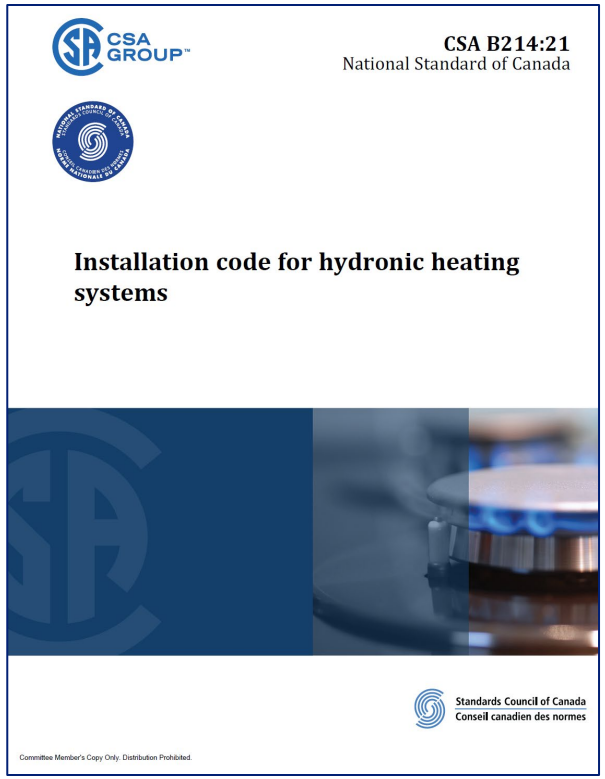
a) ASTM F876;

Piping Materials for Mechanical Applications

Each* of these materials is approved in model codes for plumbing & hydronics

**HDPE not permitted in CSA B214*

- Example from Ch. 9 of CSA B214-21



b) ASTM F3253;
c) DIN 16892 and DIN 16893; or
d) ISO 15875-1, ISO 15875-2, ISO 15875-3, and ISO 15875-5, Class A.

9.2.2 Chlorinated polyvinyl chloride (CPVC) pipe and tubing

Chlorinated polyvinyl chloride (CPVC) pipe and tubing shall comply with
a) CSA B137.6; or
b) ASTM F441/F441M.

9.2.3 Metal/plastic PEX-AL-PEX composite pipe

PEX-AL-PEX composite pipe shall comply with
a) CSA B137.10; or
b) ASTM F1281.

9.2.4 Metal/plastic PERT-AL-PERT composite pipe

PERT-AL-PERT composite pipe shall comply with
a) CSA B137.9;
b) ASTM F1282; or
c) ASTM F3346.

9.2.5 Polypropylene (PP-R and PP-RCT) pipe and tubing

Polypropylene (PP-R and PP-RCT) pipe and tubing shall comply with
a) CSA B137.11; or
b) ASTM F2389.

9.2.6 Polyethylene of raised temperature (PERT) tubing

Polyethylene of raised temperature (PERT) tubing shall comply with
a) CSA B137.18;
b) ASTM F2623; or
c) ASTM F2769.

Note: *ASTM F2623 is only approved for non-potable applications. ASTM F2769 is approved for potable applications.*

9.2.7 Flexible pre-insulated plastic piping

Flexible pre-insulated plastic piping shall comply with
a) CSA B137.5; or
b) ASTM F2165.

9.2.8 Installation of non-metallic piping in return-air plenums

All non-metallic piping materials to be installed in return-air plenums shall comply with CAN/ULC S102.2 when installed as per the manufacturer's recommendations.

9.2.9 Protection against corrosion

When using non-metallic piping materials in a closed system, steps shall be taken to prevent corrosion resulting from oxygen entering the system. See Clause 4.1.3.

Piping Materials for Mechanical Applications

Flame and Smoke Ratings: UMC

- The 2021 UMC requires that if piping is to be installed within a return air plenum that requires "non-combustible materials" then the piping must demonstrate a flame spread rating ≤ 25 and a smoke spread rating ≤ 50 when tested according to **ASTM E84** or **UL 723**

- The 2021 IMC requires testing according **ASTM E84** or **UL 723** or **UL 2846**

- In **Canada**, flame and smoke spread testing is in accordance with **CAN/ULC S102.2**

- These values are generated using the so-called "Steiner Tunnel" test

- Codes are subject to change, so check with AHJ for local requirements!

Image of Steiner Tunnel at UL LLC

Piping Materials for Mechanical Applications

Summary: The plastic piping materials recommended for mechanical piping applications are

1. **CPVC** *chlorinated polyvinyl chloride*
2. **HDPE** *high density polyethylene*
3. **PEX** *crosslinked polyethylene*
4. **PE-RT** *polyethylene of raised temperature resistance*
5. **PP (PP-R, PP-RCT)** *polypropylene*

- Each of these materials provides corrosion resistance, chemical resistance, toughness, flexibility, impact resistance, long-term hydrostatic strength (pressure capability), temperature resistance, and more

2. Typical Applications for Plastic Piping Systems

Top Ten Mechanical Applications which are ideal for plastic piping systems

1. Hot- and cold-water plumbing distribution, commercial and residential
2. Fire protection (within NFPA guidelines)
3. Water service lines
4. Reclaimed water
5. Hydronic heating and cooling
6. Radiant heating and cooling
7. Snow and ice melting
8. Chilled water
9. Geothermal system piping (ground loops and indoor piping)
10. District heating and cooling/ambient temperature loops (ATL)

Typical Applications for Plastic Piping Systems

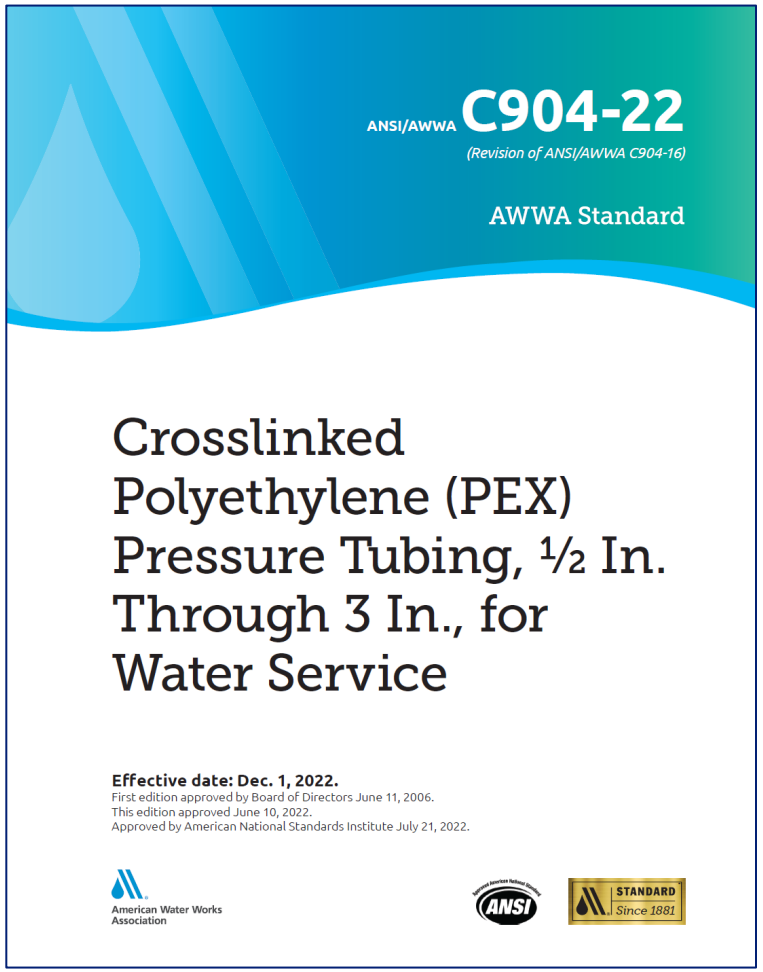
1. Hot- and cold-water plumbing distribution, commercial and residential

Typical Applications for Plastic Piping Systems

2. Fire protection (within NFPA guidelines)

Typical Applications for Plastic Piping Systems

3. Water service lines



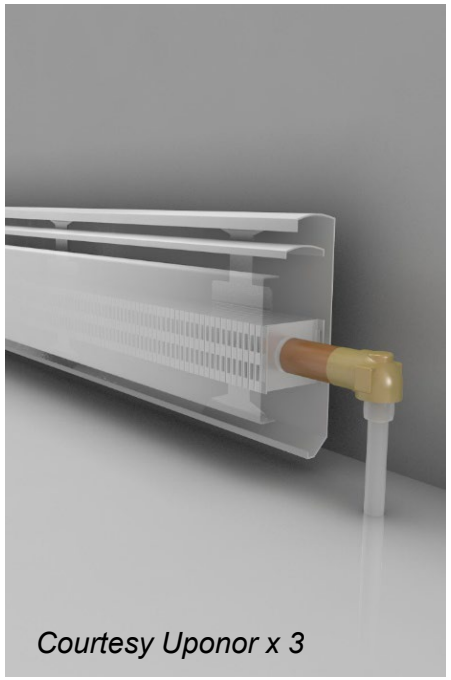
Typical Applications for Plastic Piping Systems

4. Reclaimed water

Courtesy Uponor

Typical Applications for Plastic Piping Systems

5. Hydronic heating and cooling piping


Courtesy Uponor x 3


Courtesy Aquatherm

Typical Applications for Plastic Piping Systems

6. Radiant heating and cooling


Courtesy Uponor


Courtesy REHAU

Courtesy Viega LLC

Typical Applications for Plastic Piping Systems

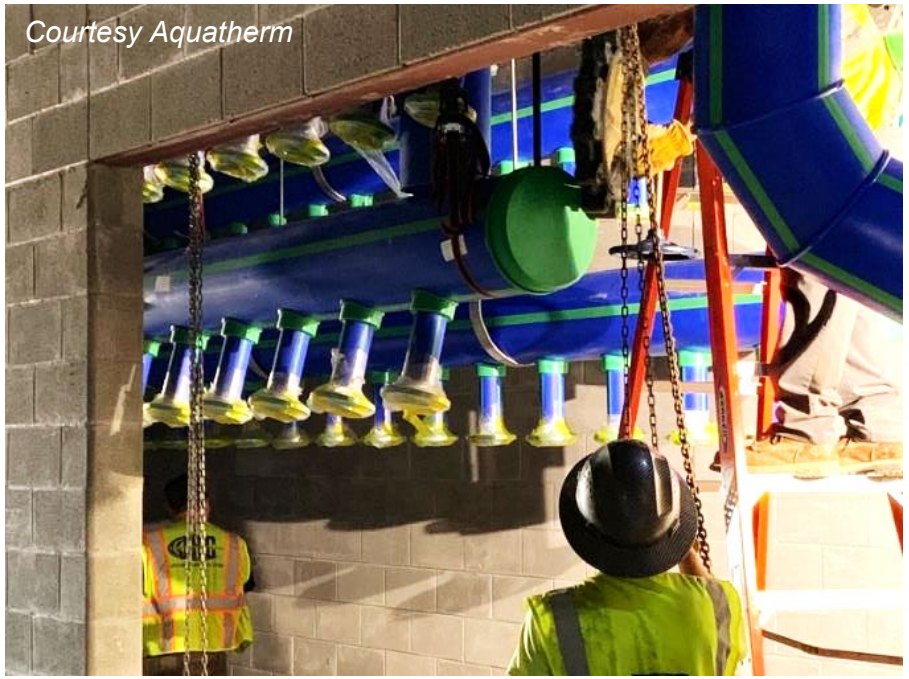
7. Snow and ice melting

Typical Applications for Plastic Piping Systems

8. Chilled water

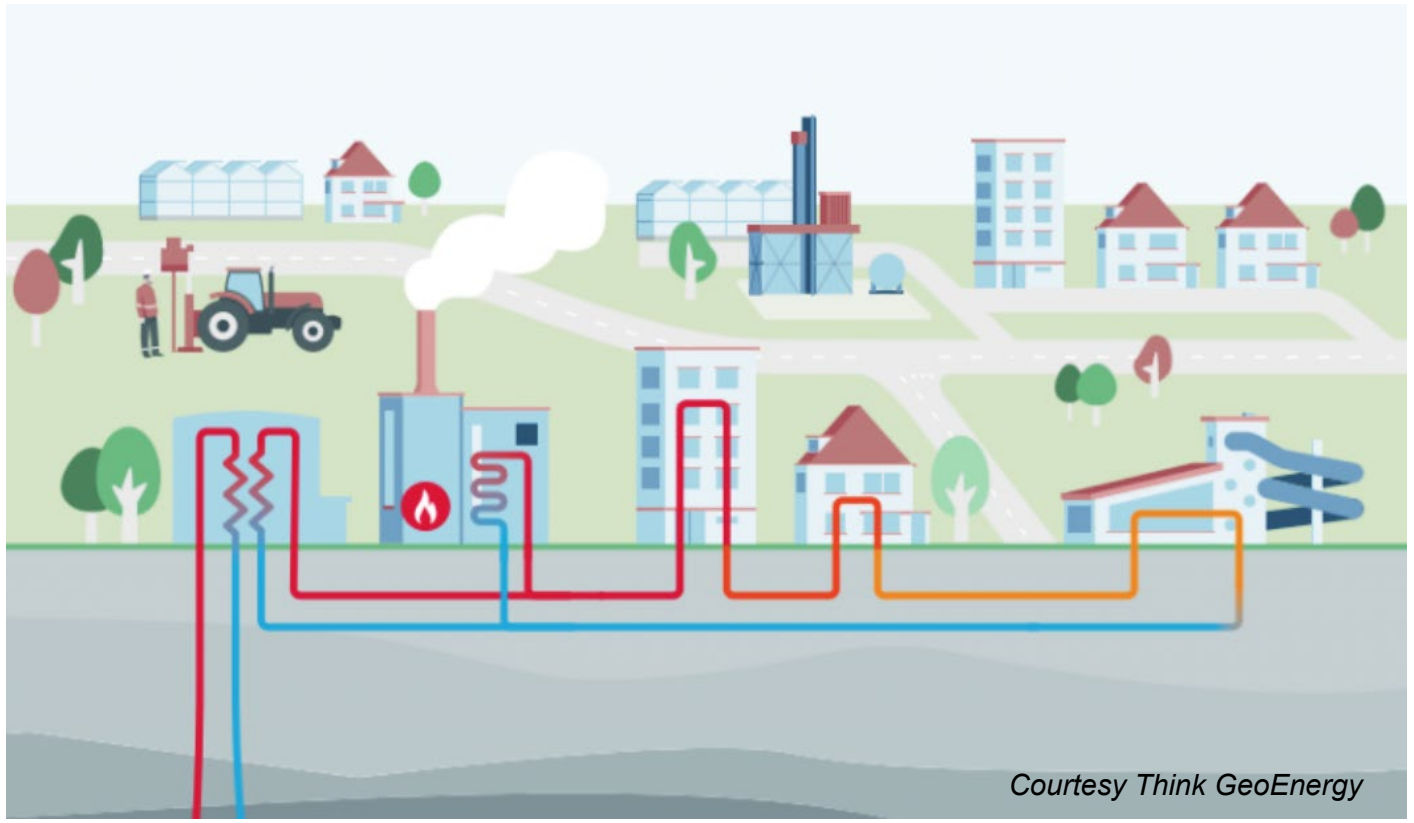
Typical Applications for Plastic Piping Systems

9. Geothermal system piping (ground loops and indoor piping)



Typical Applications for Plastic Piping Systems

10. District heating and cooling/ambient temperature loops (ATL)



3. Tools for Designing Piping Systems

Considerations for sizing and designing piping systems

1. Sizing pipes for flow rates / calculating pressure drop (head loss)
2. Addressing hydraulic shock to prevent pressure surges
3. Determining pipe weights and volumes (empty and full)
4. Predicting longitudinal thermal expansion / contraction
5. Sizing expansion arms & legs (for thermal expansion)
6. Predicting internal water pressure caused by elevation (i.e., static water column)

The **PPI Plastic Pipe Design Calculator** does all of these
Free online sizing tool at www.plasticpipecalculator.com

Tools for Designing Piping Systems

1. Plastic Pipe Design Calculator – Pressure Drop / Head Loss

BCD Plastic Pipe Design Calculator Ver 3.1

PRESSURE DROP / HEAD LOSS

Input

Is this a Geothermal Application? ☐

Pipe/Tubing Selection[1]

Pipe/Tubing Material: PEX

Sizing Type (CTS/IPS/Metric): CTS (ASTM F876/CSA B137.5)

Flow Rate:	1.5	USGPM
Length of Pipe:	333	ft
Fluid Type (Water or % Antifreeze[3]):	50% Propylene Glycol	
Average Fluid Temperature[4]:	40	°F

Calculate

Results

Flow Regime:	Laminar	
Pressure Drop:	9.60 Psi	66.2 kPa
Head Loss:	22.2 ft water	
Velocity*:	1.36 ft/s	0.41 m/s

Calculation Details Print Email

Tools for Designing Piping Systems

2. Plastic Pipe Design Calculator – Hydraulic Shock

BCD Plastic Pipe Design Calculator Ver 3.1

HYDRAULIC SHOCK

Input

Is this a Geothermal Application? ☐

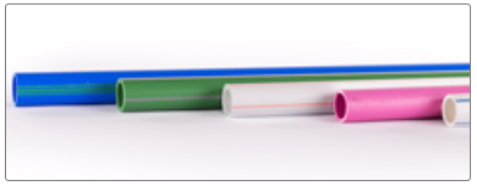
Pipe/Tubing Selection[1]

Pipe/Tubing Material: PP-R

Sizing Type (CTS/IPS/Metric): DN - Metric (ASTM F2389)

Wall Type (SDR/Schedule): DR 11

Nominal Pipe/Tubing Size[2]: 32



More information on PP-R

Calculate

Flow Rate: 8 USGPM

**The hydraulic shock calculations here are for water only at 73°F/23°C .*

Results

Pressure Surge:	42.2 Psi	291.2 kPa

Calculation Details Print Email

Tools for Designing Piping Systems

3. Plastic Pipe Design Calculator – Pipe Weight / Volume

BCD Plastic Pipe Design Calculator Ver 3.1

PIPE WEIGHT / VOLUME

Input

Is this a Geothermal Application? ☐

Pipe/Tubing Selection[1]

Pipe/Tubing Material: PE-RT (Non-potable)

Sizing Type (CTS/IPS/Metric): CTS (ASTM F2623/CSA B137.18)

Wall Type (SDR/Schedule): SDR 9

Nominal Pipe/Tubing Size[2]: 1/2

More information on PE-RT

Calculate

Length Of Pipe: 3500 ft

Fluid Type (Water or % Antifreeze[3]): 30% Propylene Glycol

Results

Dry Weight:	185.8 lb	84.3 kg
Filled Weight:	462.0 lb	209.5 kg
Volume Of Fluid In Pipe:	32.2 US Gallons	122.0 L
Volume Of Mixture Fluid:	9.7 US Gallons	36.6 L

Calculation Details Print Email

Tools for Designing Piping Systems

4. Plastic Pipe Design Calculator – Thermal Expansion

BCD Plastic Pipe Design Calculator Ver 3.1

THERMAL EXPANSION / CONTRACTION

Input

Is this a Geothermal Application? ☐

Pipe/Tubing Selection[1]

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 Size[2]: 2

More information on HDPE

Calculate

Initial Temperature:	70	°F
Final Temperature:	100	°F
Length of Pipe:	200	ft

Results

Length of Tube Expansion:	5.8 in	146 mm

Calculation Details Print Email

Tools for Designing Piping Systems

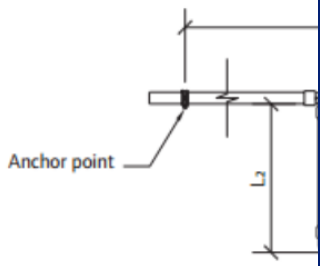
5. Plastic Pipe Design Calculator – Expansion Arm / Loop

BCD Plastic Pipe D

EXPANSION ARM/LOOP

Input

Expansion Type:



Pipe/Tubing Selection[1]

Pipe/Tubing Material:	CPVC
Sizing Type (CTS/IPS/Metric):	IPS (ASTM F441/CSA B137.6)
Wall Type (SDR/Schedule):	Schedule 80
Nominal Pipe/Tubing Size[2]:	4

More

[1] For more information about plastic piping products included in this calculator, please visit the

[2] "Tubing" refers to products with an actual Outside Diameter (OD) 1/8 inch larger than the no refers to products with an actual OD matching that of steel pipe of the same nominal size (e.g. where the actual OD matches the nominal size (e.g. DN-Metric).

Length L:	100	ft
Temperature Change:	60	°F

Calculate

Results

Length L_1:	10.9 in	277 mm
Length L_2:	21.8 in	554 mm
Expansion Length ΔL:	2.7 in	69 mm

Calculation Details Print Email

Tools for Designing Piping Systems

6. Plastic Pipe Design Calculator – Static Water Column Pressure

Pipe/Tubing Selection[1]

Pipe/Tubing Material: PP-RCT, Fiber-core Layer

Sizing Type (CTS/IPS/Metric): DN - Metric (ASTM F2389)

Wall Type (SDR/Schedule): DR 11

Calculate

$P_{Surface}$ (Surface Pressure)[3]: 15 psi

Height of Water/Fluid Column: 60 ft

Fluid T

Averag

Results

Static Water Column Pressure at Bottom of Vertical Column: 41.3 Psi 284.9 kPa

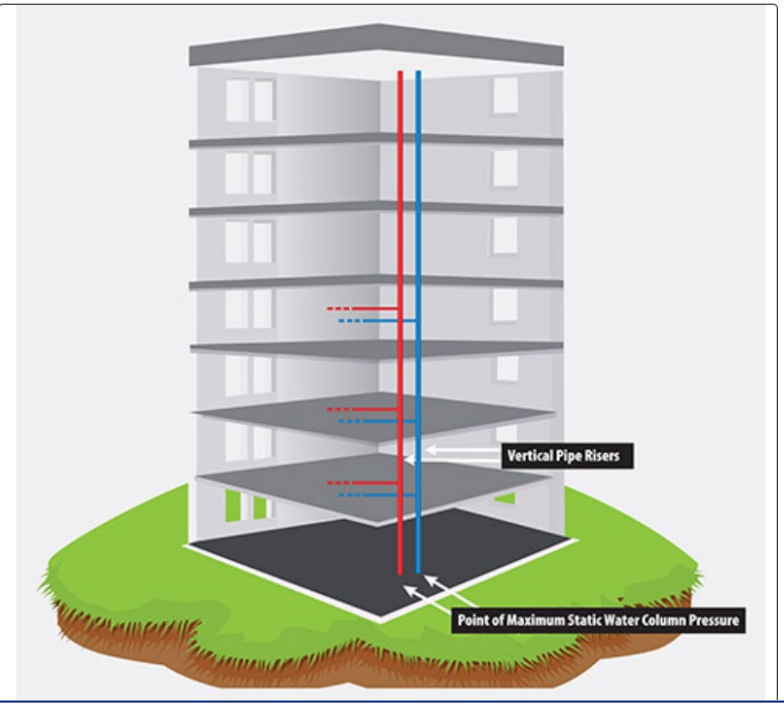
Calculation Details Print Email

***Static Water Column Pressure is shown to help the user determine if selected pipe or tubing is appropriate to withstand the calculated internal pressure. Always refer to and follow the pipe manufacturer's recommended pressure limits.**

STATIC WATER COLUMN PRESSURE

Input

Column Type: Geothermal / Plumbing, Fire Protection, Hydronic

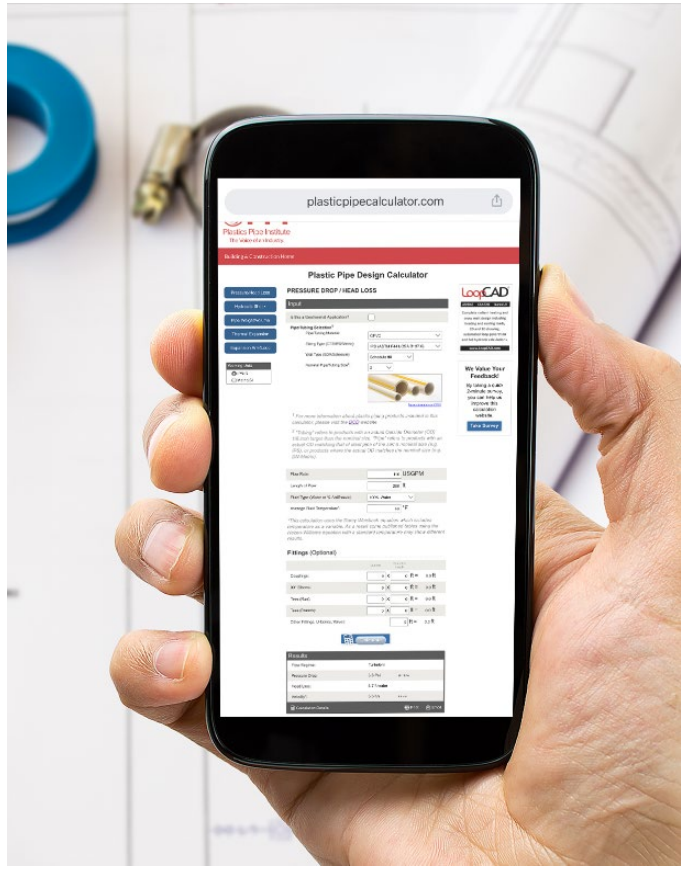


Tools for Designing Piping Systems

Summary: This free online tool is available for sizing piping systems

1. Sizing pipes for flow rates / calculating pressure drop (head loss)
2. Addressing hydraulic shock to prevent pressure surges
3. Determining pipe weights and volumes (empty and full)
4. Predicting longitudinal thermal expansion / contraction
5. Sizing expansion arms & legs (for thermal expansion)
6. Predicting internal water pressure caused by elevation

- www.plasticpipecalculator.com



4. PPI Resources for the Mechanical Piping Designer

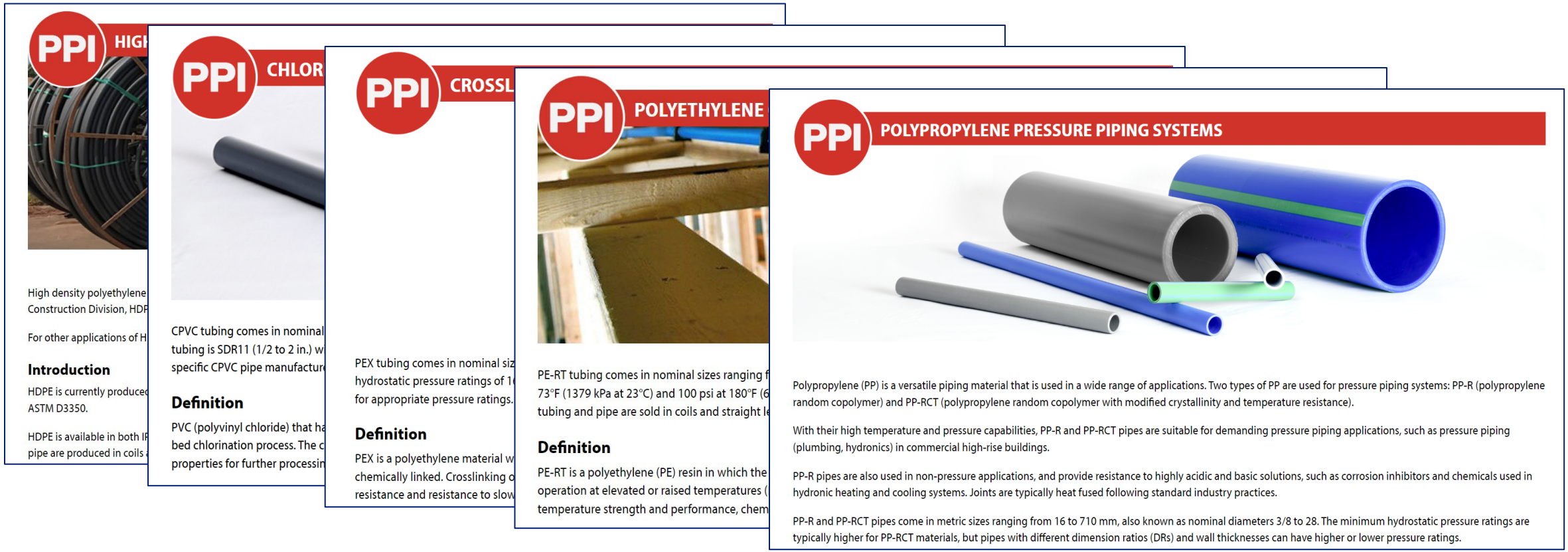
PPI Resources

- All support tools are available at no charge on PPI website www.plasticpipe.org/buildingconstruction
- As a non-profit trade association intending to support the mechanical piping industry, PPI members wish to support specifiers, designers, and installers with helpful tools

PPI Resources for the Mechanical Piping Designer

Please visit PPI website for:

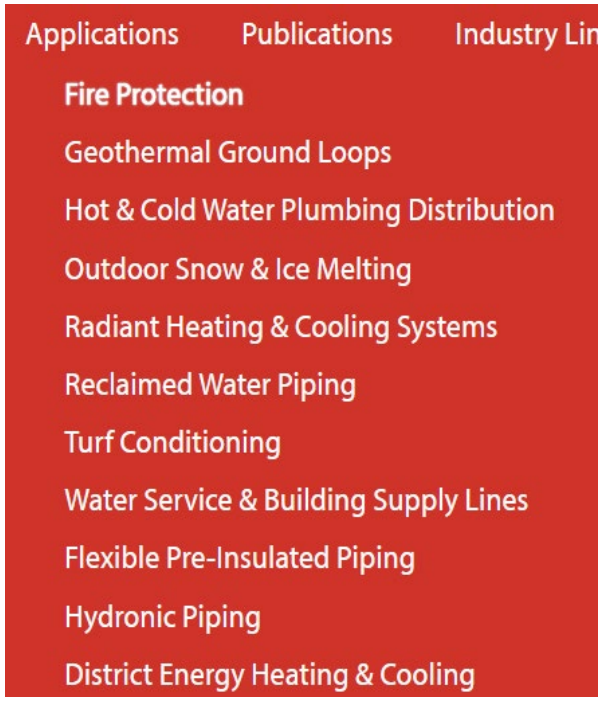
- A specific webpage for each piping material

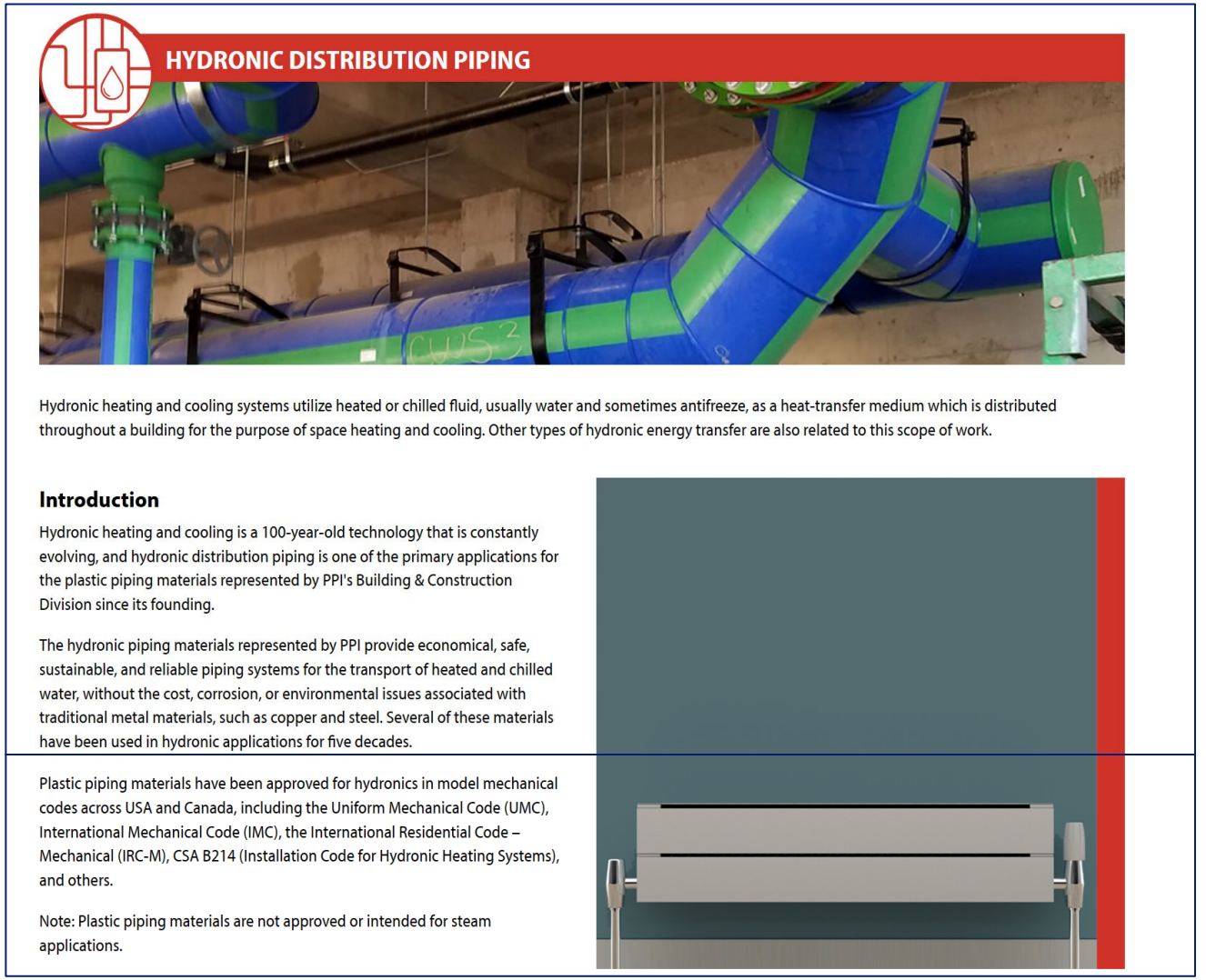


PPI Resources for the Mechanical Piping Designer

Please visit PPI website for:

- Information on various applications including Hydronic Piping Systems on our website





PPI Resources for the Mechanical Piping Designer

Please visit PPI website for:

- Technical literature on many piping topics

PPI Resources for the Mechanical Piping Designer

Please visit PPI website for:

- Example publications

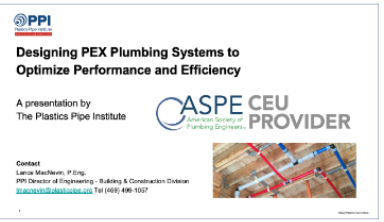
PPI Resources for the Mechanical Piping Designer

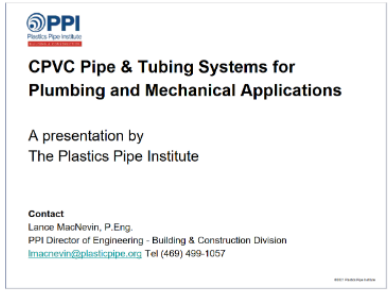
Please visit PPI website for:

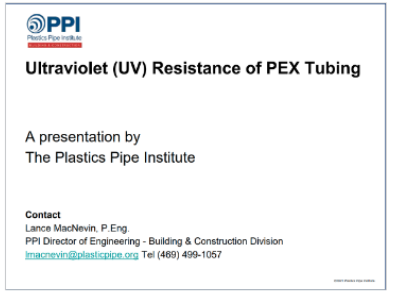
- Numerous presentations/slide decks

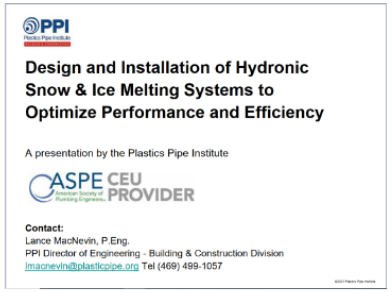
- PPI is an **ASPE CEU Provider**

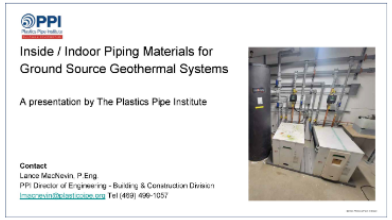
Click on images below to view PDF presentations.

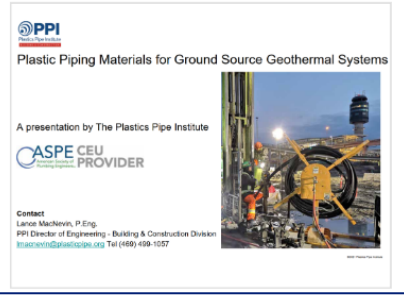


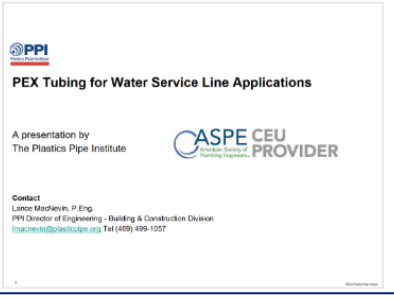












PPI Resources for the Mechanical Piping Designer

Summary

- All support tools are available at no charge on PPI website www.plasticpipe.org/buildingconstruction
- Share your thoughts and ideas and let us know how we can support you on piping topics

Achieving Higher Reliability and Sustainability with Plastic Pressure Piping Materials for Mechanical Applications

Summary: In this presentation we did:

1. Describe five plastic piping materials recommended for mechanical hydronic systems:
   - **CPVC, HDPE, PEX, PE-RT,** and **PP**

2. Indicate where and how to use these materials in applications such as plumbing, fire protection, hydronic heating and cooling, snow and ice melting, and district heating applications

3. Discuss the design of piping systems in terms of sizing for flow, pressure loss, thermal expansion and contraction, and static water column pressure etc.

4. Explain how to access industry resources for selecting mechanical piping material/s

Achieving Higher Reliability and Sustainability with Plastic Pressure Piping Materials for Mechanical Applications

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