Plastic Pressure Piping Materials for Plumbing & Mechanical Applications

A presentation by the Plastics Pipe Institute

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The Plastics Pipe Institute

PPI Represents All Sectors of the Plastic Pipe Industry

- PPI was formed in 1950 to develop test methods for plastic pressure pipes
- Today: Non-profit trade association serving North America

PPI Mission: To advance the acceptance and use of plastic pipe systems through research, education, technical expertise and advocacy

Members: PPI members share a common interest in broadening awareness and creating opportunities that expand market share and extend the use of plastics pipe in all of its many applications

2020: Over 170 members firms involved with the plastic pipe industry around the world

Website: www.plasticpipe.org

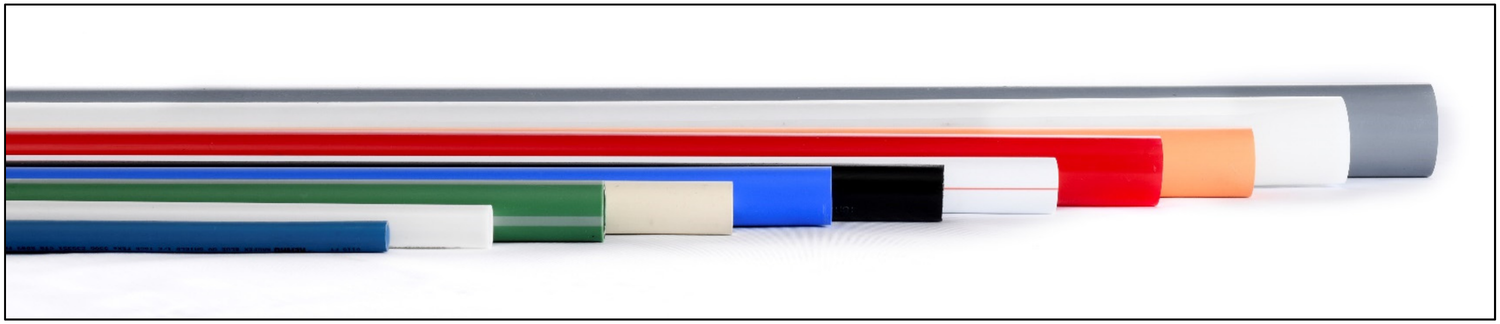
PPI Plastics Pipe Institute BUILDING & CONSTRUCTION

The Plastics Pipe Institute

PPI Represents All Sectors of the Plastic Pipe Industry

- PPI's five divisions focus on solutions for multiple applications:
  - **Building & Construction Division (BCD)**
  - Drainage
  - Energy Piping Systems
  - Municipal & Industrial
  - Power & Communications

BCD Materials: PEX, CPVC, PE-RT, PEX-AL-PEX, PP, HDPE (Geothermal)



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PPI's 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 and cooling, snow and ice melting, district heating and cooling, and ground source geothermal piping systems.

BCD involvement with industry groups:

Course Introduction – Part I

Specifiers and designers of plumbing and mechanical systems have options when selecting the optimal pipe material for each application

- Considerations include availability, cost, durability, convenience of handling and joining, safety for drinking water, and long-term reliability, which includes factors such as resistance to corrosion, mineral build-up, and disinfectants

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

- This course will demonstrate that there is an <u>affordable and reliable</u> plastic pressure pipe and fitting material for practically every plumbing and mechanical piping application

Course Introduction – Part II

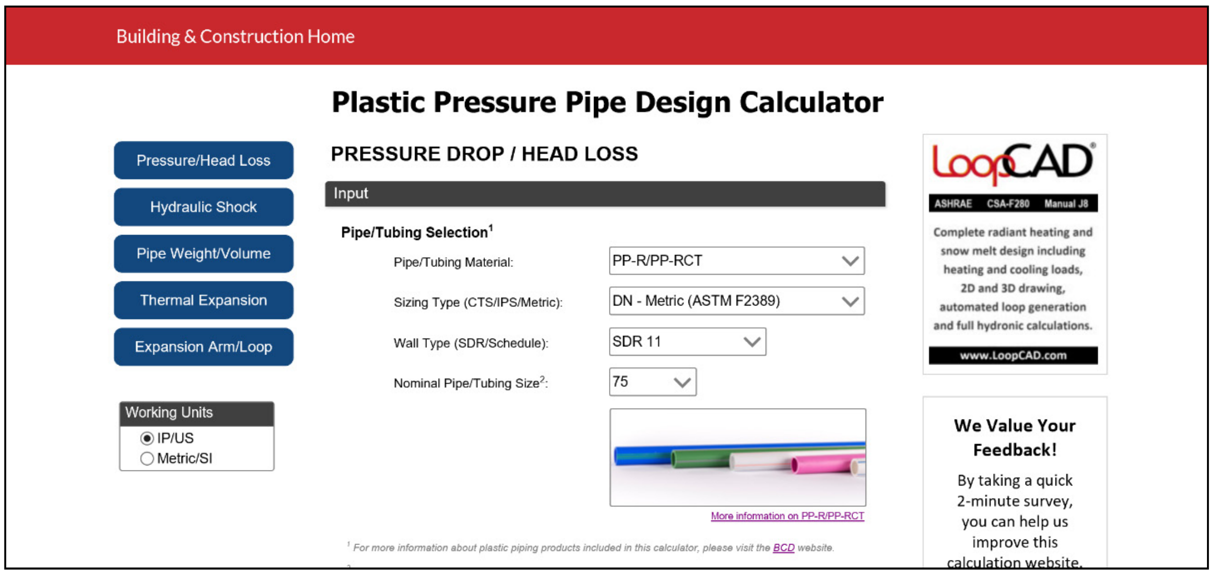
This course will also describe the proper use of plastic pressure pipe systems for various applications:

- Plumbing distribution (hot- and cold-water supply)
- Fire protection (sprinklers)
- Hydronic heating and cooling (including radiant heating & cooling)
- Snow & ice melting (for outdoor surfaces)
- Geothermal ground loops (geothermal)
- District heating applications (buried pipelines)

Course Introduction – Part III

This course will show how to access tools for plastic pipe systems:

- PPI Website
- Other industry websites
- Plastic Pressure Pipe Design Calculator www.plasticpipecalculator.com



Course Outline

By the end of this course, you will be able to:

1. Describe the piping materials CPVC, HDPE, PEX, PE-RT & PP in terms of material properties, capabilities, joining systems, applications, standards, and code compliance

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

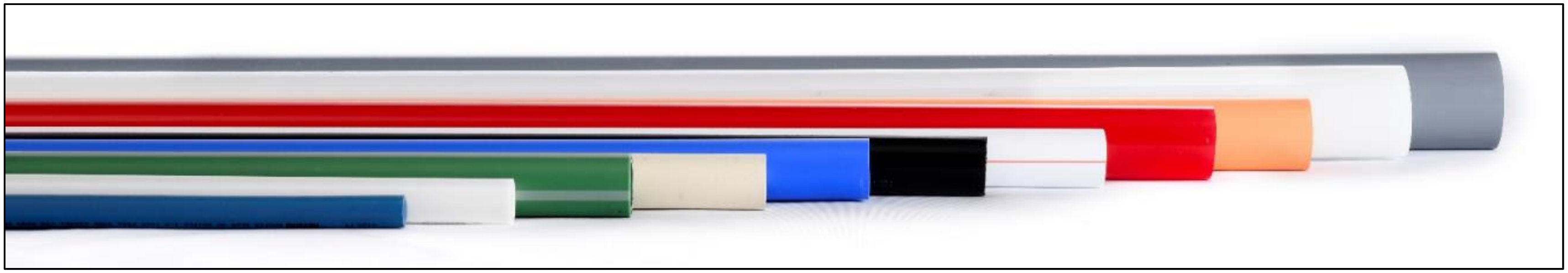
3. Discuss the design of piping materials in terms of sizing for flow, pressure loss, thermal expansion/contraction, etc. using a publicly-available software program

4. Explain how to access industry resources related to selecting and specifying the right piping material(s) for various applications

1. Plastic Pressure Piping Solutions

This Learning Objective will describe piping materials in terms of material properties, joining systems, applications, standards, and code compliance

Prologue	*Universal requirements*
1.a CPVC	*chlorinated polyvinyl chloride*
1.b HDPE	*high-density polyethylene*
1.c PEX	*crosslinked polyethylene*
1.d PE-RT	*polyethylene of raised temperature resistance*
1.e PP	*polypropylene*



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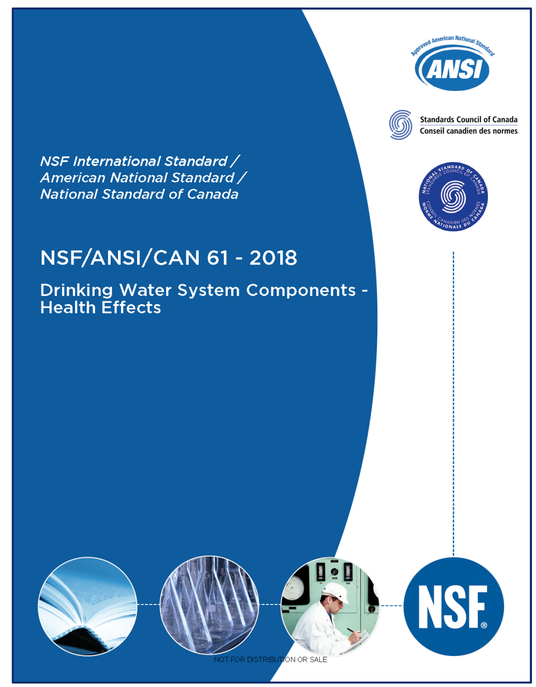
Universal Requirements: Drinking Water Safety

- **<u>All</u>** plastic tubing, pipes and fittings intended for potable (drinking) water shall 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."



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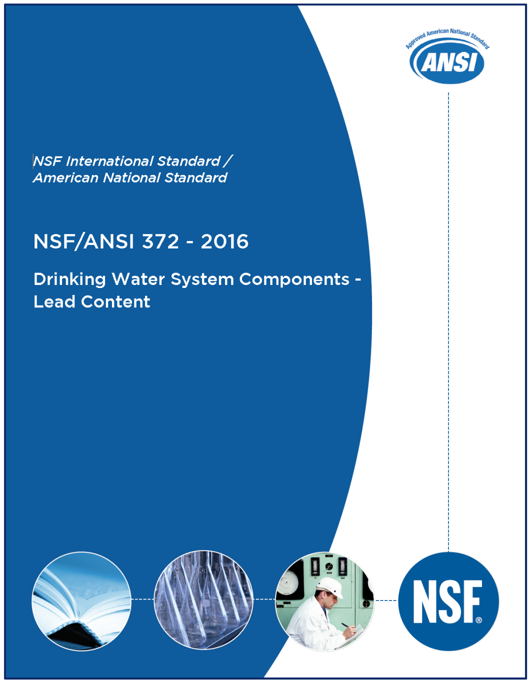
Universal Requirements: Lead-free components

- **<u>All</u>** plastic tubing, pipes and fittings intended for potable (drinking) water shall meet the requirements of **NSF/ANSI Standard 372:** *Drinking Water System Components, Lead Content*

1.1 Purpose "This Standard establishes procedures for the determination of lead content based on the wetted surface area of products."

1.2 Scope "The standard applies to any drinking water system component that conveys or dispenses water for human consumption through drinking or cooking."



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Universal Requirements: Dimension Ratios

- **<u>Most</u>*** plastic pipe and tubing uses a *Standard Dimension Ratio (SDR)*
- *Standard Dimension Ratio - the ratio of outside diameter to wall thickness, calculated by dividing the average outside diameter of the tubing by the minimum wall thickness*
- Examples:
  - PEX tubing is **SDR 9** (wall thickness is 1/9 of the OD)
  - CPVC tubing is **SDR 11** (wall thickness is 1/11 of the OD)

- Within a *Standard Dimension Ratio*, each diameter of the pipe type has the same pressure capability & rating (e.g. ½, ¾, 1, 2, etc.)

Exception: Pipes that follow* ***Schedule 40/80* *dimension schemes*

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Universal Requirements: Design Factor / Safety Factor

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

- Pressure-Temperature ratings are based on an extrapolated time-to-failure prediction using a **0.50* Design Factor** on pressure
  - Actual capability is typically **2 times** the listed (i.e. labeled) 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*

**Certain HDPE materials utilize a 0.63 design factor*

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Universal Requirements: Flame and Smoke Ratings

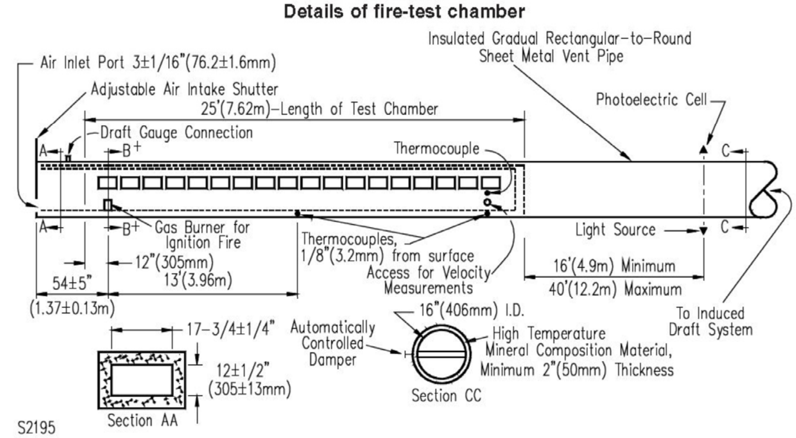
- If plastic pipe is to be installed within a return air plenum that requires "non-combustible materials", then the materials must demonstrate a flame spread rating ≤ 25 and a smoke spread rating ≤ 50

- These values are generated in standardized testing in accordance with **ASTM E84** test method using the "Steiner Tunnel" test

- **2018 Uniform Mechanical Code** requires **ASTM E84** testing

- Details of fire-test chamber from UL 2846

Figure 3.1
Details of fire-test chamber



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Universal Requirements: Flame and Smoke Ratings

- If plastic pipe is to be installed within a return air plenum that requires “non-combustible materials”, then the materials must demonstrate a peak optical density ≤ 0.50, an average optical density ≤ 0.15, and a flame spread distance not greater than 5 feet

- These values are generated in standardized testing in accordance with **UL 2846** test method using the “Steiner Tunnel” test

- **2018 International Mechanical Code** requires **UL 2846** or **ASTM E84** testing

- Steiner Tunnel at UL LLC

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Universal Benefits: Plastic Piping Systems are Sustainable and Safe

- No mining operations for the ore
- Lower cost to the environment for production
- Much lower energy cost to produce plastic as compared with metal pipes
- Smooth wall, excellent flow characteristics reduce pumping costs
- Flexibility can dampen water hammer, reducing pressure spikes
- Materials do not add minerals to drinking water, do not support biofilm growth
- Proven long life and durability provides value and reliability
- Light weight reduces transportation volume and costs
- Plastic systems protect health, safety & welfare!

NSF
Certified to NSF/ANSI 61

- Steel pipe with corrosion and build-up

Plastic Pressure Piping Solutions

1.a Chlorinated Polyvinyl Chloride: CPVC

- A high-temperature pressure piping system; up to 200°F (93°C)
- Introduced for potable plumbing in 1959
- Introduced for fire protection in 1985
- Also used for hydronic heating & cooling, industrial and process piping applications

Common types:

- CPVC 4120-05, CPVC 4120-06 (material designation codes)

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CPVC: Advantages

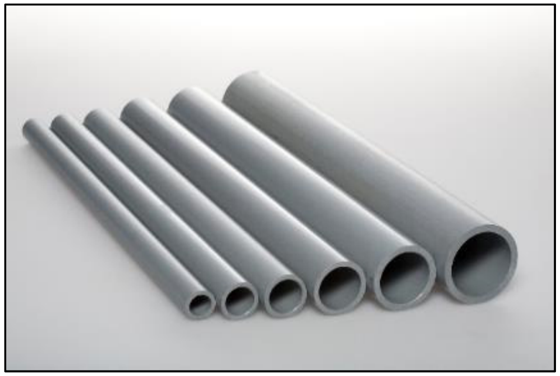
- Safety of potable water and long-term reliability
- Corrosion resistance, no mineral build-up
- Resistant to disinfectants chlorine and chloramines
- No flame used for joining; solvent cement or mechanical joints
- Ease of installation with professional appearance
- Universal compatibility of pipes/fittings
- Lightweight, easy to transport
- Lower installed cost than metal pipes
- No scrap value; avoid jobsite theft

Plastic Pressure Piping Solutions

CPVC: Configurations

- CPVC is provided in straight lengths
- Available in Copper Tube Size (CTS), Iron Pipe Size (IPS) – different ODs and IDs
- Fittings are molded in both CTS and IPS sizes
- Specific compounds for plumbing, hydronics and fire protection applications

Courtesy Lubrizol (x3)



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CPVC: Fittings/Joining

- CPVC pipe & fittings are joined via: i. Solvent Cement; ii. Grooved mechanical fittings

i. Solvent Cement joints use liquid cement that "welds" pipes to fittings for secure joints

- Available in nominal sizes from 1/2 in. to 12 in.
- Specific processes are described in material standards and installation manuals

Courtesy Lubrizol (x3)

Plastic Pressure Piping Solutions

CPVC: Fittings/Joining

- CPVC pipe & fittings are joined via: i. Solvent Cement; ii. Grooved mechanical fittings

ii. Grooved mechanical fittings connect pipes to fittings, once pipe ends are prepared

- Specific processes are described in material standards and installation manuals

Courtesy Victaulic x2

Plastic Pressure Piping Solutions

CPVC: Product Standards

- **ASTM D2846**: CTS tubing & fittings for potable water; sizes ¼ to 2 in. nominal
- **ASTM F437**: Schedule 80 Threaded CPVC fittings
- **ASTM F438**: Schedule 40 Socket-type CPVC fittings
- **ASTM F439**: Schedule 80 Socket-type CPVC fittings
- **ASTM F441**: Schedule 40 and 80 pipe sizes; sizes ¼ to 16 in. nominal
- **ASTM F442**: IPS pipe sizes; sizes ¼ to 12 in. nominal
- **ASTM F493**: Solvent Cements for CPVC pipe and fittings
- **CSA B137.5:** All sizing types; sizes ¼ to 12 in. nominal

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CPVC: Properties

- Product standards establish capabilities and test requirements, such as:
    - Materials
    - Workmanship
    - Dimensions and tolerances
    - Quick burst pressures
    - Long-term (sustained) pressure ratings
    - Thermocycling resistance
    - Solvent Cement and Adhesives
    - Test Methods
    - Marking requirements
    - More…

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CPVC: Short-term Burst Pressure

- Product standards have requirements for short-term burst pressure at 73°F (23°C)

- CPVC Pipe Minimum Requirements:

- **ASTM F442:** 1,250 psi for SDR 11 wall thickness; 1,000 psi for SDR 13.5; etc.

TABLE 4 Burst Pressure Requirements for Water at 73°F (23°C) for CPVC 4120 Plastic Pipe

SDR	Minimum Burst Pressure[A]	
	psi	kPa
11	1250	[8 620]
13.5	1000	[6 890]
17	800	[5 520]
21	630	[4 340]
26	500	[3 450]
32.5	400	[2 760]

[A] The fiber stress used to derive these test pressures is 6400 psi [44.1 MPa].

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CPVC: Long-term (Sustained) Pressure

- Product standards have requirements for long-term (sustained) pressure ratings:

- CPVC Tubing & Fitting Assembly, Minimum Requirements:

- **ASTM D2846:** 364 psig at 180°F for SDR 11 wall thickness

TABLE 5 Minimum Hydrostatic Sustained Pressure Requirements for CPVC 4120, SDR 11, Pipe, Tubing, and Fitting Assemblies Tested in Either Water or Air Bath External Environment at 180°F [82°C][A]

Test Condition	Test Duration	Hydrostatic Test Pressure	
		Water Bath	Air Bath
A	6 min	521 psi [3 590 kPa]	551 psi [3 800 kPa]
B	4 h	364 psi (2 510 kPa)	403 psi [2 780 kPa]

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CPVC: Code Compliance

- **Plumbing**: CPVC pipe and fittings are listed within model codes such as the *International Plumbing Code* (**IPC**), *Uniform Plumbing Code* (**UPC**), and *National Standard Plumbing Code* (**NSPC**) for plumbing distribution

- **Mechanical**: CPVC pipe and fittings are listed within model codes such as the *International Mechanical Code* (**IMC**), *Uniform Mechanical Code* (**UMC**), and *Uniform Solar, Hydronics, and Geothermal Code* (**USHGC**) for hydronic piping

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1.b High Density Polyethylene: HDPE

- A medium-temperature pressure piping system; up to 140°F (60°C)
- Introduced for potable water in the 1960s
- Bimodal materials introduced in the 2000s – third generation of HDPE
- Used for municipal water/sewer; geothermal ground loop pipes, low-temperature (chilled water) district cooling

Common types:

- PE 3608, PE 4710 (material designation codes)

Courtesy Versaprofiles

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

Plastic Pressure Piping Solutions

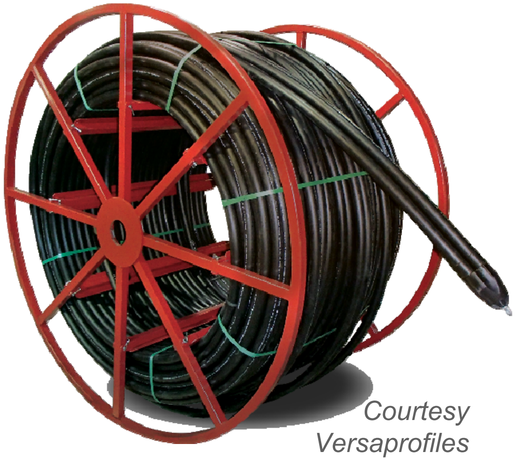
HDPE: Advantages

- Safety of potable water and long-term reliability
- Corrosion resistance, no mineral build-up
- Resistant to disinfectants chlorine and chloramines
- No flame used for joining; heat fusion or mechanical joints
- Lightweight, easy to transport
- Lower installed cost than metal pipes
- No scrap value; avoid jobsite theft
- Strong and tough material

Plastic Pressure Piping Solutions

HDPE: Configurations

- HDPE tubing is available in coils or straight lengths, depending on the customer preference, the diameter, and the application
- HDPE tubing is Copper Tube Size (CTS); typical for water service
- HDPE pipe is Iron Pipe Size (IPS); typical for geothermal ground loops
- Typically black for long-term UV resistance

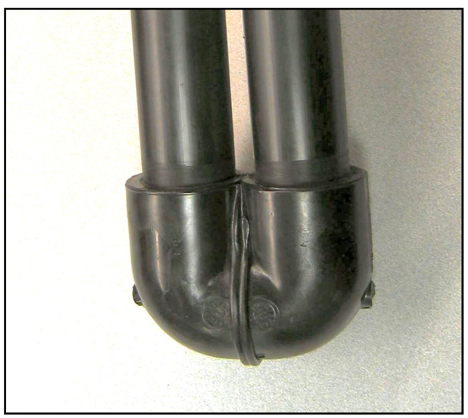


Courtesy Versaprofiles

Plastic Pressure Piping Solutions

HDPE: Fittings/Joining

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



Socket and Butt fusion joints

Electrofusion fitting

Socket fusion caps for testing

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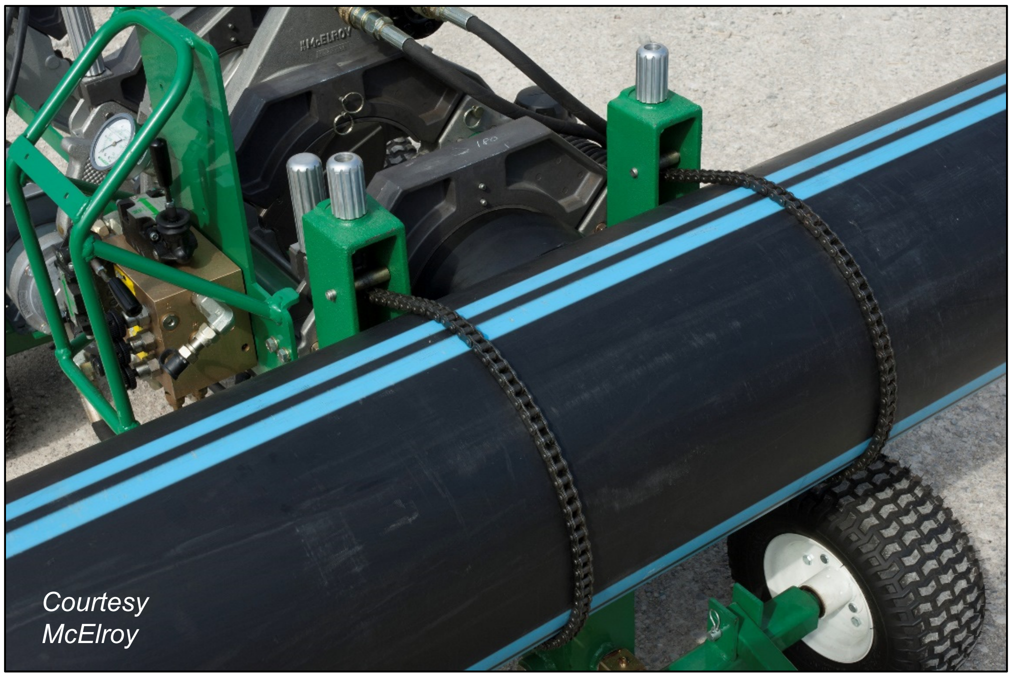
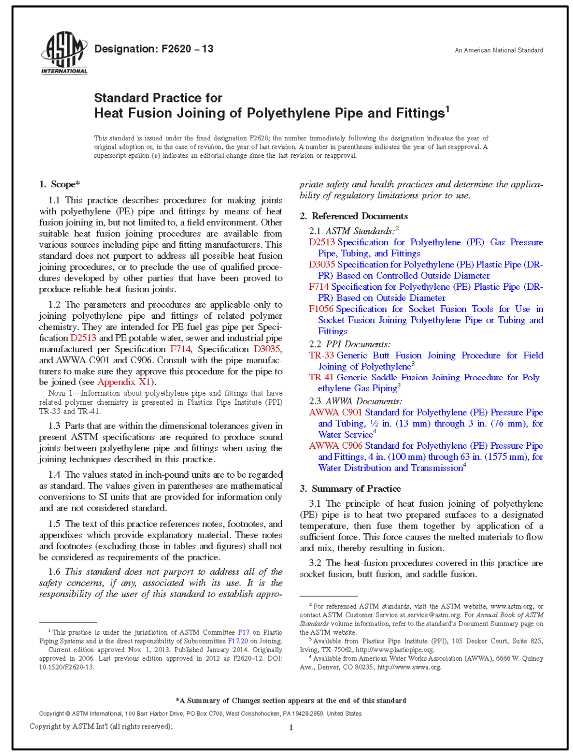
HDPE: Fittings/Joining

- **ASTM F2620** *Standard Practice for Heat Fusion Joining of Polyethylene Pipe and Fittings*
- First published in 2006, latest edition 2019



Courtesy McElroy



Designation: F2620 – 13

An American National Standard

Standard Practice for
Heat Fusion Joining of Polyethylene Pipe and Fittings[1]

This standard is issued under the fixed designation F2620; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope*

1.1 This practice describes procedures for making joints with polyethylene (PE) pipe and fittings by means of heat fusion joining in, but not limited to, a field environment. Other suitable heat fusion joining procedures are available from various sources including pipe and fitting manufacturers. This standard does not purport to address all possible heat fusion joining procedures, or to preclude the use of qualified procedures developed by other parties that have been proved to produce reliable heat fusion joints.

1.2 The parameters and procedures are applicable only to joining polyethylene pipe and fittings of related polymer chemistry. They are intended for PE fuel gas pipe per Specification D2513 and PE potable water, sewer and industrial pipe manufactured per Specification F714, Specification D3035, and AWWA C901 and C906. Consult with the pipe manufacturers to make sure they approve this procedure for the pipe to be joined (see Appendix X1).

NOTE 1—Information about polyethylene pipe and fittings that have related polymer chemistry is presented in Plastics Pipe Institute (PPI) TR-33 and TR-41.

1.3 Parts that are within the dimensional tolerances given in present ASTM specifications are required to produce sound joints between polyethylene pipe and fittings when using the joining techniques described in this practice.

1.4 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

1.5 The text of this practice references notes, footnotes, and appendixes which provide explanatory material. These notes and footnotes (excluding those in tables and figures) shall not be considered as requirements of the practice.

1.6 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D2513 Specification for Polyethylene (PE) Gas Pressure Pipe, Tubing, and Fittings
D3035 Specification for Polyethylene (PE) Plastic Pipe (DR-PR) Based on Controlled Outside Diameter
F714 Specification for Polyethylene (PE) Plastic Pipe (DR-PR) Based on Outside Diameter
F1056 Specification for Socket Fusion Tools for Use in Socket Fusion Joining Polyethylene Pipe or Tubing and Fittings

2.2 *PPI Documents:*

TR-33 Generic Butt Fusion Joining Procedure for Field Joining of Polyethylene[3]
TR-41 Generic Saddle Fusion Joining Procedure for Polyethylene Gas Piping[3]

2.3 *AWWA Documents:*

AWWA C901 Standard for Polyethylene (PE) Pressure Pipe and Tubing, ½ in. (13 mm) through 3 in. (76 mm), for Water Service[4]
AWWA C906 Standard for Polyethylene (PE) Pressure Pipe and Fittings, 4 in. (100 mm) through 63 in. (1575 mm), for Water Distribution and Transmission[4]

3. Summary of Practice

3.1 The principle of heat fusion joining of polyethylene (PE) pipe is to heat two prepared surfaces to a designated temperature, then fuse them together by application of a sufficient force. This force causes the melted materials to flow and mix, thereby resulting in fusion.

3.2 The heat-fusion procedures covered in this practice are socket fusion, butt fusion, and saddle fusion.

[1] This practice is under the jurisdiction of ASTM Committee F17 on Plastic Piping Systems and is the direct responsibility of Subcommittee F17.20 on Joining.
Current edition approved Nov. 1, 2013. Published January 2014. Originally approved in 2006. Last previous edition approved in 2012 as F2620–12. DOI: 10.1520/F2620-13.

[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] Available from Plastics Pipe Institute (PPI), 105 Decker Court, Suite 825, Irving, TX 75062, http://www.plasticpipe.org.

[4] Available from American Water Works Association (AWWA), 6666 W. Quincy Ave., Denver, CO 80235, http://www.awwa.org.

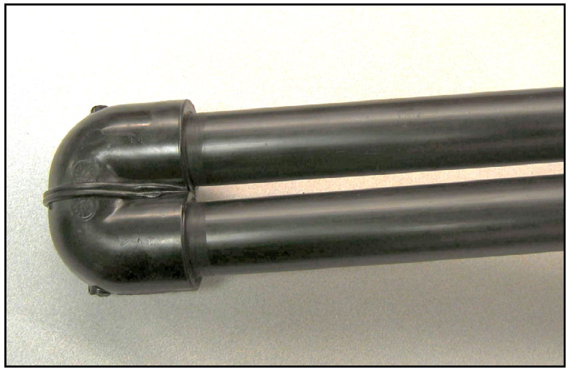
***A Summary of Changes section appears at the end of this standard**

1

Plastic Pressure Piping Solutions

HDPE: Fittings/Joining

- Geothermal U-bends can be fabricated from elbows, or
- Molded from the same polymer as the pipe material



U-bend fabricated with butt-fused elbows

Molded HDPE U-bend already fused to pipe ends

Coil of HDPE pipe with U-bend

Plastic Pressure Piping Solutions

HDPE: Fittings/Joining

- Grooved mechanical fittings connect pipes to fittings

Courtesy Victaulic x2

Plastic Pressure Piping Solutions

HDPE: Code Compliance

- **Plumbing**: HDPE pipe and fittings are listed within model codes such as the *International Plumbing Code* (**IPC**), *Uniform Plumbing Code* (**UPC**), and *National Standard Plumbing Code* (**NSPC**) for water service pipes

- **Mechanical**: HDPE pipe and fittings are listed within model codes such as the *International Mechanical Code* (**IMC**), *Uniform Mechanical Code* (**UMC**), and *Uniform Solar, Hydronics, and Geothermal Code* (**USHGC**) for hydronic piping

Plastic Pressure Piping Solutions

1.c Crosslinked Polyethylene: PEX

- A flexible high-temperature pressure piping system; up to 200°F (93°C)
- Introduced for radiant heating in the early 1970s in Europe
- Introduced to USA and Canada in early 1980s for heating and plumbing
- Today, PEX tubing systems are used for water service lines, hot- and cold-water distribution, radiant heating and cooling, outdoor snow and ice melting, residential fire protection, geothermal ground loops, district heating & cooling, and other demanding applications

Courtesy REHAU

Common types:

- PEX 1006, PEX 3206, PEX 5106 (material designation codes*)

*For PEX, the 1st digit refers to chlorine resistance, the 2nd digit refers to UV resistance, and the 3rd and 4th digits refer to hydrostatic strength

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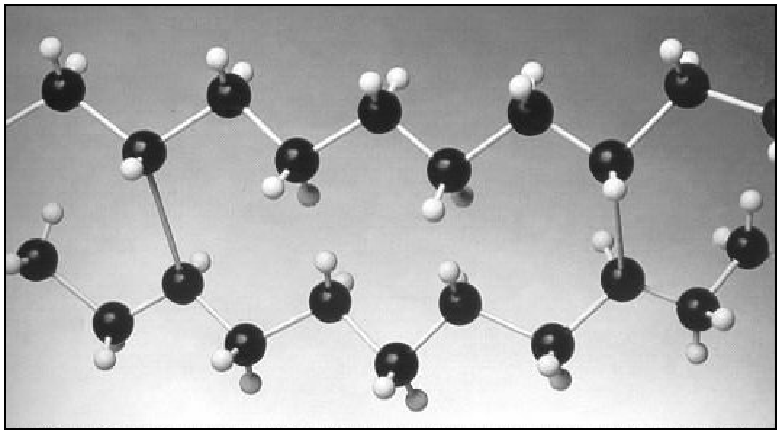
PEX: Formal Definition

- "Crosslinked Polyethylene is a polyethylene material which has undergone a change in molecular structure using a chemical or a physical process whereby the polymer chains are chemically linked.

Source: PPI Technical Note 17 "Crosslinked Polyethylene Pipe & Tubing"



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PEX: Advantages

- Safety of potable water and long-term reliability
- Corrosion resistance, no mineral build-up
- Resistant to disinfectants chlorine and chloramines
- No flame used for joining; compression-style fittings
- Ease of installation with professional appearance
- Noise and water hammer resistance
- Many fitting and joining options
- Lightweight, easy to transport
- Lower installed cost than metal pipes
- No scrap value; avoid jobsite theft

Courtesy Viega

Plastic Pressure Piping Solutions

PEX: Configurations

- PEX tubing is available in coils or straight lengths, depending on the customer preference, the diameter, and the application
- PEX tubing is Copper Tube Size (CTS); PEX pipe is Iron Pipe Size (IPS) or DN size
- PEX is available in natural, white, or colors such as red, white, blue, black, orange




Courtesy BOW x 3

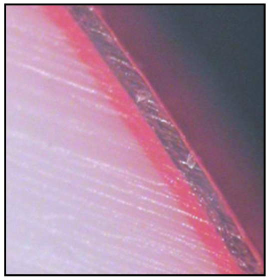
Plastic Pressure Piping Solutions

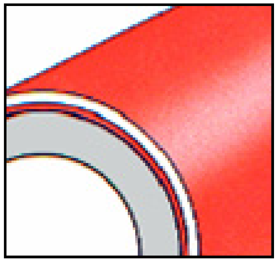
PEX: Oxygen Diffusion Barrier

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

Solution:

- Certain PEX tubing has an oxygen diffusion barrier (layer) to resist permeation
- This oxygen diffusion barrier is required when pipes are used in most closed-loop hydronic systems with ferrous components





Plastic Pressure Piping Solutions

PEX: Fittings/Joining

- There are several types of "compression" fittings designed for use with PEX tubing
- PEX fittings are produced from **lead-free brass alloys** and **engineered polymers**
- **Lead-free brass alloy** fittings are in compliance with latest SDWA
- **Polysulfone** (PLS) and **polyphenylsulfone** (PPSU) are thermoplastic polymers known for their toughness, stability at high temperatures, and chlorine resistance
- These are the typical polymers used for fittings and manifolds as part of PEX systems
- HDPE Electrofusion fittings can also be used with some PEX materials

Plastic Pressure Piping Solutions

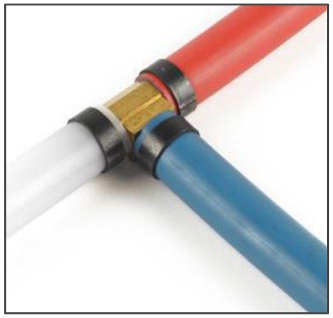
ASTM F1807 Crimp ring fitting
Available in lead-free brass

***ASTM F1807** copper crimp ring (not to scale!)*

***ASTM F2159** polymer crimp fitting*

Typical Crimp ring fitting assembly tool

ASTM F1807
Crimp Assembly

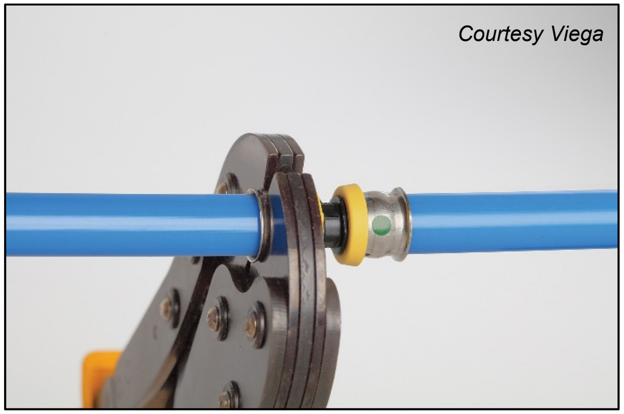


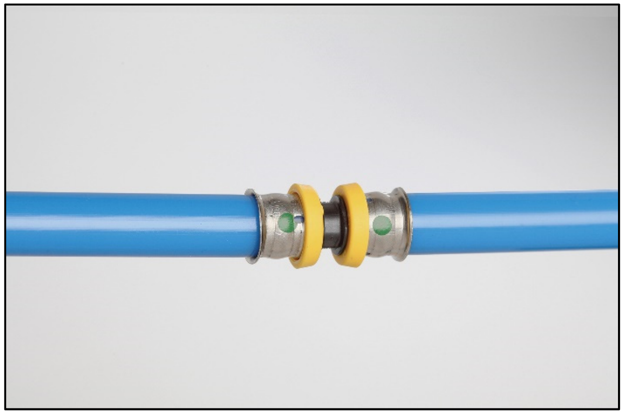
Plastic Pressure Piping Solutions

Courtesy Uponor

ASTM F1960 Cold-expansion fitting using a PEX ring
Available in polymer and lead-free brass

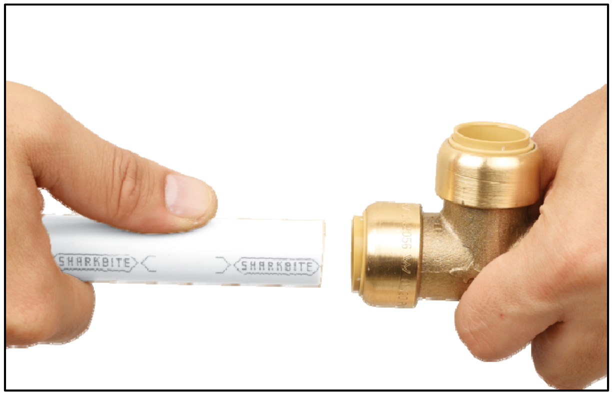
Plastic Pressure Piping Solutions

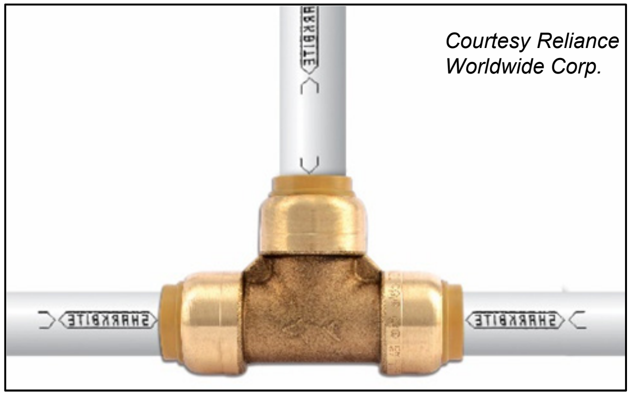




ASTM F3347/F3348 Press fittings using stainless steel sleeve.
Available in polymer and lead-free brass.

Plastic Pressure Piping Solutions



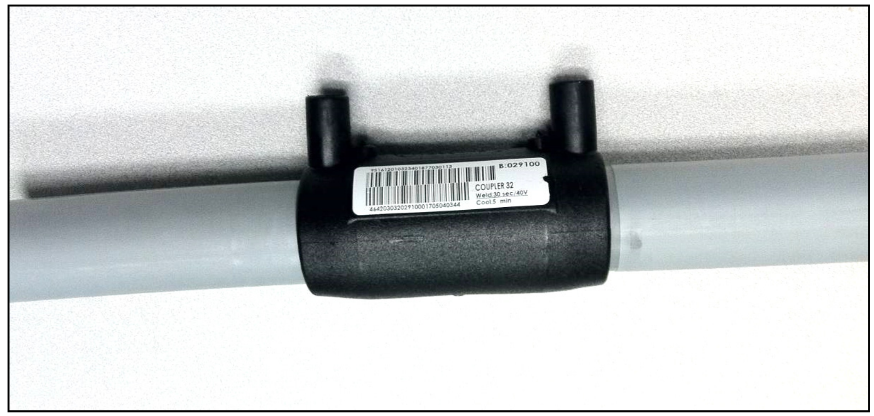


Courtesy Reliance Worldwide Corp.

ASSE 1061 Push-fit fittings

Available in polymer and lead-free brass

Plastic Pressure Piping Solutions



ASTM F1055 Electrofusion fitting
Molded HDPE fitting with embedded wire

Plastic Pressure Piping Solutions

PEX: Product Standards

- **ASTM F876**: CTS sizes; nominal diameters ¼ to 6 in.
- **ASTM F877**: CTS "systems" – fittings, manifolds, assemblies, etc.
- **ASTM F2788**: IPS sizes in nominal diameters 3 to 54 in.; DN sizes 16 to 1,000 mm
- **ASTM F3253**: CTS PEX tubing with oxygen diffusion barrier
- **CSA B137.5:** CTS sizes; nominal diameters ¼ to 6 in. (harmonized with F876)
- More than ten ASTM standards for various fitting designs

Plastics Pipe Institute
BUILDING & CONSTRUCTION

Plastic Pressure Piping Solutions

PEX: Product Standards

- Product standards establish capabilities and test requirements, such as:
  - Materials
  - Workmanship
  - Dimensions and tolerances
  - Degree of Crosslinking
  - Quick burst pressures
  - Long-term (sustained) pressure ratings
  - Thermocycling resistance
  - Chlorine resistance
  - UV resistance
  - Excessive pressure-temperature capability
  - Hot-bend and cold-bend tests
  - Marking requirements
  - More…

CSA Group

Plastic Pressure Piping Solutions

PEX: Short-term Burst Pressure

- Product standards have requirements for short-term burst pressure

- PEX Tubing & Fitting Assembly Minimum Requirements:
  - **ASTM F876**: 475 psig at 73°F; 210 psig at 180°F (for tubing)
  - **ASTM F877:** 475 psig at 73°F; 210 psig at 180°F (for connections)

- Fittings/connections must have same capabilities as the tubing

Plastic Pressure Piping Solutions

PEX: Long-term (Sustained) Pressure

- Product standards have requirements for long-term (sustained) pressure ratings:

- PEX Tubing & Fitting Assembly Minimum Requirements:

- **ASTM F876**: 160 psig at 73°F, 100 psig at 180°F (for tubing)
- **ASTM F877:** 160 psig at 73°F, 100 psig at 180°F (for connections)

- Fittings/connections must have same capabilities as the tubing

Plastic Pressure Piping Solutions

PEX: Oxidative Resistance Testing

- All PEX intended for use with potable water must have a minimum extrapolated lifetime of **50 years** when tested in accordance with **ASTM Test Method F2023**

- **ASTM F2023** *Standard Test Method for Evaluating the Oxidative Resistance of Crosslinked Polyethylene (PEX) Tubing and Systems to Chlorinated Hot Water*

- "Extrapolated time-to-failure" of tubing at each end-use condition (**1, 3, 5**) is calculated using Miner's Rule formula based on end-use conditions of **80 psig @ 140°F**

- See PPI TN-53 *Guide to Chlorine Resistance Ratings*… for more information

Plastic Pressure Piping Solutions

PEX: Code Compliance

- **Plumbing**: PEX pipe and fittings are listed within model codes such as the *International Plumbing Code* (**IPC**), *Uniform Plumbing Code* (**UPC**), and *National Standard Plumbing Code* (**NSPC**) for plumbing distribution

- **Mechanical**: PEX pipe and fittings are listed within model codes such as the *International Mechanical Code* (**IMC**), *Uniform Mechanical Code* (**UMC**), and *Uniform Solar, Hydronics, and Geothermal Code* (**USHGC**) for hydronic piping

Plastic Pressure Piping Solutions

1.d Polyethylene of Raised Temperature: PE-RT

- A high-temperature flexible pressure piping system; up to 180°F (82°C)
- First used for warm-water radiant heating in the 1990s in Europe
- Introduced to North America in the 2000s
- Today, PE-RT systems are used for hot- and cold-water plumbing, water service lines, radiant heating and cooling, outdoor snow and ice melting, district heating & cooling, and other demanding applications

Courtesy Dow

Plastic Pressure Piping Solutions

PE-RT: Advantages

- Safety of potable water and long-term reliability
- Corrosion resistance, no mineral build-up
- Resistant to disinfectants chlorine and chloramines
- No flame used for joining; compression-style fittings
- Ease of installation with professional appearance
- Noise and water hammer resistance
- Many fitting and joining options
- Lightweight, easy to transport
- Lower installed cost than metal pipes
- No scrap value; avoid jobsite theft

Plastic Pressure Piping Solutions

PE-RT: Configurations

- PE-RT tubing is available in coils or straight lengths, depending on the customer preference, diameter, and the application
- PE-RT tubing is Copper Tube Size (CTS); PE-RT pipe is Iron Pipe Size (IPS)
- PE-RT is available in white or colors such as red, white, blue, black, orange


Courtesy Legend Valve

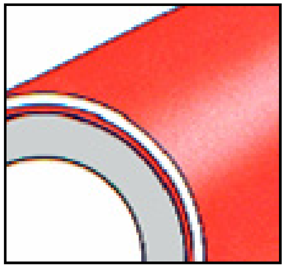
Plastic Pressure Piping Solutions

PE-RT: Oxygen Diffusion Barrier

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

Solution:

- Certain PE-RT tubing has an oxygen diffusion barrier (layer) to resist permeation
- This oxygen diffusion barrier is required when pipes are used in most closed-loop hydronic systems with ferrous components



Plastic Pressure Piping Solutions

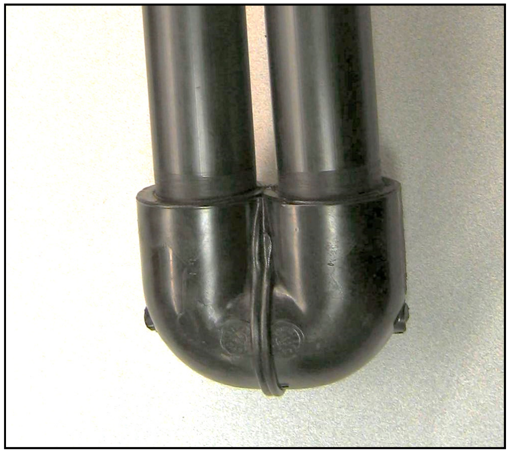
PE-RT: Fittings/Joining

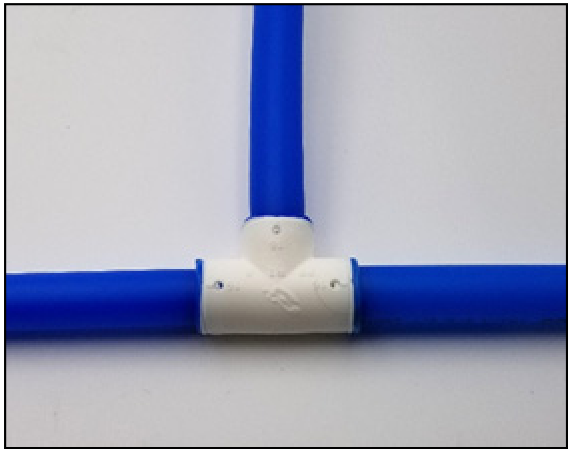
- PE-RT tubing has same dimensions as PEX tubing, works with most of the same fittings
- PE-RT fittings are produced from **lead-free brass alloys** and **engineered polymers**
- **Lead-free brass alloy** fittings are in compliance with latest SDWA
- **Polysulfone** (PLS) and **polyphenylsulfone** (PPSU) are thermoplastic polymers known for their toughness, stability at high temperatures, and chlorine resistance
- These are the typical polymers used for fittings and manifolds as part of PE-RT systems
- PE-RT may also be joined using heat fusion or grooved mechanical fittings

Plastic Pressure Piping Solutions

PE-RT: Fittings/Joining

- As an HDPE material, PE-RT pipe can also be joined using heat fusion (welding)
  - Butt fusion HDPE fittings
  - Socket fusion HDPE fittings
  - Electrofusion HDPE fittings





Plastic Pressure Piping Solutions

PE-RT: Fittings/Joining

- PE-RT pipe is also available in large diameters for hydronic applications
- Can be joined using grooved mechanical fittings

Plastic Pressure Piping Solutions

PE-RT: Product Standards

- **ASTM F2623**: CTS sizes; nominal diameters ¼ to 6 in. for <u>hydronic</u> applications
- **ASTM F2769**: CTS sizes; nominal diameters ¼ to 6 in for <u>potable</u> applications
- **CSA B137.18:** CTS sizes; nominal diameters ¼ to 6 in. (harmonized with F2769)

Plastic Pressure Piping Solutions

PE-RT: Product Standards

- Product standards establish capabilities and test requirements, such as:
  - Materials
  - Workmanship
  - Dimensions and tolerances
  - Quick burst pressures
  - Long-term (sustained) pressure ratings
  - Thermocycling resistance
  - Excessive pressure-temperature capability
  - Hot-bend and cold-bend tests
  - Marking requirements
  - More…

Plastic Pressure Piping Solutions

PE-RT: Short-term Burst Pressure

- Product standards have requirements for short-term burst pressure

- **PE-RT Tubing & Fitting Assembly Minimum Requirements:**
  - **ASTM F2623**: 475 psig at 73°F; 180 psig at 180°F (for hydronic systems)
  - **ASTM F2769:** 475 psig at 73°F; 265 psig at 180°F (for potable systems)

- Fittings/connections must have same capabilities as the tubing

Plastic Pressure Piping Solutions

PE-RT: Long-term (Sustained) Pressure

- Product standards have requirements for long-term (sustained) pressure ratings:

- PE-RT Tubing & Fitting Assembly Minimum Requirements:

- **ASTM F2623**: 325 psig at 73°F; 165 psig at 180°F (for hydronic systems)
- **ASTM F2769:** 325 psig at 73°F; 190 psig at 180°F (for potable systems)

- Fittings/connections must have same capabilities as the tubing

Plastic Pressure Piping Solutions

PE-RT: Oxidative Resistance Testing

- All PE-RT intended for use with potable water must have a minimum extrapolated lifetime of **50 years** when tested in accordance with **ASTM Test Method F2023**

- **ASTM F2023** *Standard Test Method for Evaluating the Oxidative Resistance of Crosslinked Polyethylene (PEX) Tubing and Systems to Chlorinated Hot Water*

- "Extrapolated time-to-failure" of tubing at each end-use condition (**1, 3, 5**) is calculated using Miner's Rule formula based on end-use conditions of **80 psig @ 140°F**

Plastic Pressure Piping Solutions

PE-RT: Code Compliance

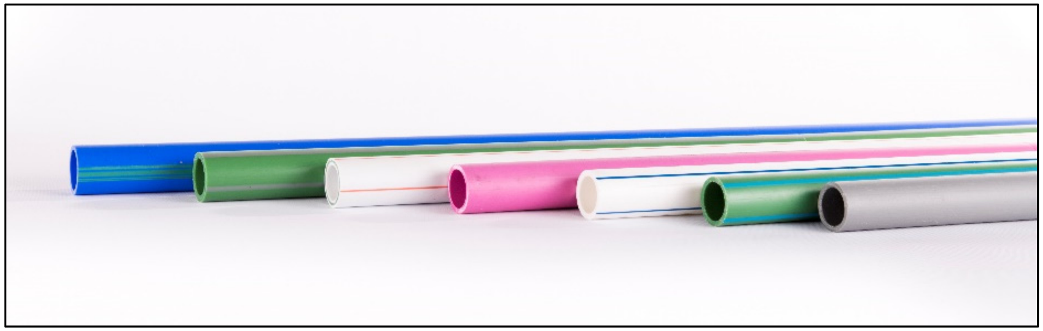
- **Plumbing**: PE-RT pipe and fittings are listed within model codes such as the *International Plumbing Code* (**IPC**), *Uniform Plumbing Code* (**UPC**), and *National Standard Plumbing Code* (**NSPC**) for plumbing distribution

- **Mechanical**: PE-RT pipe and fittings are listed within model codes such as the *International Mechanical Code* (**IMC**), *Uniform Mechanical Code* (**UMC**), and *Uniform Solar, Hydronics, and Geothermal Code* (**USHGC**) for hydronic piping

Plastic Pressure Piping Solutions

1.e Polypropylene Pressure Pipes (PP)

- High-temperature rigid pressure piping systems; up to 180°F (82°C)
- First used in the 1970s in Europe for hydronic heating, then in the 1990s for plumbing
- Introduced to North America in the 2000s
- Two types or grades of PP material available: **PP-R** and **PP-RCT**
- PP pressure piping systems are used for hot- and cold-water plumbing, hydronic heating and cooling, industrial and food-grade piping and other demanding applications
- PP pipes also provide resistance to highly acidic and basic solutions



Plastic Pressure Piping Solutions

PP: Advantages

- Safety of potable water and long-term reliability
- Corrosion resistance, no mineral build-up
- Resistant to disinfectants chlorine and chloramines
- Heat-fused or mechanical joints; no flame used for joining
- Ease of installation with professional appearance
- Lightweight, easy to transport
- Lower installed cost than metal pipes
- No scrap value; avoid jobsite theft

Courtesy Aquatherm

Plastic Pressure Piping Solutions

PP: Configurations

- PP is provided in straight lengths
- Available in Iron Pipe Size (IPS), multiple SDRs depending on pressure requirements
- Fittings are molded to match pipe sizes
- Solid wall pipe is used when thermal expansion/contraction is not a concern
- Fiber-core layer pipe is used when thermal expansion/contraction is a concern

Solid wall pipe on far left and far right
Fiber-core layer pipe inside left and inside right

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Plastic Pressure Piping Solutions

PP: Fittings/Joining

- PP pipe & fittings are joined via: i. Heat fusion; ii. Electrofusion; iii. Grooved mechanical fittings

i. Heat Fusion joints are "welded" under pressure to form continuous piping systems

- Specific processes are described in material standards and installation manuals

Plastic Pressure Piping Solutions

PP: Fittings/Joining

- PP pipe & fittings are joined via: i. <u>Heat fusion</u>; ii. <u>Electrofusion</u>; iii. <u>Grooved mechanical fittings</u>

ii. <u>Electrofusion joints</u> have embedded copper wires that heat the fitting, welding it to pipe ends; computerized machine controls the process

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Plastic Pressure Piping Solutions

PP: Fittings/Joining

- PP pipe & fittings are joined via: i. Heat fusion; ii. Electrofusion; iii. Grooved mechanical fittings

ii. Grooved mechanical fittings connect pipes to fittings

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BUILDING & CONSTRUCTION

Plastic Pressure Piping Solutions

PP: Product Standards

- **ASTM F2389**: IPS pipe & fittings; DN sizes 16 - 355 mm nominal (similar to ½ - 14 in.)
- **CSA B137.11:** All sizing types; sizes 3/8 - 28 in. nominal

Courtesy Aquatherm

ASTM INTERNATIONAL

CSA Group

Plastic Pressure Piping Solutions

PP: Properties

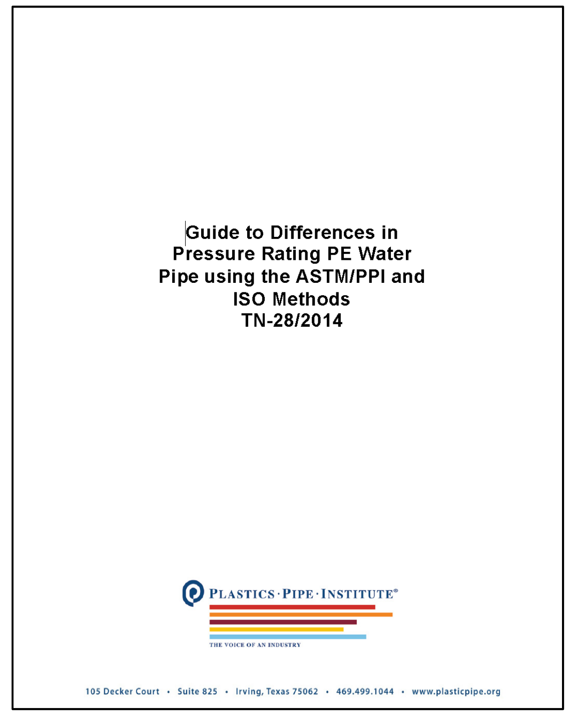
- Product standards establish capabilities and test requirements, such as:
    - Materials
    - Workmanship
    - Dimensions and tolerances
    - Quick burst pressures
    - Long-term (sustained) pressure ratings
    - Thermal stability
    - Oxidative stability
    - Thermocycling resistance
    - Test Methods
    - Marking requirements
    - More…

Plastic Pressure Piping Solutions

PP: Long-term (Sustained) Pressure

- Product standards have requirements for <u>long-term</u> (sustained) pressure ratings:

- PP materials follow **ISO methodology** for long-term pressure ratings
- See **PPI TN-28** for details


Guide to Differences in
Pressure Rating PE Water
Pipe using the ASTM/PPI and
ISO Methods
TN-28/2014

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PPI
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PP: Long-term (Sustained) Pressure

- Product standards have requirements for long-term (sustained) pressure ratings:

- PP Pipe, Minimum Requirements:

- **PP-R**: 2,320 psi Hoop stress at 68°F; 510 psi Hoop stress at 203°F
- **PP-RCT**: 2,175 psi Hoop stress at 68°F; 551 psi Hoop stress at 203°F

TABLE 11 Hydrostatic Test Conditions

Material	Hoop Stress, psi, (MPa)	Temperature, °F (°C)	Time, h
PP-R	2320 (16.0)	68 (20)	1
	510 (3.5)	203 (95)	1000
PP-RCT	2175 (15.0)	68 (20)	1
	551 (3.8)	203 (95)	1000

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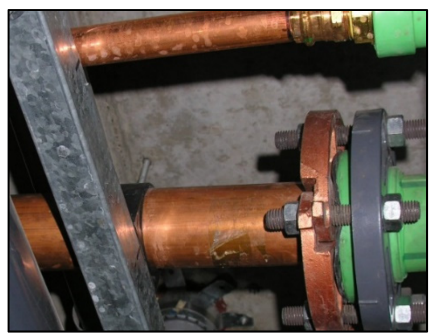
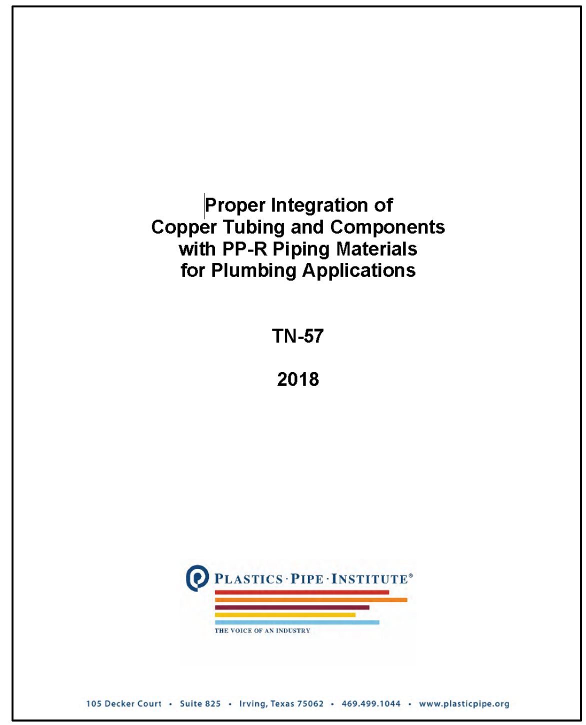
PP: Compatibility with dissolved Copper

- **PPI TN-57** ***Proper Integration of Copper Tubing and Components with PP-R Piping Materials for Plumbing Applications***
- Improper or excessive flow rates within mixed-material plumbing systems that contain both copper materials (i.e. tubing, fittings, valves) combined with PP-R piping materials can result in premature failure of both the copper components and the PP-R materials, potentially resulting in plumbing system leaks




Proper Integration of
Copper Tubing and Components
with PP-R Piping Materials
for Plumbing Applications

TN-57

2018

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PP: Code Compliance

- **Plumbing**: PP pipe and fittings are listed within model codes such as the *International Plumbing Code* (**IPC**), *Uniform Plumbing Code* (**UPC**), and *National Standard Plumbing Code* (**NSPC**) for plumbing distribution

- **Mechanical**: PP pipe and fittings are listed within model codes such as the *International Mechanical Code* (**IMC**), *Uniform Mechanical Code* (**UMC**), and *Uniform Solar, Hydronics, and Geothermal Code* (**USHGC**) for hydronic piping

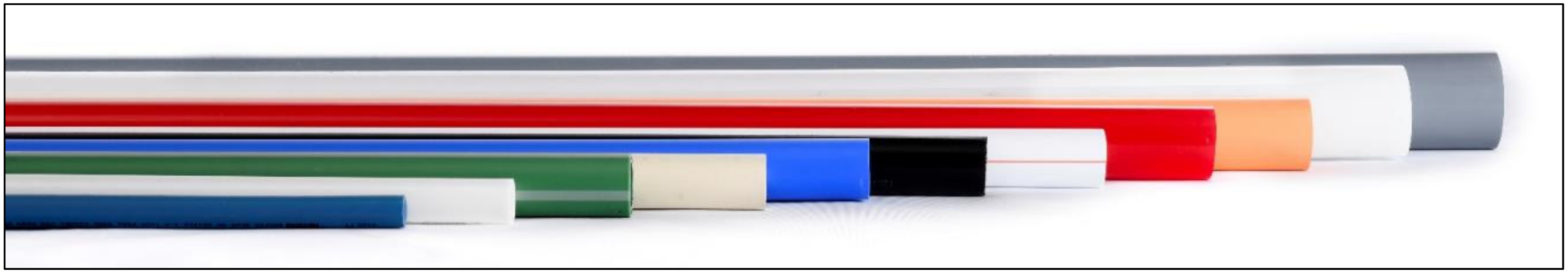
ICC INTERNATIONAL CODE COUNCIL®

IAPMO

Plastic Pressure Piping Solutions

Summary: Piping materials in terms of material properties, joining systems, applications, standards, and code compliance

Prologue	*Universal requirements*
1.a CPVC	*chlorinated polyvinyl chloride*
1.b HDPE	*high-density polyethylene*
1.c PEX	*crosslinked polyethylene*
1.d PE-RT	*polyethylene of raised temperature resistance*
1.e PP	*polypropylene*



2. Plumbing & Mechanical Applications

This Learning Objective focuses on plastic pipes in applications:

2.a Plumbing distribution (hot- and cold-water supply)
2.b Fire protection (sprinklers)
2.c Hydronic heating and cooling (including radiant heating & cooling)
2.d Snow & ice melting (for outdoor surfaces)
2.e Geothermal ground loops (geothermal)
2.f District heating applications (buried pipelines)

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Plumbing & Mechanical Applications

2.a Hot- and Cold-Water Plumbing Distribution

- PEX, PE-RT and CPVC are used for residential plumbing supply pipes
- CPVC, PEX and PP are commonly used in commercial applications
- Some systems use both flexible (PEX, PE-RT) and rigid (CPVC, PP) pipes

System Benefits:

- Plastic piping systems save costs and last longer
- Plastic pipes are corrosion-resistant, no build-up
- Pipes are quieter and transfer less heat
- Optimized designs can save water
  - Hot-water recirculation reduces waste
  - Design tools help to optimize flowrates


Courtesy Lubrizol

Plumbing & Mechanical Applications

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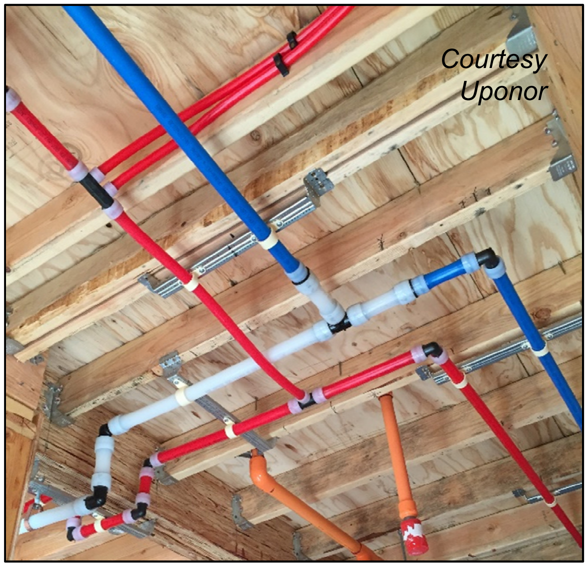

Plumbing & Mechanical Applications

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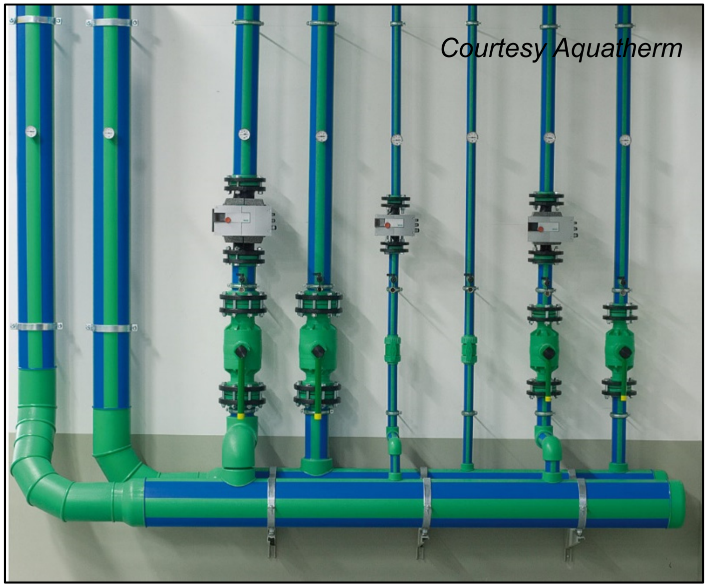

Plumbing & Mechanical Applications

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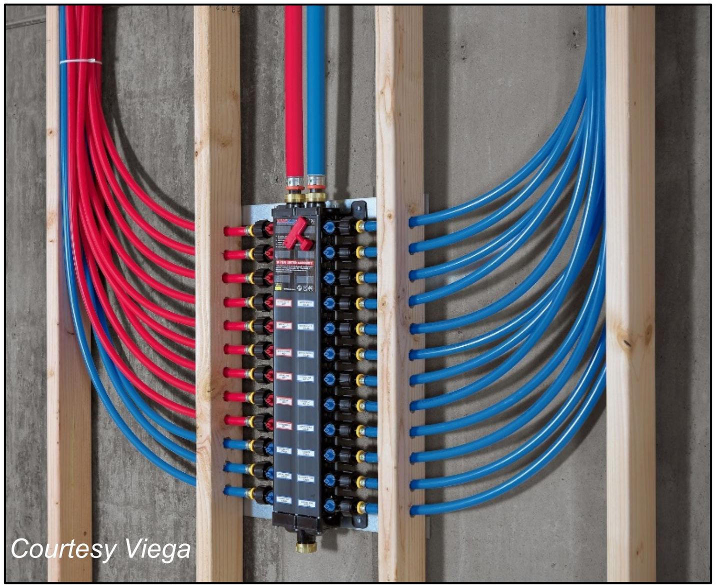

Courtesy Viega

Plumbing & Mechanical Applications

2.a Hot- and Cold-Water Plumbing Distribution

Case Study:

- High-rise residential towers, 300,000 ft^2
- 78,000 feet of PEX tubing for hot- and cold-water plumbing distribution
- Corrosion-resistant
- Faster installation
- Reduced heat transfer
- Quieter

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BUILDING COMMUNITY BE A HERO

PEX SAVES TIME AND MONEY FOR RESIDENTIAL HIGH RISE PLUMBING SYSTEMS

VANCOUVER, B.C. -- John Jacobsen of Phoenix Mechanical is so impressed with WISBRO AQUAPEX, he won't use anything else.

Time is money — especially in the building industry. John Jacobsen of Phoenix Mechanical in Vancouver, B.C., reaffirmed this belief when he began using UPONOR'S crosslinked polyethylene (PEX) tubing for his plumbing systems.

Jacobsen switched to PEX tubing after learning about its benefits over copper — flexibility, durability, reliable fittings, faster installations and a 30-year history of dependable service. WISBRO AQUAPEX is also extremely resistant to corrosive water and soil that can eat away at copper pipe, and it comes with a 25-year limited warranty when installed by an UPONOR-trained plumber.

Since installing WISBRO AQUAPEX in all his projects, Jacobsen has realized great time savings, money savings and a more reliable plumbing system.

"The flexibility of PEX allows us to eliminate many of the fittings that were required with copper," Jacobsen says. "This means our systems are installed faster and at a lower cost."

Phoenix Mechanical works with one of Vancouver's largest developers, Concord Pacific, which has built 41 residential high- and low-rise buildings in the past few years. Three of their buildings, which contain over 300 units each, are plumbed with more than 120,000 feet of PEX tubing.

In these buildings, PEX is tied to structural rebar in the concrete slab. Using flexible PEX tubing eliminates joints within the slab and cuts installation time by approximately 50% when compared with copper.

"I have used WISBRO AQUAPEX since the day it was approved in Vancouver, and I think it is an absolutely wonderful product," Jacobsen said. "The installation is fast and easy, and the tubing can be buried directly in concrete — something the codes won't allow us to do with copper. We put the tubing in a sleeve so it can easily be removed in case of construction damage."

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Plumbing & Mechanical Applications

2.b Fire Protection

- Piping materials **CPVC** and **PEX** have been listed for residential fire sprinkler systems since the 1980s and 1990s, respectively

- According to installation standard **NFPA 13D**, where the intent is to provide an affordable sprinkler system in homes while maintaining a high level of life safety, CPVC and PEX fire sprinkler systems that are listed to system standard **UL 1821** are approved to supply water to fire sprinklers for one- and two-family dwellings

- **UL 1821** is the system performance standard for plastic fire protection systems

PPI Plastics Pipe Institute
BUILDING & CONSTRUCTION

Plumbing & Mechanical Applications

2.b Fire Protection

- **UL 1821** ***Thermoplastic Sprinkler Pipe and Fittings for Fire Protection Service***
- **1.2** "Thermoplastic pipe and fittings covered by these requirements are intended for use in sprinkler systems in any of the following types of occupancies:
  a) Light hazard occupancies as defined in the Standard for Installation of Sprinkler Systems, **NFPA 13**;
  b) Residential occupancies as defined in the Standard for Installation of Sprinkler Systems in One- and Two-Family Dwellings and Manufactured Homes, **NFPA 13D**; and
  c) Residential occupancies as defined in the Standard for Installation of Sprinkler Systems in Low-Rise Residential Occupancies, **NFPA 13R**."


UL 1821

STANDARD FOR SAFETY

Thermoplastic Sprinkler Pipe and Fittings for Fire Protection Service

Plumbing & Mechanical Applications

2.b Fire Protection

- **CPVC**, when listed, can be used for **NFPA 13D**, **NFPA 13R**, and **NFPA 13 light hazard** fire protection applications built according to codes
- Each brand / pipe must be tested and third-party certified for FP applications

System Benefits:

- Plastic piping systems save costs and last longer
- Plastic pipes are corrosion-resistant, no build-up
- Plastic systems are joined without flame
  - No hot-work permits required

Courtesy Lubrizol

Plumbing & Mechanical Applications

2.b Fire Protection

- **CPVC**, when listed, can be used for **NFPA 13D**, **NFPA 13R**, and **NFPA 13 light hazard** fire protection applications built according to codes
- Each brand / pipe must be tested and third-party certified for FP applications

System Benefits:

- Plastic piping systems save costs and last longer
- Plastic pipes are corrosion-resistant, no build-up
- Plastic systems are joined without flame
  - No hot-work permits required

Courtesy Lubrizol

Plumbing & Mechanical Applications

2.b Fire Protection

- **PEX** is used for residential fire protection applications built according to **NFPA 13D**
- Each brand / pipe must be tested and third-party certified for FP applications

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Courtesy Uponor

Plumbing & Mechanical Applications

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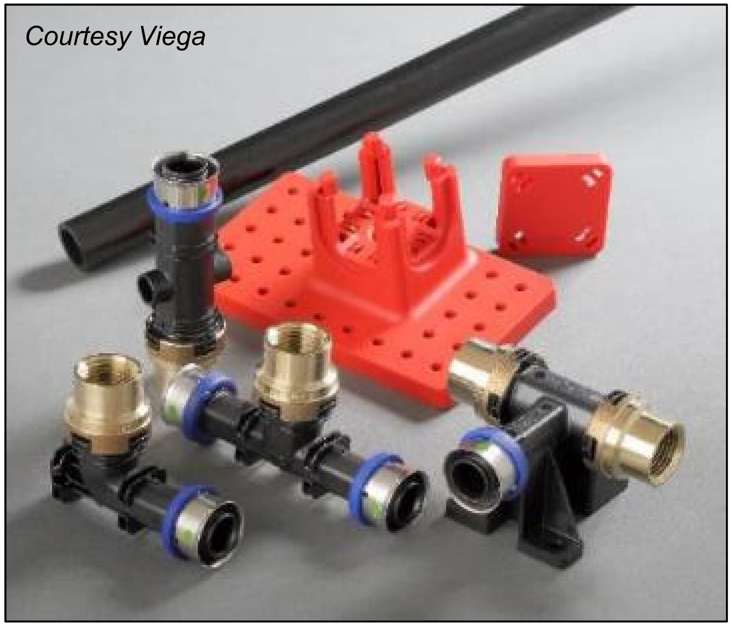


Courtesy Viega

Plumbing & Mechanical Applications

2.b Fire Protection

Case Study:

- Dormitory retrofit, University of Notre Dame (IN)
- 750,000 ft^2 in 12 buildings
- 8,000 sprinkler heads
- Installed during winter & summer breaks, 7 months
- Chosen due to speed, no hot work, resistance to corrosion and MIC

BlazeMaster®
FIRE SPRINKLER SYSTEMS

Case Study

Officials Install State-of-the-Art BlazeMaster® CPVC Fire Sprinklers to Meet an Aggressive Schedule Under a Tight Budget

Type of Construction: Dormitory

Installation Type: Retrofit

Location: Indiana

Scope of Project:
Heads: ≈8,000
Sq. Feet: ≈750,000
Stories: 12 Buildings: 4 Floors Each

Fire Sprinkler Contractor: McDaniel Fire Systems

As one of only six universities with its own fire department, the University of Notre Dame, founded in 1842, is a prime example of an institution that places a high priority on fire protection. To minimize the potential devastation of residence hall fires, Notre Dame launched a retrofit program in 1979, installing sprinkler systems during the renovation of old buildings and the construction of new ones. However, a deadly blaze that roared through a Seton Hall University residence hall in January of 2000 catapulted student life safety to the forefront of crisis prevention, triggering an outpouring of concern from Notre Dame fire officials.

Historically, University administrators have found traditional retrofits to be necessary but disruptive. They tend to be multi-year projects, due in large part to the inherent engineering challenges of metallic systems. Notre Dame has 27 residence halls housing 80% of the student population. At the time of the Seton Hall fire, only 12 halls had sprinkler systems. In the wake of this tragedy, Notre Dame Fire Operations Chief John Antonucci presented school officials with a plan mandating that the more than 750,000 remaining square feet of residence hall space be completely retrofitted within a 7-month timeframe. This was seemingly impossible as this project was estimated to span 4-5 years under best conditions using traditional systems.

A Race Against Time

Now working under an aggressive time schedule, Antonucci turned to McDaniel Fire Systems (Valparaso, IN) to install BlazeMaster® CPVC (chlorinated polyvinyl chloride) fire sprinkler systems. According to Antonucci, BlazeMaster CPVC sprinkler systems offered the superior, reliable performance he sought, and also featured simplistic, flexible engineering. Highly durable and lightweight, BlazeMaster CPVC systems were also proven to exhibit excellent impact resistance and natural immunity to corrosion and MIC (Microbiologically Influenced Corrosion). The key benefit for Notre Dame's residence hall project, however, was ease and speed of installation.

Plumbing & Mechanical Applications

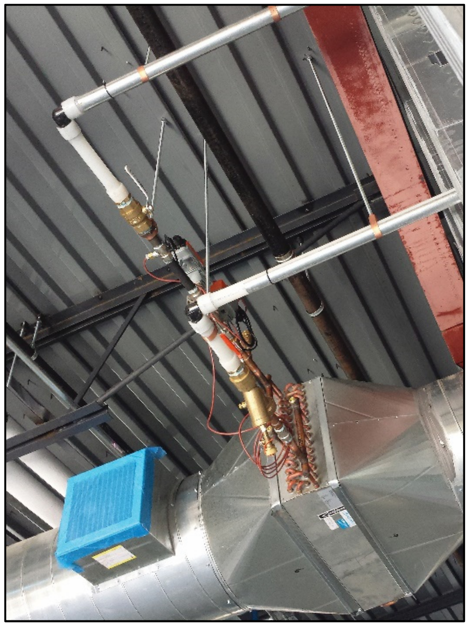
2.c Hydronic Heating & Cooling

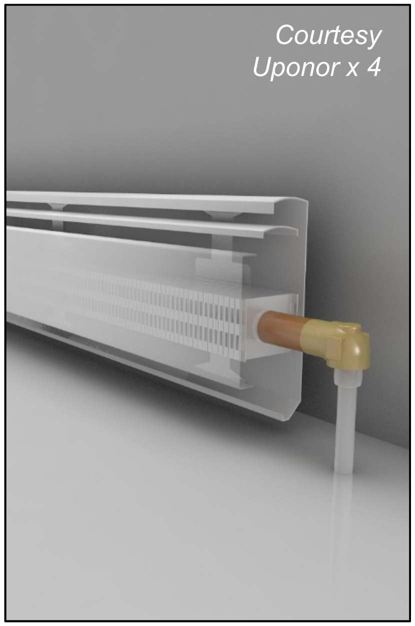
- Water (R718) is the optimal heat transfer medium or fluid
- Typical hydronic systems actually outperform VRF (variable refrigerant flow) systems by 30 to 40 percent thanks mainly to lower pumping costs
- Hydronic distribution systems do not distribute refrigerants throughout buildings

Plumbing & Mechanical Applications

2.c Hydronic Heating & Cooling

- All plastic piping materials in this presentation are suitable for hydronic heating & cooling distribution throughout buildings



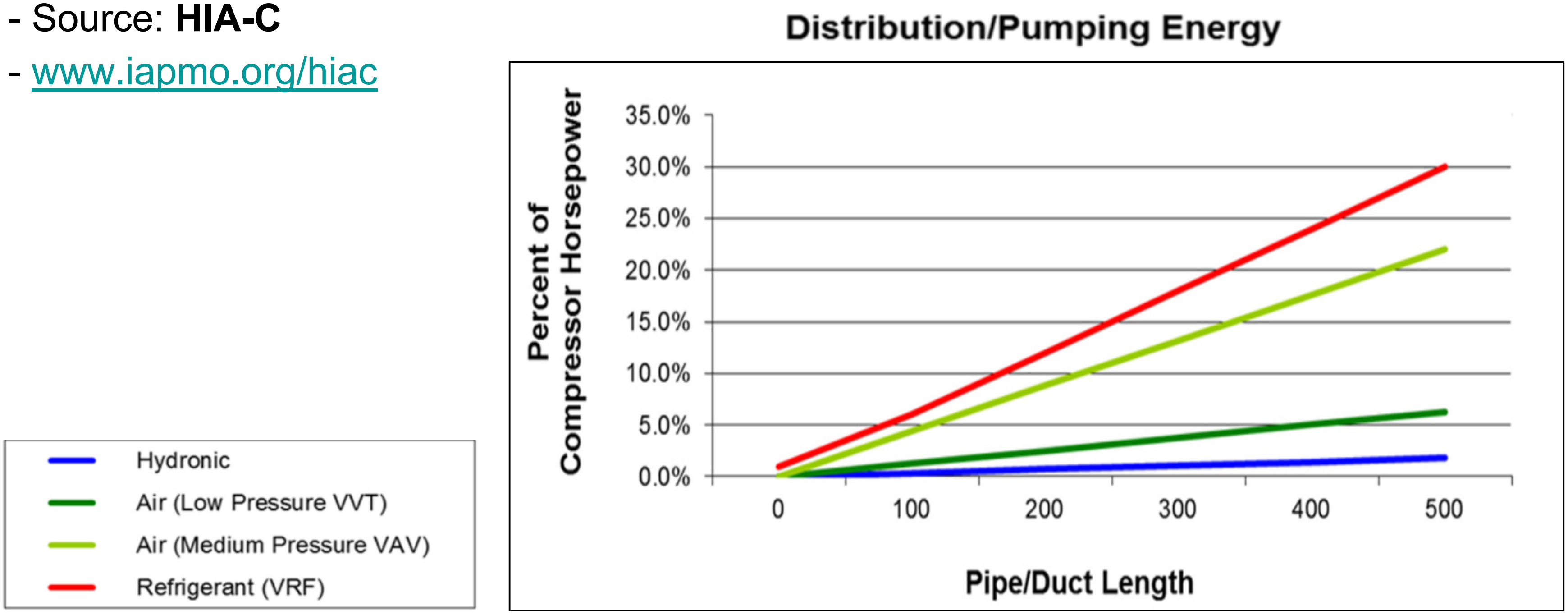


Plastics Pipe Institute
BUILDING & CONSTRUCTION

Plumbing & Mechanical Applications

2.c Hydronic Heating & Cooling

- The chart below compares the energy used by various systems to distribute heating or cooling capacity throughout a building
- Source: **HIA-C**
- www.iapmo.org/hiac

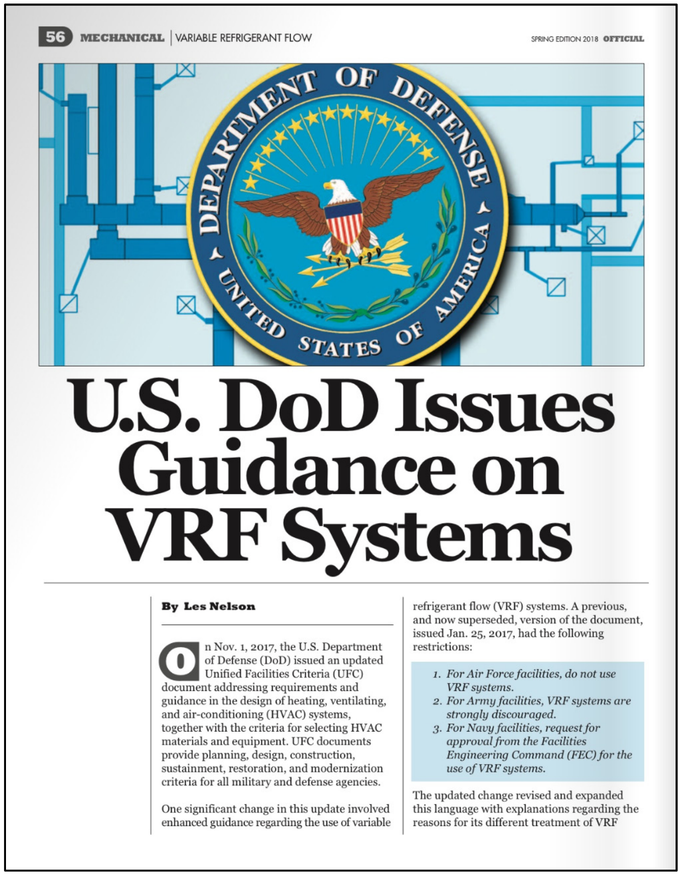


Plumbing & Mechanical Applications

2.c Hydronic Heating & Cooling

- Information from DOD on VRF systems
- Source: HIA-C

1. *For Air Force facilities, do not use VRF systems.*
2. *For Army facilities, VRF systems are strongly discouraged.*
3. *For Navy facilities, request for approval from the Facilities Engineering Command (FEC) for the use of VRF systems.*



56 MECHANICAL | VARIABLE REFRIGERANT FLOW — SPRING EDITION 2018 OFFICIAL

U.S. DoD Issues Guidance on VRF Systems

By Les Nelson

On Nov. 1, 2017, the U.S. Department of Defense (DoD) issued an updated Unified Facilities Criteria (UFC) document addressing requirements and guidance in the design of heating, ventilating, and air-conditioning (HVAC) systems, together with the criteria for selecting HVAC materials and equipment. UFC documents provide planning, design, construction, sustainment, restoration, and modernization criteria for all military and defense agencies.

One significant change in this update involved enhanced guidance regarding the use of variable refrigerant flow (VRF) systems. A previous, and now superseded, version of the document, issued Jan. 25, 2017, had the following restrictions:

1. *For Air Force facilities, do not use VRF systems.*
2. *For Army facilities, VRF systems are strongly discouraged.*
3. *For Navy facilities, request for approval from the Facilities Engineering Command (FEC) for the use of VRF systems.*

The updated change revised and expanded this language with explanations regarding the reasons for its different treatment of VRF

Plastics Pipe Institute
BUILDING & CONSTRUCTION

Plumbing & Mechanical Applications

2.c Hydronic Heating & Cooling

- Information from DOD on VRF systems
- Source: HIA-C

US Army Corps of Engineers®

ENGINEERING AND CONSTRUCTION BULLETIN

No. 2017-7 **Issuing Office:** CECW-CE **Issued:** 22 Mar 17 **Expires:** 22 Mar 19

SUBJECT: Changes to UFC 3-410-01, Heating, Ventilating and Air Conditioning Systems, with Change 3

CATEGORY: Directive and Guidance

REFERENCES:

a. Unified Facilities Criteria (UFC) 3-410-02, Lonworks ® Direct Digital Control for HVAC and other Local Building Systems, with Change 1

b. Unified Facilities Criteria (UFC) 3-410-01, Heating, Ventilating and Air Conditioning Systems, with Change 3

1. The following changes to the HVAC Systems UFC were recently completed.

2. A paragraph on Variable Refrigerant Flow (VRF) Systems has been added to the HVAC Systems UFC (Par 3-5.16). VRF Systems will no longer be permitted in Air Force facilities. The Army will allow VRF Systems; however, they will be strongly discouraged. The Navy is not restricting VRF systems as long as they comply with ASHRAE 15 Safety Standard for Refrigeration Systems.

Plumbing & Mechanical Applications

2.c Hydronic Radiant Heating, Radiant Heating & Cooling

- **PEX** or **PE-RT** tubing is typically embedded in floors, walls or ceilings
- Heated or chilled water is circulated through the tubing for energy transfer
- The <u>most comfortable and efficient method</u> to heat or cool any space

System Benefits:

- Improved thermal comfort, silent
- Architectural freedom, invisible
- Energy flexibility, controllability
- Reduced temperature stratification
- Higher overall system efficiency
- Radiant systems help to achieve compliance with **ASHRAE Standard 55** ***Thermal Conditions for Human Occupancy***


Courtesy REHAU

Plastics Pipe Institute
BUILDING & CONSTRUCTION

Plumbing & Mechanical Applications

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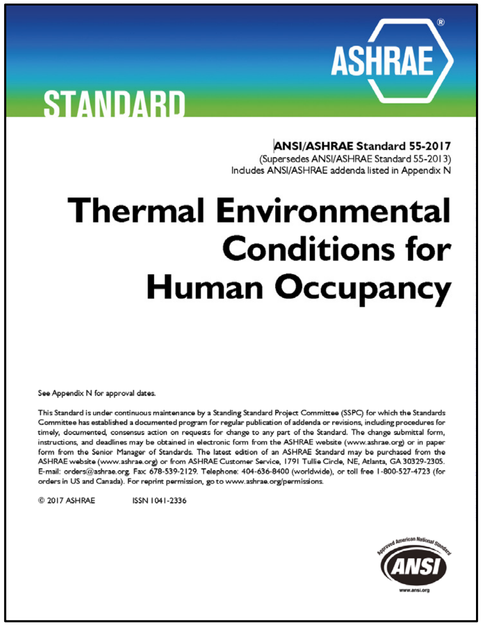
STANDARD
ASHRAE

ANSI/ASHRAE Standard 55-2017
(Supersedes ANSI/ASHRAE Standard 55-2013)
Includes ANSI/ASHRAE addenda listed in Appendix N

Thermal Environmental Conditions for Human Occupancy

See Appendix N for approval dates.

This Standard is under continuous maintenance by a Standing Standard Project Committee (SSPC) for which the Standards Committee has established a documented program for regular publication of addenda or revisions, including procedures for timely, documented, consensus action on requests for change to any part of the Standard. The change submittal form, instructions, and deadlines may be obtained in electronic form from the ASHRAE website (www.ashrae.org) or in paper form from the Senior Manager of Standards. The latest edition of an ASHRAE Standard may be purchased from the ASHRAE website (www.ashrae.org) or from ASHRAE Customer Service, 1791 Tullie Circle, NE, Atlanta, GA 30329-2305. E-mail: orders@ashrae.org. Fax: 678-539-2129. Telephone: 404-636-8400 (worldwide), or toll free 1-800-527-4723 (for orders in US and Canada). For reprint permission, go to www.ashrae.org/permissions.

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ANSI

PPI
Plastics Pipe Institute
BUILDING & CONSTRUCTION

Plumbing & Mechanical Applications

2.c Hydronic Radiant Heating, Radiant Heating & Cooling

- In cooling mode, radiant surfaces are regulated, temperatures stay above the dew point
- Radiant designers are well aware of how to design and control these systems

Case Study:

- San Francisco **Pier 15** Exploratorium
- 330,000 ft^2, Net-Zero, LEED® Gold
- 200,000 feet of PEX tubing embedded in concrete floor
- System operates in radiant heating or radiant cooling mode

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NEW SAN FRANCISCO ATTRACTION AWARDED FOR USE OF PEX PIPE HEATING AND COOLING SYSTEM

IRVING, Texas - San Francisco's Pier 15 Exploratorium was named Project of the Year for the Plastics Pipe Institute's Building & Construction Division.

The new Pier 15 Exploratorium (explore-a-tour-ium) will host more than one million visitors annually as a cultural and science learning center. Formerly a vacant eyesore, the recent renovation included a PEX-based radiant heating and cooling system. It is now a net-zero energy and a net-zero carbon, 330,000-square-foot facility with LEED-Gold certification.

"This project of the year shows how PEX can be a significant and important, modern, green building innovation," stated Tony Radoszewski, executive director of PPI, the major trade association representing all segments of the plastic pipe industry. He presented the award to PPI member company Uponor during the association's annual 2013 meeting.

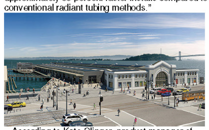
The project used 200,000 feet of Uponor North America's Wirsbo hePEX™ crosslinked polyethylene (PEX-a) tubing for the radiant heating and cooling system that uses the San Francisco Bay as a heat sink/heat source.

The project renovated a century-old building on San Francisco's Pier 15 into the largest net-zero energy and net-zero carbon museum in the United States. The 330,000-square-foot, LEED®-Gold structure is projected to be 57 percent more efficient than the ASHRAE 90.1 energy standard requires, due in part to the Uponor radiant heating and cooling system.

"We are very proud to receive this recognition by our peers in the plastics pipe industry," said Bill Gray, president, Uponor North America. "The Pier 15 Exploratorium is an excellent example of the benefits of flexible plastic pipe and how it can transform a historic building into an impressively sustainable project."

The use of Uponor's Radiant Rollout™ Mats reduced installation time on approximately 80 percent of the floor surface. The custom-designed mats are prefabricated to project specifications at Uponor's factory in Apple Valley, Minn.

"The mats feature pre-pressurized rolls of PEX-a tubing loops fitted with Uponor ProPEX® engineered polymer (EP) fittings, which are safe for burial in the slab," said Him Ly, senior design engineer of Technical Services at Uponor. "Once on the job site, the mats roll out like carpeting over the floor space, providing approximately 85 percent faster installs compared to conventional radiant tubing methods."



According to Kate Olinger, product manager of Plumbing at Uponor and member of PPI, the Pier 15 project showcases the importance of plastic pipe in two ways. It shows how flexible PEX can work around existing structural components to renew an old building into a high-performance structure that showcases best-practices for sustainable design. Additionally, it provides another educational tool for the Exploratorium where visitors can learn about the energy-efficiency of PEX-based radiant heating and cooling systems.

About PPI:
The Plastics Pipe Institute Inc. (PPI) is the major trade association representing all segments of the plastic pipe industry and is dedicated to promoting plastics as the material of choice for pipe applications. PPI is the premier technical, engineering and industry knowledge resource publishing data for use in development and design of plastic pipe systems. Additionally, PPI collaborates with industry organizations that set standards for manufacturing practices and installation method.

Plumbing & Mechanical Applications

2.d Snow and Ice Melting (SIM)

- SIM systems augment the removal of snow and ice by circulating a heat transfer fluid through plastic pipes

System Benefits:

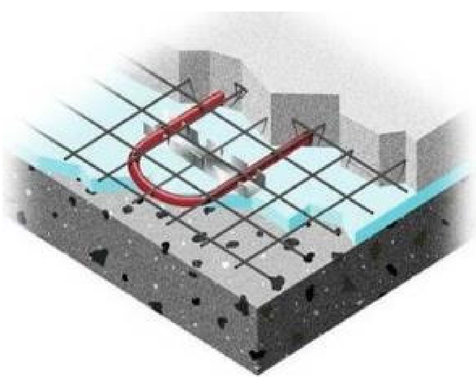
- Convenience
- Increased safety and reduced liability
- Minimized environmental impact
- Lower operating costs
- Long-lasting reliability

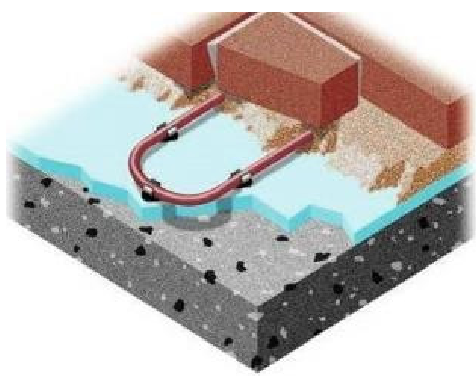
Plastics Pipe Institute
BUILDING & CONSTRUCTION

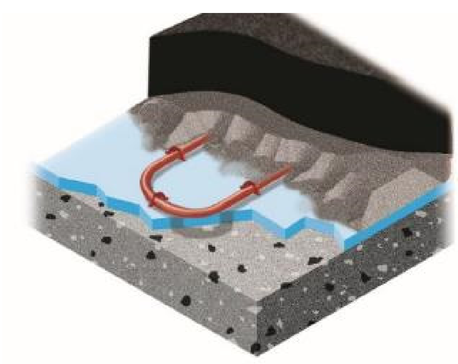
Plumbing & Mechanical Applications

2.d Snow and Ice Melting (SIM)

- **PEX** or **PE-RT** tubing is embedded in or below outdoor surfaces
- Outdoor moisture sensors can detect when operation is needed
- Heated antifreeze (glycol + water) is circulated through the tubing for energy transfer







Courtesy REHAU x3

Plumbing & Mechanical Applications

2.d Snow and Ice Melting (SIM)

- Typical applications (residential, commercial, institutional, industrial)

- Sidewalks
- Steps
- Pool decks
- Driveways
- Ramps
- Roads
- Parking garages
- Train stations
- Hangers
- Aviation surfaces

Plastics Pipe Institute
BUILDING & CONSTRUCTION

Plumbing & Mechanical Applications

2.d Snow and Ice Melting (SIM)

- ASHRAE HVAC Applications "Ch. 51 Snow Melting and Freeze Protection" provides guidance to designers

Table 1 Frequencies of Snow-Melting Surface Heat Fluxes at Steady-State Conditions[a]

Location	Snowfall Hours per Year	Snow-Free Area Ratio, A_r	Heat Fluxes Not Exceeded During Indicated Percentage of Snowfall Hours from 1982 Through 1993, Btu/h·ft²[b]					
			75%	90%	95%	98%	99%	100%
Albany, NY	156	1	89	125	149	187	212	321
		0.5	60	86	110	138	170	276
		0	37	62	83	119	146	276
Albuquerque, NM	44	1	70	118	168	191	242	393
		0.5	51	81	96	117	156	229
		0	30	46	61	89	92	194
Amarillo, TX	64	1	113	150	168	212	228	318
		0.5	71	88	108	124	142	305
		0	24	46	62	89	115	292
Billings, MT	225	1	112	164	187	212	237	340
		0.5	64	89	102	116	128	179
		0	22	33	45	60	68	113
Bismarck, ND	158	1	151	199	231	275	307	477
		0.5	83	107	124	148	165	243
		0	16	30	39	60	73	180

Plumbing & Mechanical Applications

2.d Snow and Ice Melting (SIM)

- Operating costs are often 50% less expensive (or better) than typical contracting costs for mechanical snow removal, plus frequent sanding and salting (and the inconvenience and cost of snow banks left behind)
- Plus, the SIM system is automatic and is always on time

- **Example**: National Museum of the American Indian, Washington, DC

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BUILDING & CONSTRUCTION

Plumbing & Mechanical Applications

2.d Snow and Ice Melting (SIM)

- Operating costs are often 50% less expensive (or better) than typical contracting costs for mechanical snow removal, plus frequent sanding and salting

Case Study:

- **Solara** development, Vail, Co
- 60,000 ft^2 of outdoor surfaces melted
- 200,000 feet of PEX tubing installed outdoors
- Sidewalks, steps, street, parking areas
- Multiple sensors, multiple zones

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PEX PIPE TURNS COLD SPACE INTO HAUTE DESTINATION

PEX Pipe Used For Ice Melting & Radiant Heating Wins Industry Award

VAIL, Colo - One very upscale project with two different and very large PEX pipe systems was acknowledged as the Plastics Pipe Institute's (PPI's) Building and Construction Division 2011 "Project of the Year". The award was given in recognition of the application of some 75 miles of durable PEX (cross-linked polyethylene) pipe installed at the exclusive Solaris town center in Vail, Colorado where it's being used for both indoor radiant heating and outdoor ice and snow melting systems. The award was presented to the pipe system's equipment manufacturer, REHAU, Inc. (Leesburg, Va.), during PPI's annual meeting in May 2011. The PPI is the major trade association representing all segments of the plastic pipe industry, and its annual awards program cites projects for exemplary installations of distinguishing character. The Solaris project was selected due to its scope, performance capabilities and sustainability features.

"This project demonstrates two excellent applications of PEX pipe - radiant floor heating (RFH), and snow and ice melting (SIM). Both are technologies found in many LEED-certified facilities, and recognized throughout the design community for supplying comfort, service-longevity and energy efficiency – these are extremely important factors in environmentally-conscious places like Colorado," stated Tony Radoszewski, executive director of the PPI. "In short, this state-of-the-art town center used a proven, technologically advanced pipe to provide comfort, safety, reliability, and cost-efficiency for the long-term."

Vail's new Solaris town center has 79 condominiums that range in price from $1.4 million for a studio to more than $19 million for a six-bedroom penthouse. Amenities include a public plaza, ice rink, a three-screen movie theatre, casual and fine dining restaurants, 10-lane bowling alley, private swimming pool and hot tub, spa, fitness facility, heated underground garage and 75,000 square feet of commercial space with high-end retail shopping. These interior areas are heated with a PEX pipe radiant heating system.

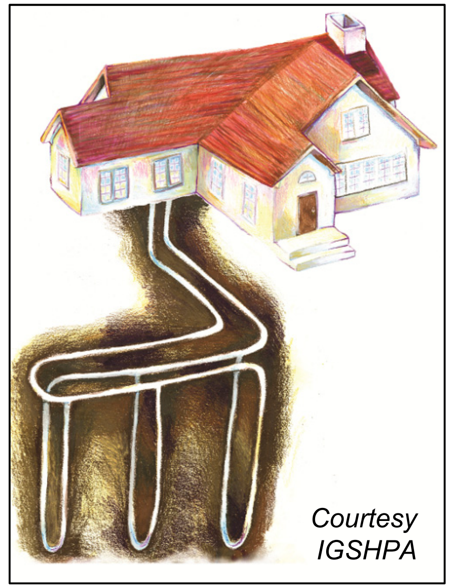
Plumbing & Mechanical Applications

2.e Ground Source Geothermal

- Ground source heat pumps are the most efficient source of heating and cooling energy for any type of building (vs. VRF, boilers, chillers, etc.)
- **HDPE**, **PEX**, **PE-RT** and **PP** piping materials are used for ground loop piping

System Benefits:

- Systems exchange heat with the Earth ("geoexchange")
- Geothermal heat pumps can have efficiencies (COP) greater than **450%** when operating in heating mode
- Heat is rejected to the earth when cooling (high EER)
- Heat pumps are indoors, out of sight, no noise
- Low operating costs, high reliability, economical



Courtesy IGSHPA

Plumbing & Mechanical Applications

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Courtesy Versaprofiles

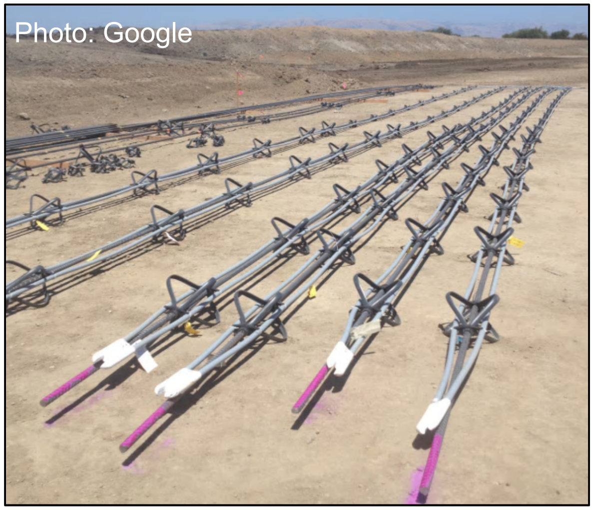
Photo: Google

Plumbing & Mechanical Applications

2.f District Heating & Cooling Pipelines

- For transferring heated or chilled fluids from one location to another, buried pipelines of plastic piping materials are often ideal
- **HDPE**, **PEX**, **PE-RT** and **PP** piping materials are used for district heating & cooling energy transfer pipelines

System Benefits:

- Lower costs, faster installation, no corrosion
- With pre-insulated pipes, insulation is factory-made, watertight, and consistent in R-value
- Flexible pre-insulated pipes install in long lengths with fewer joints, faster installation

Plastics Pipe Institute
BUILDING & CONSTRUCTION

Plumbing & Mechanical Applications

2.f District Heating & Cooling Pipelines

- See ASTM F2165-19 *Standard Specification for Flexible Pre-insulated Plastic Piping*


Courtesy Watts

Designation: F2165 – 19

An American National Standard

Standard Specification for Flexible Pre-Insulated Plastic Piping[1]

This standard is issued under the fixed designation F2165; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope*

1.1 This specification covers flexible, pre-insulated plastic piping systems commonly used to convey hot and cold fluids, including piping systems that are supplied complete with plastic carrier pipe, thermal insulation, and outer jacket manufactured as an integrated system, and are supplied in a coil or as a straight length. Both bonded and non-bonded insulation types are included. Included are requirements and test methods for material, workmanship, dimensions, and endseal testing. Requirements for markings are also given. The components covered by this specification are intended for use in, but not limited to, residential and commercial, hot- and cold-potable water distribution systems, reclaimed water, fire protection, municipal water service lines, radiant heating and cooling systems, hydronic distribution systems, snow and ice melting

mental practices and determine the applicability of regulatory limitations prior to use.

1.6 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

C168 Terminology Relating to Thermal Insulation

C177 Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded-Hot-Plate Apparatus

Plastics Pipe Institute
BUILDING & CONSTRUCTION

Plumbing & Mechanical Applications

2.f District Heating & Cooling Pipelines

- **HDPE**, **PEX**, **PE-RT** and **PP** piping materials are used for district heating & cooling energy transfer pipelines

Case Study:

- **Four Seasons Resort**, Napa Valley, CA
- 5,000 feet HDPE in sizes 2 in. to 8 in.
- Grooved mechanical connections

Courtesy Victaulic

Case Study

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MECHANICAL JOINING SYSTEM BENEFITS
NEW NAPA VALLEY RESORT
Hydronic Water Pipelines Run in Time to Beat Area Fires

CALISTOGA, Calif. - The new Four Seasons resort under construction here required an underground network of nearly a mile of pipe to provide hydronic hot and cold water to the new complex. Not just a luxury Four Seasons hotel, the Napa Valley resort, which is scheduled to open in 2019, will have 85 guest rooms and 20 private residence villas. For the five-star resort that includes a six-acre private vineyard, the cooling and heating water distribution lines for every building had to be installed quickly in order to meet tight construction schedules, which ultimately allowed the crew to beat the widespread fires that suddenly enveloped the area during the summer of 2017. The contractor, Greenberry Industrial (Vancouver, WA), used some 5,000 feet of high-density polyethylene (HDPE) pipe in diameters of two, four, six and eight inches for the heating and cooling system.

The layout required both insulated and non-insulated underground HDPE lines, which run from a central utility plant to each building throughout the property. According to the Plastics Pipe Institute, Inc. (PPI), this type of hydronic system is a very efficient way to heat and cool a complex of this size.

The Four Seasons requested an HDPE piping system as a more affordable and non-corrosive alternative to copper. To meet this requirement, the contractor needed a way to join HDPE pipe in a timely and cost-effective manner. To connect the pipe sections together and also where the HDPE pipe would transition to carbon steel in the water plant, Greenberry elected to use couplings from Victaulic (Easton, PA), which would increase the speed of installation while providing a permanent joint that could also be buried.

The insulated and non-insulated HDPE pipe is joined to *Victaulic* HDPE fittings using *Victaulic* Style 905 Couplings. A fully restrained system, *Victaulic* fittings and couplings are designed to be buried.

Plumbing & Mechanical Applications

Summary: Plastic pipes are used in multiple applications

2.a Plumbing distribution (hot- and cold-water supply)
2.b Fire protection (sprinklers)
2.c Hydronic heating and cooling (including radiant heating & cooling)
2.d Snow & ice melting (for outdoor surfaces)
2.e Geothermal ground loops (geothermal)
2.f District heating applications (buried pipelines)

3. Design of Plastic Piping Systems

This Learning Objective will show tools for sizing and designing systems

3.a Sizing pipes for flow rates / calculating pressure loss (head loss)
3.b Addressing hydraulic shock to prevent pressure surges
3.c Determining pipe weights and volumes (empty and full)
3.d Predicting longitudinal thermal expansion / contraction
3.e Sizing expansion arms & legs (for thermal expansion)

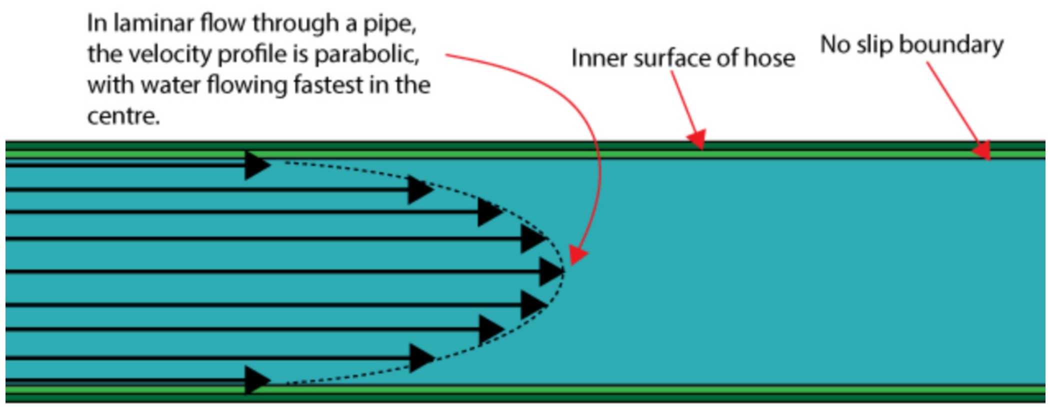
PPI Plastics Pipe Institute BUILDING & CONSTRUCTION

Design of Plastic Piping Systems

3.a Sizing pipes for flow rates / calculating pressure loss (head loss)

- Sizing pipe seems easy enough – make it large enough to carry the required fluid

- Priority #1: Keep friction low to <u>reduce pumping costs</u>
- Priority #2: Do not exceed allowable velocities (<u>noise, vibration, erosion</u>)
- Priority #3: Keep fluid moving fast enough to prevent stagnation of water, mineral build-up, possible biofilm growth (<u>plumbing</u>)



Design of Plastic Piping Systems

3.a Sizing pipes for flow rates / calculating pressure loss (head loss)

- Sizing pipe seems easy enough – make it large enough to carry the required fluid

- Priority #1: Keep friction low to reduce pumping costs
- Priority #2: Do not exceed allowable velocities (noise, vibration, erosion)
- Priority #3: Keep fluid moving fast enough to prevent stagnation of water, mineral build-up, possible biofilm growth (plumbing)
- Priority #4: Keep fluid moving fast enough to have turbulent flow for heat transfer (where heat transfer through the pipe wall is needed; e.g. radiant piping, geothermal)
- Priority #5: Cost (material and labor), space

Design of Plastic Piping Systems

3.a Sizing pipes for flow rates / calculating pressure loss (head loss)

- In reality, designers of hydronic heating/cooling, geothermal and other piping systems need to know several factors to make good decisions for sizing pipes:

1. Required flow rate (GPM)
2. Specific fluid type (water or glycol mix)
3. Fluid temperature (affects viscosity)
4. Pipe length and associated fittings
5. Pipe type and inside diameter
6. Fluid chemistry, etc.

Note: *Certain data is still being added to BCD Calculator*
Final updates going live in 2020

Plastics Pipe Institute
BUILDING & CONSTRUCTION

Design of Plastic Piping Systems

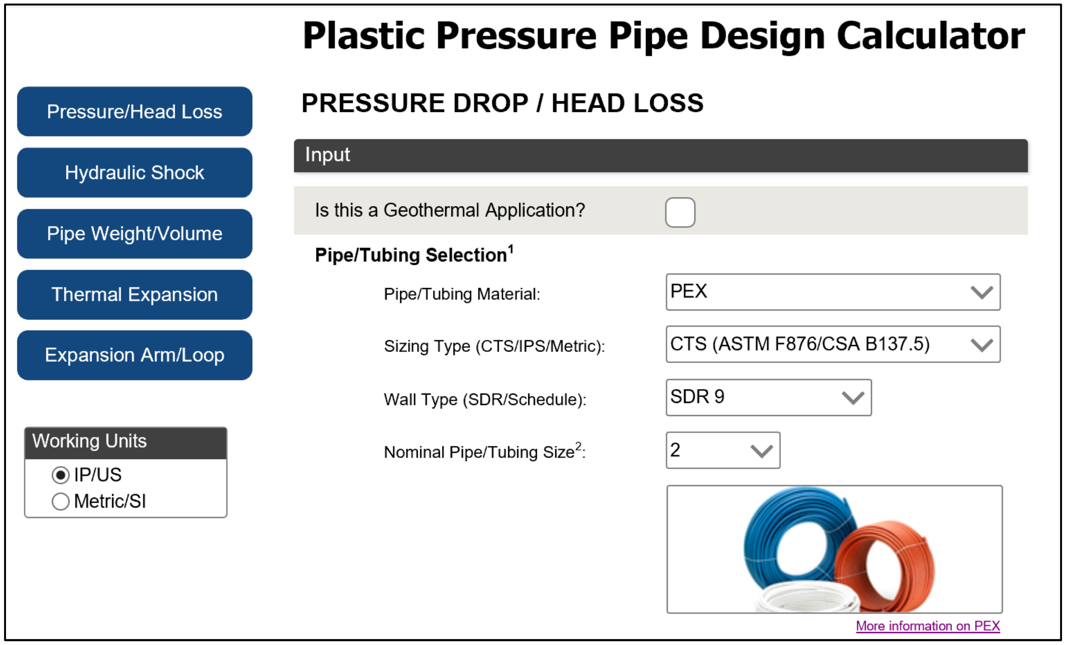
3.a Sizing pipes for flow rates / calculating pressure loss (head loss)

- Plastic Pressure Pipe Design Calculator www.plasticpipecalculator.com
- Data for all types of plastic pressure pipes

Five Sets of Functions:

- Pressure/Head Loss
- Hydraulic Shock
- Pipe Weight/Volume
- Thermal Expansion/Contraction
- Expansion Arm/Loop Design

Example: Head loss calculation with PEX tubing nominal size 2



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Design of Plastic Piping Systems

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- Data for all types of plastic pressure pipes

Five Sets of Functions:

- Pressure/Head Loss
- Hydraulic Shock
- Pipe Weight/Volume
- Thermal Expansion/Contraction
- Expansion Arm/Loop Design

Example: Head loss calculation with PEX tubing nominal size 2

Flow Rate:	33	USGPM
Length of Pipe:	99	ft
Fluid Type (Water or % Glycol):	100% Water	
Average Fluid Temperature*:	73	°F

**This calculation uses the Darcy Weisbach equation which includes temperature as a variable. As a resu tables using the Hazen-Williams equation with a standard temperature may show different results.*

Design of Plastic Piping Systems

3.a Sizing pipes for flow rates / calculating pressure loss (head loss)

- Plastic Pressure Pipe Design Calculator www.plasticpipecalculator.com
- Data for all types of plastic pressure pipes

Five Sets of Functions:

- Pressure/Head Loss
- Hydraulic Shock
- Pipe Weight/Volume
- Thermal Expansion/Contraction
- Expansion Arm/Loop Design

Example: Head loss calculation with PEX tubing nominal size 2

Calculate

Results

Flow Regime:	Turbulent	
Pressure Drop:	2.5 Psi	17.3 kPa
Head Loss:	5.8 ft water	
Velocity*:	5.1 ft/s	1.5 m/s

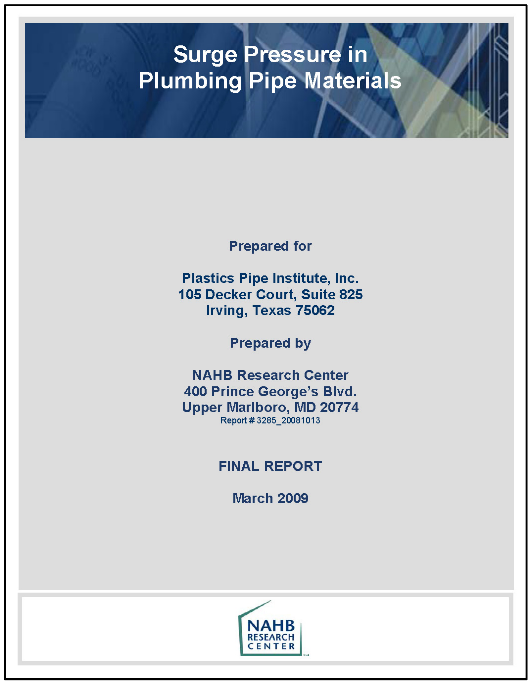
Calculation Details · Print · Email

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

Design of Plastic Piping Systems

3.b Addressing hydraulic shock (surge pressures)

- NAHB report “Surge Pressure in Plumbing Pipe Materials”
- Plastic pipes can significantly reduce surge pressures & water hammer



Surge Pressure in Plumbing Pipe Materials

Prepared for

Plastics Pipe Institute, Inc.
105 Decker Court, Suite 825
Irving, Texas 75062

Prepared by

NAHB Research Center
400 Prince George's Blvd.
Upper Marlboro, MD 20774
Report # 3285_20081013

FINAL REPORT

March 2009

NAHB RESEARCH CENTER

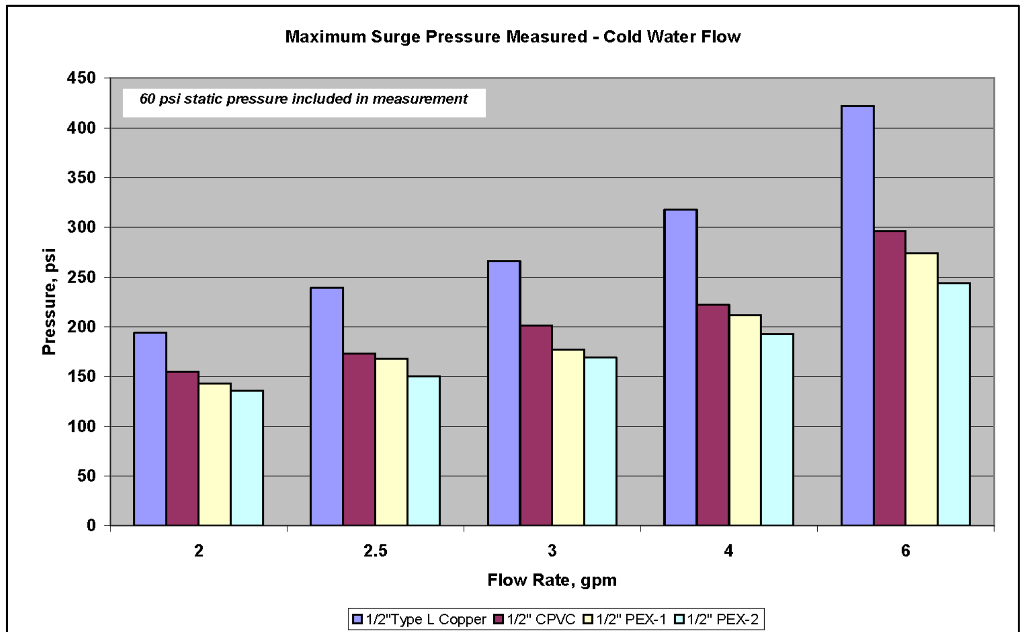
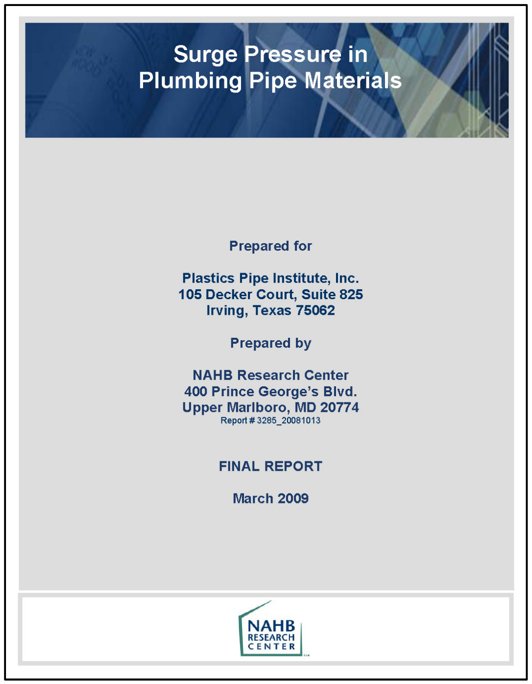


Figure 7: Comparison of Piping Pressure Response to Quick-Acting Valve with Cold Water Flows

Design of Plastic Piping Systems

3.b Addressing hydraulic shock (surge pressures)

- NAHB report "Surge Pressure in Plumbing Pipe Materials"
- Plastic pipes can significantly reduce surge pressures & water hammer



Surge Pressure in Plumbing Pipe Materials

Prepared for

Plastics Pipe Institute, Inc.
105 Decker Court, Suite 825
Irving, Texas 75062

Prepared by

NAHB Research Center
400 Prince George's Blvd.
Upper Marlboro, MD 20774
Report # 3285_20081013

FINAL REPORT

March 2009

Table 3: Peak Pressure Comparison – 2.5 GPM Cold Water Flow, 54°F Water (See Figure 4b)

	Pipe Peak 1 (psig)	% Difference
½" Type L Copper	239	0
½" CPVC	173	28
½" PEX-1	168	30
½" PEX-2	150	37

Table 4: Peak Pressure Comparison – 2.5 GPM Hot Water Flow, 130°F Water (see Figure 5b)

	Pipe Peak 1 (psig)	% Difference
½" Type L Copper	181	0
½" CPVC	149	18
½" PEX-1	113	38
½" PEX-2	109	40

Design of Plastic Piping Systems

3.b Addressing hydraulic shock (surge pressures)

- NAHB report "Surge Pressure in Plumbing Pipe Materials"
- Plastic pipes can significantly reduce surge pressures & water hammer

Five Sets of Functions:

- Pressure/Head Loss
- Hydraulic Shock
- Pipe Weight/Volume
- Thermal Expansion/Contraction
- Expansion Arm/Loop Design

Example: Hydraulic shock calculation with CPVC pipe nominal size 12

Plastic Pressure Pipe Design Calculator

HYDRAULIC SHOCK

Input

Is this a Geothermal Application?

Pipe/Tubing Selection[1]

Pipe/Tubing Material: CPVC

Sizing Type (CTS/IPS/Metric): IPS (ASTM F441/CSA B137.6) SCHD

Wall Type (SDR/Schedule): Schedule 80

Nominal Pipe/Tubing Size[2]: 12

More information on CPVC

Plastics Pipe Institute
BUILDING & CONSTRUCTION

Design of Plastic Piping Systems

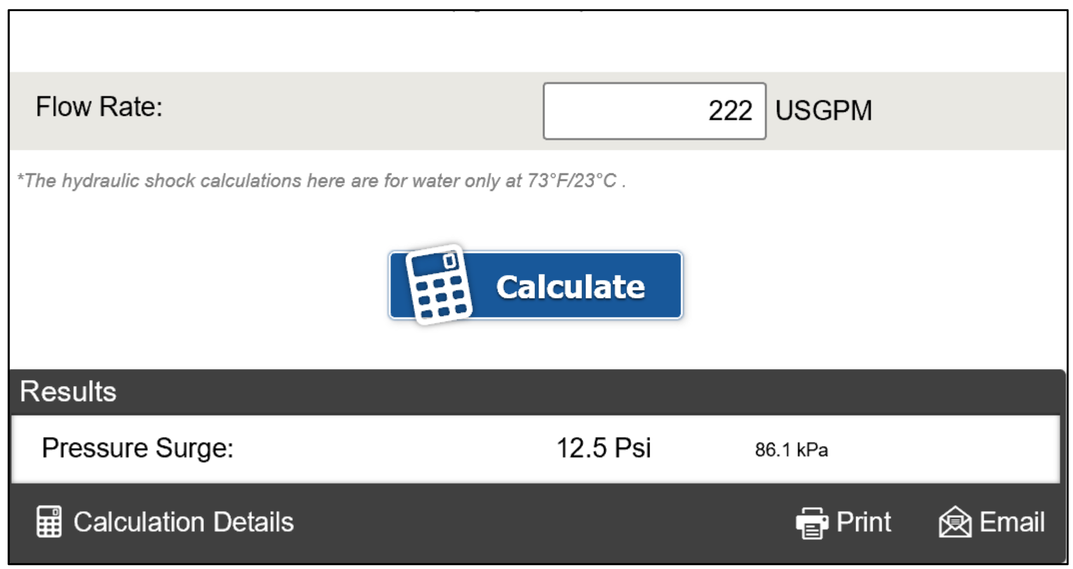
3.b Addressing hydraulic shock (surge pressures)

- NAHB report "Surge Pressure in Plumbing Pipe Materials"
- Plastic pipes can significantly reduce surge pressures & water hammer

Five Sets of Functions:

- Pressure/Head Loss
- Hydraulic Shock
- Pipe Weight/Volume
- Thermal Expansion/Contraction
- Expansion Arm/Loop Design

Example: Hydraulic shock calculation with CPVC pipe nominal size 12



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BUILDING & CONSTRUCTION

Design of Plastic Piping Systems

3.c Determining pipe weights and volumes (empty and full)

- Data is necessary when selecting glycol, for instance
- Data for all types of plastic pressure pipes

Five Sets of Functions:

- Pressure/Head Loss
- Hydraulic Shock
- Pipe Weight/Volume
- Thermal Expansion/Contraction
- Expansion Arm/Loop Design

Example: Pipe weight/volume calculation with CPVC pipe nominal size 4

PIPE WEIGHT / VOLUME

Input

Is this a Geothermal Application? ☐

Pipe/Tubing Selection[1]

Pipe/Tubing Material:	CPVC
Sizing Type (CTS/IPS/Metric):	IPS (ASTM F442/CSA B137.6) SDR
Wall Type (SDR/Schedule):	SDR 11
Nominal Pipe/Tubing Size[2]:	4

More information on CPVC

Design of Plastic Piping Systems

3.c Determining pipe weights and volumes (empty and full)

- Data is necessary when selecting glycol, for instance
- Data for all types of plastic pressure pipes

Five Sets of Functions:

- Pressure/Head Loss
- Hydraulic Shock
- Pipe Weight/Volume
- Thermal Expansion/Contraction
- Expansion Arm/Loop Design

Example: Pipe weight/volume with CPVC pipe nominal size 4

Results

Dry Weight:	372.3 lb	168.9 kg
Filled Weight:	820.1 lb	372.0 kg
Volume Of Fluid In Pipe:	53.9 US Gallons	203.8 L
Volume Of Mixture Fluid:	0.0 US Gallons	0.0 L

Calculation Details | Print | Email

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BUILDING & CONSTRUCTION

Design of Plastic Piping Systems

3.d Longitudinal thermal expansion/contraction

- Longitudinal thermal expansion/contraction is higher for plastics than metals
- This is accommodated in proper design

Five Sets of Functions:

- Pressure/Head Loss
- Hydraulic Shock
- Pipe Weight/Volume
- Thermal Expansion/Contraction
- Expansion Arm/Loop Design

Example: Thermal expansion/contraction calculation with PP pipe nominal size 75

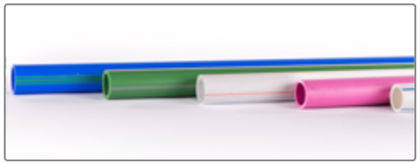
THERMAL EXPANSION / CONTRACTION

Input

Is this a Geothermal Application? ☐

Pipe/Tubing Selection[1]

Pipe/Tubing Material:	PP-R/PP-RCT, Fiber-core Layer
Sizing Type (CTS/IPS/Metric):	DN - Metric (ASTM F2389)
Wall Type (SDR/Schedule):	SDR 7.3
Nominal Pipe/Tubing Size[2]:	75



More information on PP-R/PP-RCT

Design of Plastic Piping Systems

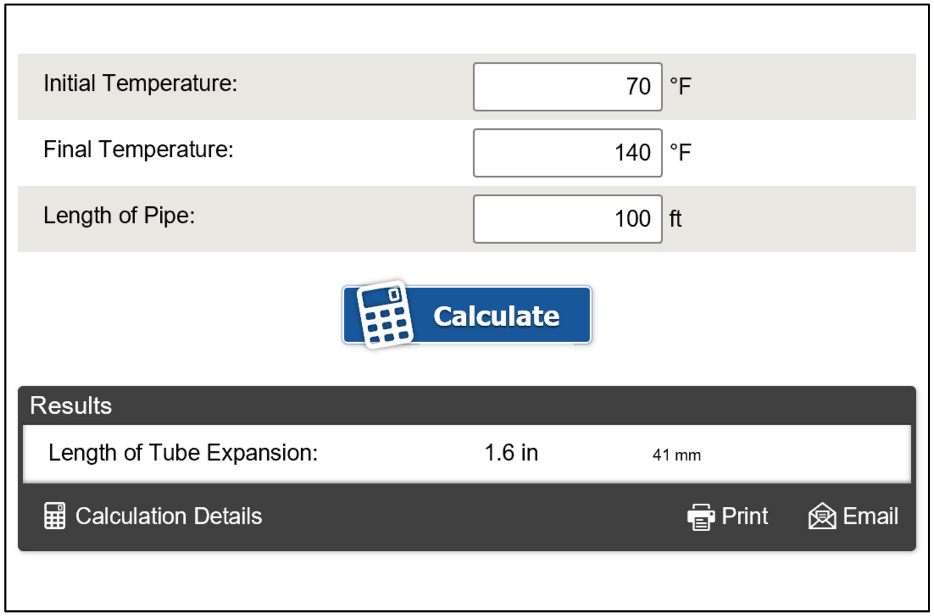
3.d Longitudinal thermal expansion/contraction

- Longitudinal thermal expansion/contraction is higher for plastics than metals
- This is accommodated in proper design

Five Sets of Functions:

- Pressure/Head Loss
- Hydraulic Shock
- Pipe Weight/Volume
- <u>Thermal Expansion/Contraction</u>
- Expansion Arm/Loop Design

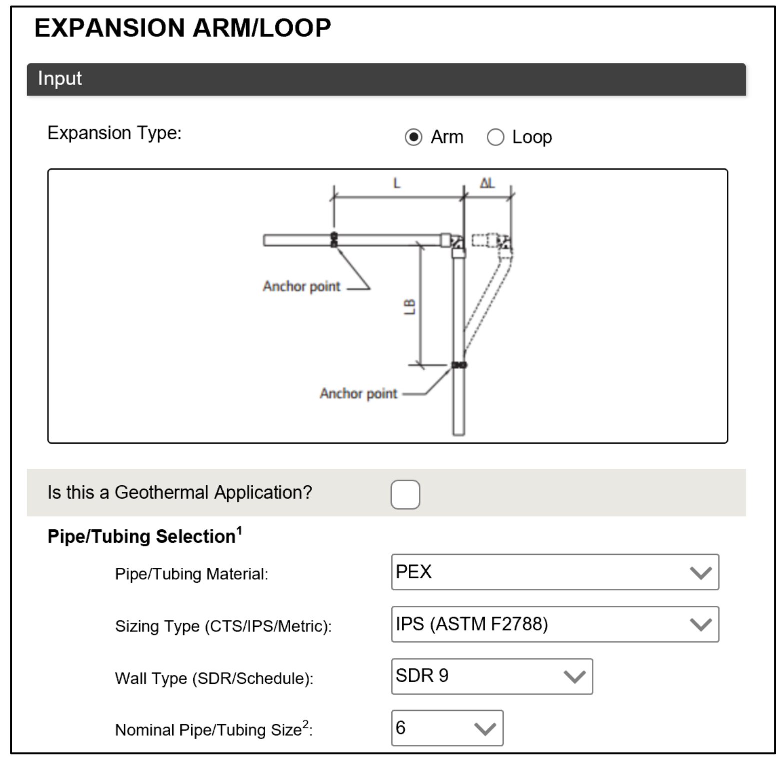
Example: Thermal expansion/contraction calculation with PP pipe nominal size 75



Design of Plastic Piping Systems

3.e Sizing expansion arms & legs

- Longitudinal thermal expansion/contraction is higher for plastics than metals
- This is accommodated in proper design



Five Sets of Functions:

- Pressure/Head Loss
- Hydraulic Shock
- Pipe Weight/Volume
- Thermal Expansion/Contraction
- Expansion Arm/Loop Design

Example: Expansion arm design with PEX pipe nominal size 6

Design of Plastic Piping Systems

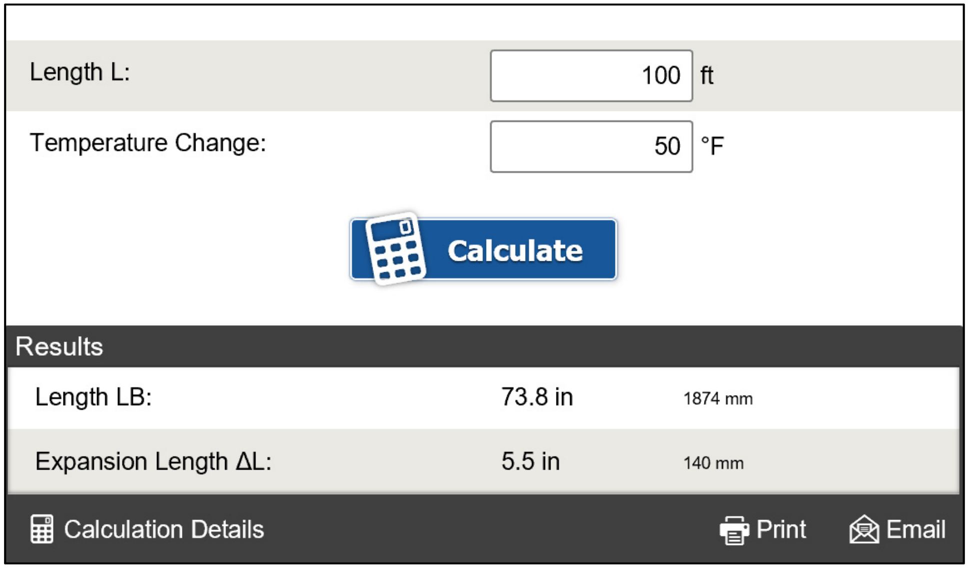
3.e Sizing expansion arms & legs

- Longitudinal thermal expansion/contraction is higher for plastics than metals
- This is accommodated in proper design

Five Sets of Functions:

- Pressure/Head Loss
- Hydraulic Shock
- Pipe Weight/Volume
- Thermal Expansion/Contraction
- Expansion Arm/Loop Design

Example: Expansion arm design with PEX pipe nominal size 6



Design of Plastic Piping Systems

Summary: Tools to assist with sizing and designing

3.a Sizing pipes for flow rates / calculating pressure loss (head loss)
3.b Addressing hydraulic shock to prevent pressure surges
3.c Determining pipe weights and volumes (empty and full)
3.d Predicting longitudinal thermal expansion / contraction
3.e Sizing expansion arms & legs (for thermal expansion)


Courtesy REHAU

4. Industry Resources

This Learning Objective will suggest industry resources to assist with selecting & specifying pipes and systems

4.a HIA-C
4.b IGSHPA
4.c RPA
4.d PPI

Courtesy Aquatherm

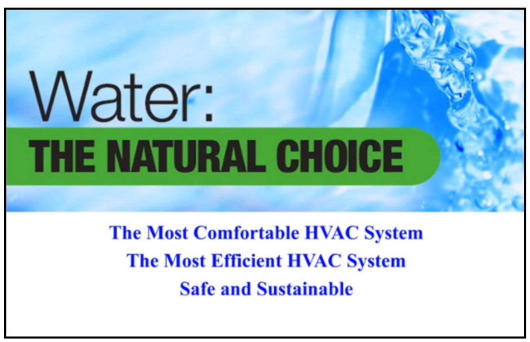
Plastics Pipe Institute
BUILDING & CONSTRUCTION

Hydronics Industry Alliance Commercial

Industry Resources

4.a Hydronics Industry Alliance-Commercial (HIA-C)

- "The Hydronic Industry Alliance-Commercial (HIA-C) is a non-profit alliance of hydronic equipment manufacturers and partners operating in North America."
- "Operating under the principle that <u>water is the most efficient and greenest energy transfer medium on the planet</u>, the alliance serves as a resource within the HVAC and Service Water Heating industry."



best
building efficiency system tool™

VRF
REJECTED
Before you build, learn what the Department of Defense, building owners, and others have learned through their experience with VRF systems.

Industry Resources

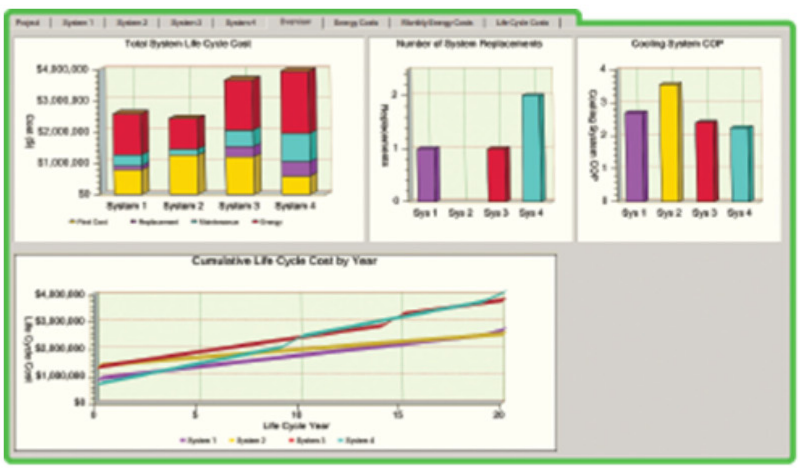
4.a Hydronics Industry Alliance-Commercial (HIA-C)

- **Building Efficiency System Tool** (BEST) for commercial system HVAC design
- "BEST provides annual energy consumption and lifecycle cost comparisons, based on actual system performance data, for your building's HVAC system in just minutes!
- "BEST uses AHRI-certified performance data and building energy efficiency ratings to model the HVAC system as it will operate in real life – not the test lab."

Industry Resources

4.a Hydronics Industry Alliance-Commercial (HIA-C)

- **Building Efficiency System Tool** (BEST) for commercial system HVAC design
- www.iapmo.org/hiac

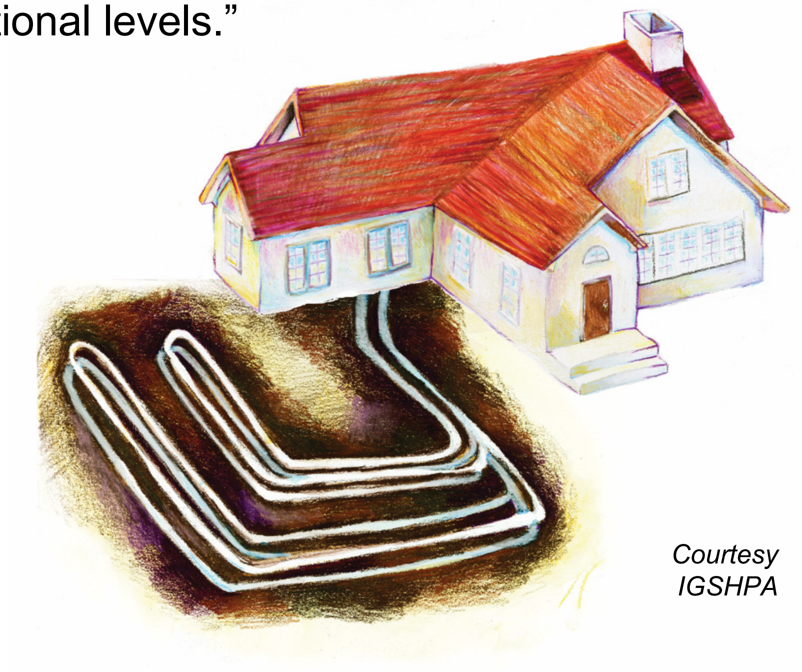


Courtesy HIA-C

Industry Resources

4.b International Ground Source Heat Pump Association (IGSHPA)

- "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."
- www.igshpa.org



Courtesy IGSHPA

Industry Resources

4.b International Ground Source Heat Pump Association (IGSHPA)

IGSHPA provides multiple tools to the industry, as well as training programs

- Guides, manuals
- Technical explanations
- Conferences
- Access to “accredited installers” through website
- Most comprehensive Geothermal “code” is ANSI/CSA/IGSHPA C448
- www.igshpa.org

Courtesy IGSHPA

Industry Resources

4.c Radiant Professionals Alliance (RPA)

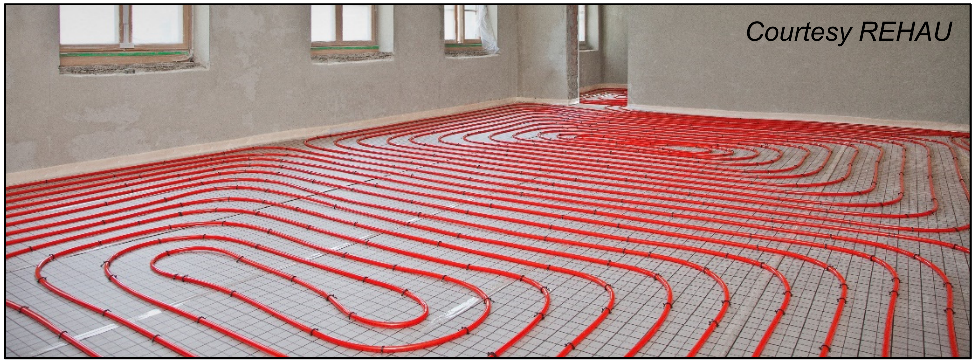
- “The RPA is an international trade association comprised of individuals and companies dedicated to increasing the use of radiant heating and cooling technologies through education and the development of codes and standards language reflecting best practices.”
- “Guiding the future of the radiant and hydronics industry through technical expertise for code development, professional certification, and industry advocacy.”

- *Adaptability, Architectural freedom, Control, Efficiency, Invisibility, Longevity, Reduced maintenance, Safety – the Advantages of Hydronic Radiant Systems*

Industry Resources

4.c Radiant Professionals Alliance (RPA)

- Education at conferences (E.g. AHR)
- *Radiant Comfort Guide*
- Webinars, manuals
- *ASSE 19210, Hydronics Heating and Cooling Installer Professional Qualification Standard*
- www.radiantpros.org




GUIDE GALLERY OF RADIANT SYSTEMS

HYDRONIC
Slab on Grade
Radiant tubing is embedded in cement. The tubing is typically attached to metal mesh with plastic ties. A 4-inch slab is most typical. The tubing is best placed in the middle of the slab. Full under-slab insulation is recommended for most residential applications. Slabs have a large thermal mass, which stabilizes temperature swings but slows response. This method is recommended whenever a slab is poured.
Estimated Assembly R-value*: R-0.69 - R-1.0

HYDRONIC
Thin Slab on Subfloor
Radiant tubing is attached on top of subfloor with approved staples or plastic clips. A thin slab of gypsum-based cement or cement is poured over the tubing. Typical slabs are 1-1/2 inches thick when using 1/2-inch tubing, but may be as thin as 1-1/4 inch thick when using 3/8-inch tubing. Gypsum cement is lighter than cement, but a little less conductive.
Estimated Assembly R-value*: R-0.69 - R-1.0

HYDRONIC
Hanging or Attached Below Subfloor
Radiant tubing is hung or attached to the underside of the subfloor in an air space with insulation below. This requires higher water temperatures and has more limited heat output than other systems. It is often used for retrofitting when access from below is possible. Hanging systems have more even joist cavity temperatures than when pipe is attached in contact with subfloor joists.
Estimated Assembly R-value*: R-1.7 - R-2.2 (pipe + 3/4-inch plywood only)

HYDRONIC
With Plates Below Subfloor
Radiant tubing is attached to the underside of the subfloor with metal plates to diffuse the heat. Insulation is recommended below the plates. This has higher water temperatures and more limited heat output than above subfloor systems, but plates make it more effective than hanging pipe from under joists. It is often used for retrofitting when access to joist space is available.
Estimated Assembly R-value*: R-1.3 - R-1.8 (pipe + 3/4-inch plywood only)

HYDRONIC
Structural Radiant Subfloor with Aluminum and Grooves
Premanufactured 1-1/8-inch-thick panels have grooves for tubing and an aluminum sheet bonded to the board. In this case, the premanufactured panels serve both as the structural subfloor and as the channel into which the tubing is installed. The aluminum sheet makes the system accelerate rapidly and spreads out the heat. Tubing is installed 12 inches on center in the grooves.
Estimated Assembly R-value*: R-0.6

www.radiantpros.org Radiant Comfort Guide 31

Industry Resources

4.c Radiant Professionals Alliance (RPA)

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- Webinars, manuals
- *ASSE 19210, Hydronics Heating and Cooling Installer Professional Qualification Standard*
- www.radiantpros.org

TOP RADIANT TRENDS

is good for radiant in-floor applications," Freidt says, though he adds that the "up-front cost of the boiler system can be a barrier to cost-conscience buyers."

"Underfloor heating is particularly attractive with hard-surface flooring, whether it be hardwood, laminate or tile," Uponor Senior Business Advisor **Dale Stroud** says. "And with hard-surface flooring continuing to grow in popularity, especially with tile surfaces that feature woodgrain-like appearances, the use of radiant marries very well with this trend."

Modular flooring is a major trend affecting the radiant heating market.

"It has made putting in radiant heated flooring much easier than it used to be," Omer-Cooper says. "PEX tubing has also made installing radiant heated flooring easier.

"The rising popularity of hard flooring surfaces like laminate, concrete and hardwood also has contributed to a rise in radiant heated floor systems because these types of floors generally are colder underfoot," he adds. "Ultimately, radiant flooring is growing in popularity because people don't like to be cold."

The advent of new tile products has also created an increase in electric radiant applications.

"These new flooring options have expanded the use of hard surfaces in areas of homes where carpet or wood have traditionally been used," Marshall says. "The use of tile is a natural fit for an electric product. Add to this the shift in homeowners allocating more resources to improve existing home values, and we've seen an increase in electric radiant applications."

Photo credit: Xylem

THE ROLE OF TRAINING

Manufacturers and distributors of radiant products recognize how quickly radiant technologies are changing and are ensuring ample training opportunities for radiant professionals. But how this training is offered may soon be changing.

"Training has always been a focus for our industry, and that continues today," Marshall says. "Innovation never stops, and the need to present these new products and techniques is always present. Add to that the constant rotation in the trade with new tradesmen entering the field daily, and it makes training an important function. The methods for training, however, have evolved to include more hands-on and interactive experiences and more field-based role-playing to give installers a chance to practice with actual install conditions."

"Good, quality training opportunities exist, provided by radiant heat product manufacturers, but the audiences are small due to the industry workforce shortage," Freidt says. "Today's training materials must be available online, friendly to today's tools — iPads, laptops and phones — and available 24/7 for convenient access. Actual in-class training has become very rare.

"Caleffi provides high-quality industry training in the form of one-hour webinars that are archived on YouTube for viewing at the convenience of the workforce, and our technical journal idronics, which is a printed and electronic technical reference, is used by many radiant and plumbing industry engineers, dealers and contractors," Freidt adds.

Olinger says Uponor is responding to the need for more accessible training by "offering several different avenues for contractors to learn, including customized training courses, job-site training venues and online training opportunities. Also, offering continuing education

18 www.radiantpros.org Radiant Comfort Guide

Plastics Pipe Institute
BUILDING & CONSTRUCTION

Industry Resources

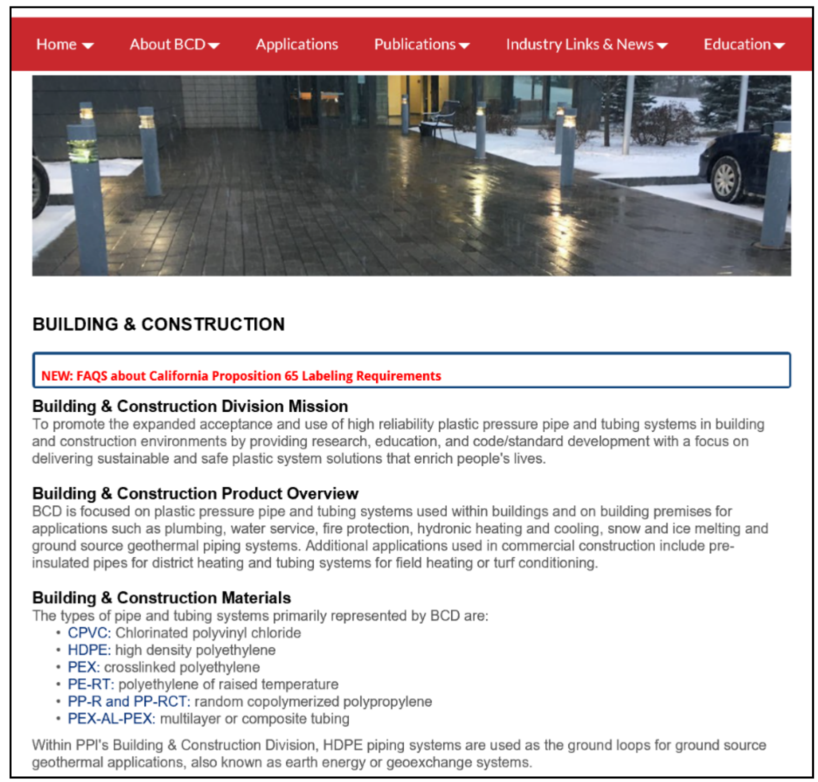
4.d The Plastic Pipe Institute (PPI)

- "PPI is a 501(c)(6) non-profit trade association representing all sectors of the plastic pipe industry across North America.
- "Based in Irving, TX, PPI's five divisions provide expertise about piping materials, design, applications, standards requirements, and code compliance."

Industry Resources

4.d The Plastic Pipe Institute (PPI): Building & Construction Division

- Webpage for each piping material
- Technical Publications & Guides
- Plastic Pressure Pipe Design Calculator
- Webpages on all major Applications
- Magazine articles
- Educational videos
- Case studies
- Presentations and recorded webinars
- Lists of Members and Producers
- www.plasticpipe.org



Plastics Pipe Institute
BUILDING & CONSTRUCTION

Industry Resources

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- www.plasticpipe.org

CROSSLINKED POLYETHYLENE (PEX)

PEX tubing comes in nominal sizes ranging from 1/4 to 3 in. copper tube size (CTS), and pipe sizes in both inch and metric sizes. PEX tubing is SDR9 with standard hydrostatic pressure ratings of 160 psi at 73°F (1105 kPa at 23°C) and 100 psi at 180°F (690 kPa at 82°C). Consult the specific PEX manufacturer's literature and listings for appropriate pressure ratings. PEX tubing and pipe are sold in coils and straight lengths.

Definition: PEX is a polyethylene material which has undergone a change in molecular structure using a chemical or a physical process whereby the polymer chains are chemically linked. Crosslinking of polyethylene into PEX for pipes results in improved properties such as elevated temperature strength and performance, chemical resistance and resistance to slow crack growth.

Overview: PEX is a high-temperature flexible plastic 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. PEX is approved in all model plumbing and mechanical codes across the United States and Canada, and some PEX pipe is listed for use in fire sprinkler systems as defined in NFPA standard 13D.

PEX Advantages

- Safety of potable water and long-term reliability
- Resistance to corrosion, tuberculation, deposits
- Chlorine and chloramine resistance
- Flexibility to speed installations
- Freeze-break resistance
- Lightweight, easy to transport
- Noise and water hammer resistance
- No scrap value, avoiding jobsite theft
- Durability and toughness to survive jobsite installations
- No flame used for joining, with many fitting and joining options

PPI Plastics Pipe Institute
BUILDING & CONSTRUCTION

Industry Resources

4.d The Plastic Pipe Institute (PPI): Building & Construction Division

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- Webpages on all major Applications
- Magazine articles
- Educational videos
- Case studies
- Presentations and recorded webinars
- Lists of Members and Producers
- www.plasticpipe.org

BUILDING & CONSTRUCTION RELATED LITERATURE

Statements
- PPI Technical Response to "Metal Accumulation in Representative Plastic Drinking Water Plumbing Systems"
- Statement A - Relative Oxidative Aggressiveness of Chloramines and Free Chlorine Disinfectants on Crosslinked Polyethylene (PEX) Pipes Used in Treated Potable Water
- Statement Y - Taste and Odor of Drinking Water from Plastic Piping Systems

Recommendations
- Recommendation E - Recommendation Against Mixing Hydronic Heating Water with Potable Water
- Recommendation F - Testing PEX Pipe and Tubing Systems with Air
- Recommendation G - Epoxy Pipe Coatings

Position Papers
- Installation of CPVC Fittings Within and Under Concrete Slabs
- Installation of PEX Fittings Within and Under Concrete Slabs

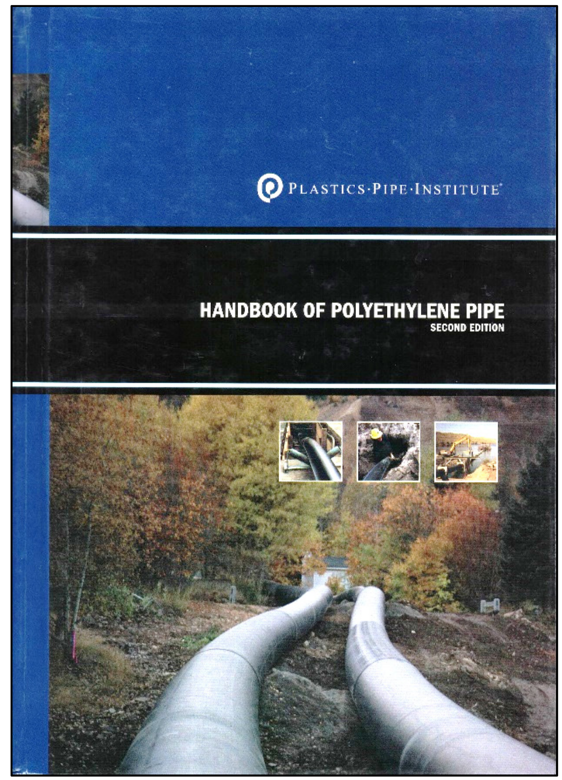
Technical Notes
- TN-17 - Crosslinked Polyethylene (PEX) Pipe & Tubing
- TN-26 - Erosion Study on Brass Insert Fittings used in PEX Piping Systems
- TN-31 - Differences Between PEX and PB Piping Systems for Potable Water Applications
- TN-32 - UV Labeling Guidelines for PEX Pipes
- TN-39 - Recommended Practices Regarding Application of Pesticides and Termiticides near PEX Pipes
- TN-52 - Guide to High-Temperature Applications of Non-Potable PEX Pipe and Tubing Systems
- TN-53 - Guide to Chlorine Resistance Ratings of PEX Pipes and Tubing for Potable Water Applications
- TN-55 - Plastic Piping Materials for Geo Applications
- TN-56 - Plastic Piping Materials Near Recessed Lighting Fixtures
- TN-57 - Proper Integration of Copper Tubing and Components with PP-R Piping Materials for Plumbing Applications
- TN-62 - Suitability and Fitness of CPVC Piping Systems for Commercial Building Applications

Technical Reports
- PPI Technical Response to AWWA Journal Paper 11-17
- TR-11 - Resistance of Thermoplastic Piping Materials to Micro- and Macro-Biological Attack
- TR-48 - R-Value and Thermal Conductivity of PEX and PE-RT
- Fixture Flow Rate Comparison Cross-Linked Polyethylene (PEX) Piping and Copper Tubing
- NAHB-RC Surge Pressure in Plumbing Pipe Materials
- Jana Report 05-1059 - Proposal for the Evaluation of the Chlorine Resistance of UV Exposed PEX Pipe
- Jana Report 09-1190 - Usage and Effects of Chlorine Dioxide on PEX Plumbing
- Jana Report (2003) - Oxidative Resistance of Sulfone Polymers to Chlorinated Potable Water
- Jana Report - Chlorine Resistance Testing of PEX Piping Materials

Industry Resources

4.d The Plastic Pipe Institute (PPI): Building & Construction Division

- Webpage for each piping material
- Technical Publications & Guides
- Example: ***Handbook of Polyethylene Pipe, 2nd Edition***



Industry Resources

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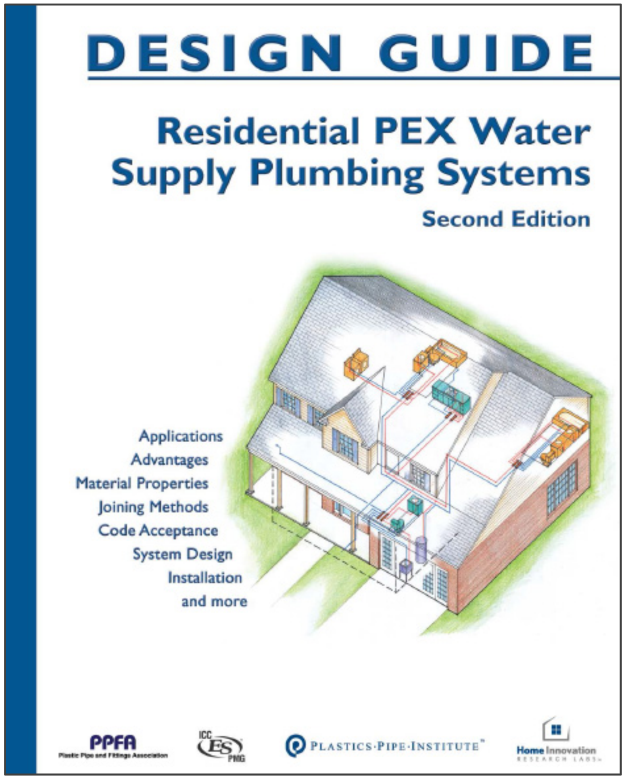
- Webpage for each piping material
- Technical Publications & Guides
- Example: ***DESIGN GUIDE - Residential PEX Water Supply Plumbing Systems***



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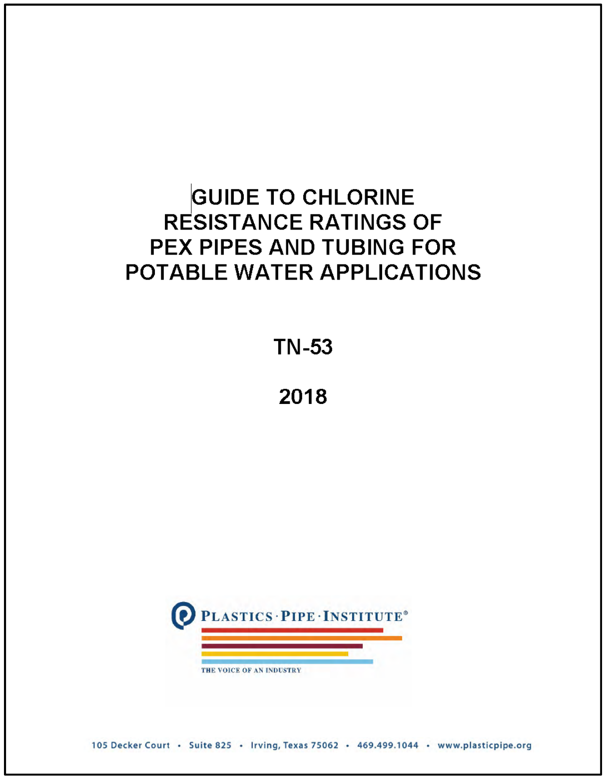
GUIDE TO CHLORINE RESISTANCE RATINGS OF PEX PIPES AND TUBING FOR POTABLE WATER APPLICATIONS

TN-53

2018

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Industry Resources

4.d The Plastic Pipe Institute (PPI): Building & Construction Division

- Webpage for each piping material
- Technical Publications & Guides
- Plastic Pressure Pipe Design Calculator
- Webpages on all major Applications
- Magazine articles
- Educational videos
- Case studies
- Presentations and recorded webinars
- Lists of Members and Producers
- www.plasticpipe.org

BCD APPLICATIONS

PPI's Building & Construction Division (BCD) is focused on plastic pressure pipe and tubing systems u
buildings and on building premises for a wide variety of applications:

- Fire protection
- Geothermal ground loops
- Hot- and cold-water plumbing distribution
- Outdoor snow and ice melting
- Radiant heating and cooling systems
  - Radiant Control Systems
  - Thermal Comfort - Radiant Heating & Cooling
- Reclaimed water piping
- Turf conditioning
- Water service lines
- Chilled water piping
- District heating and cooling
- Flexible pre-insulated piping
- Hydronic piping and distribution

PPI
Plastics Pipe Institute
BUILDING & CONSTRUCTION

Industry Resources

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CASE STUDIES

Hydronic Piping
- Mechanical Joining System Benefits New Napa Valley Resort
- These Pipes Make HVAC Systems Run More Efficiently

Plumbing
- Riyadh, Saudi Arabia: King Abdullah Financial District (KAFD) Development Chooses Plastic Pipes for Heating/Plumbing Needs
- Boston-Area "Quiet House" Offers Unique Selection of Noise-Reducing Features
- Prestigious Westgate Building in Austin Save Over $1 Million in Repiping Expenses as Result of Innovative Plumbing Design and Conversion to Flowguard Gold CPVC
- Psychiatric Hospital Preserves Patient Comfort and Safety While Replacing Failed Plumbing in Main Care Facility
- Dallas-Based G-H Plumbing Calculates Substantial Savings with Installation of Flowguard Gold CPVC Pipe and Fittings
- Award-Winning Custom Builder Solves Aggressive Water and Noise Problems with High-Performance CPVC Plumbing SystemAward Winning Building
- Homeowners, Frustrated by Pinhole Leaks in Copper Plumbing, Find Relief with PEX
- Uponor PEX Saves Time and Money for Residential High Rise
- Uponor Plumbing Systems Overcome Re-pipe Challenge

Radiant Heating & Cooling
- PEX Pipe Helps Zoo Provide Comfort to Animals and Visitors While Reducing Energy Use and Costs
- FedEx® Air Hanger - Radiant Heating System
- Harley Davidson Liberal, KA - Heating & Cooling System
- LUMENHAUS at Farnsworth House - Geothermal Ground Loop Heat Exchanger
- Mercedes Benz Burlington - Heating and Snow and Ice Melt System
- Pier One - Radiant Heating and Cooling System
- Spring Creek Mountain Village - Radiant Heating
- YWCA Toronto Elm Center - Radiant Heating & Cooling
- Color This Radiant Home GREEN - Branson, MO
- Clean Heat and Comfortable Warmth Make Breathing Easier

PPI Plastics Pipe Institute BUILDING & CONSTRUCTION

Industry Resources

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BCD Members

Pipe and Fittings Manufacturers

Aquatechnik North America	Poloplast
Aquatherm	REHAU Inc.
Asahi-America	Reliance Worldwide Corp.
Auray Managing S.L.	Rifeng Systems Co., LTD
Bow Plumbing Group	Teel Plastics
Centennial Plastics, Inc.	Uponor, Inc.
Charter Plastics, Inc.	Versaprofiles Products Inc.
Flying W Plastics	Victaulic
Golan Plastic Products LTD	Viega LLC
Heatlink Group Inc	Watts Water Technologies
IPEX USA LLC	WL Plastics Corp
Legend Valve	WRW Westfalische Rohrwerke GmbH
Mercury Plastics LLC	YogaPipeACR
Mr. PEX Systems	Zurn PEX, Inc.
NUPI Americas	

Industry Resources

Summary: Resources to assist with selecting & specifying piping systems

4.a HIA-C
4.b IGSHPA
4.c RPA
4.d PPI

Summary

At this time, participants should be able to:

1. Describe the piping materials CPVC, HDPE, PEX, PE-RT & PP in terms of material properties, capabilities, joining systems, applications, standards, and code compliance

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

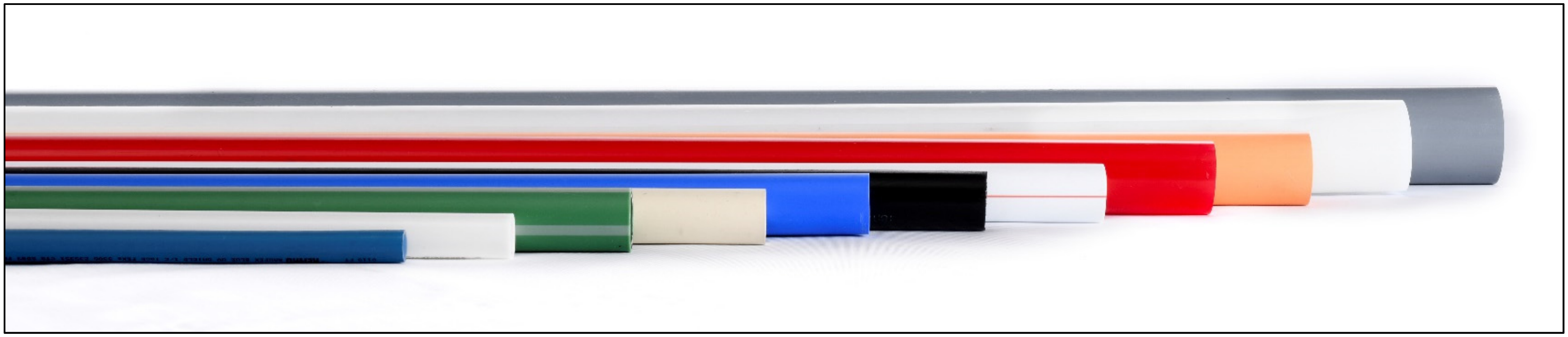
3. Discuss the design of piping materials in terms of sizing for flow, pressure loss, thermal expansion/contraction, etc. using a publicly-available software program

4. Explain how to access industry resources related to selecting and specifying the right piping material(s) for various applications

Conclusion

Plastic piping systems can deliver the optimum combination of performance, efficiency, cost and longevity

When applied correctly, plastic piping systems can improve buildings' comfort, efficiency, and operating costs



Plastic Pressure Piping Materials for Plumbing & Mechanical Applications

Thank you!

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