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# *PEX Pipes for Plumbing Applications*

- Introduction
- How PEX pipes are made
- Reasons for using PEX systems
- Industry standards and tests
- PEX joining systems
- Code acceptance
- Design considerations
- Installation considerations
- PEX for water service line
- PEX systems for other applications

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# *Who is PPI?*

- PPI is the major trade association representing all segments of the plastics piping industry
- PPI is dedicated to promoting the safe use of plastic piping systems through:
  - Contributing to development of standards
  - Educating designers, installers, users and government officials
  - Establishing a forum for problem solving and new ideas
  - Maintaining liaison with industry, educational and government groups
- PPI has five divisions: Municipal and Industrial, Corrugated Polyethylene Pipe, Fuel Gas, Conduit, Building and Construction

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# *Building and Construction Division: Mission Statement*

- To promote the expanded acceptance and use of high reliability plastic pressure pipe and tubing systems in building and construction environments by providing research, education, and code/standard development with a focus on delivering sustainable and safe plastic system solutions that enrich people's lives.

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# *Building and Construction Division: Members - Manufacturers of PEX Pipes*

- Bow Plastics
- IPEX, Inc.
- JM Eagle
- Mercury Plastics
- NIBCO
- Reliance Worldwide USA
- REHAU
- Viega
- Watts Water Technologies
- Uponor
- Zurn PEX, Inc.

- Other members include manufacturers of polyethylene resin, compounds, and additives; test laboratories; consultants

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# *Why PEX Pipes for Plumbing Applications?*

- Delivery of clean, safe drinking water
- Smooth interior reduces pressure loss
- Corrosion resistance
- Reliable pipes and fittings
- Flexibility in design and installation
- Approved in all model plumbing codes
- More than 30 years of experience worldwide in potable water applications
- A Green solution!

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# *PEX is Crosslinked (X) PolyEthylene Description from PPI TN-17 (2008)*

- "PEX is a polymeric material formed by the chemical joining of individual polyethylene molecules in a process called crosslinking."
- "Crosslinking alters the performance of the original polyethylene polymer improving several key properties."
- "Crosslinking can not be reversed."
- "The primary reason for crosslinking polyethylene (PE) is to increase the material's elevated temperature performance under load."
- "In addition, crosslinking substantially improves the pipe's environmental stress crack resistance (ESCR), resistance to slow crack growth, chemical resistance, toughness and abrasion resistance."

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# *How is PEX Pipe made?*

- There are 3 commercial processes known as:
  1. PEXa: High-pressure peroxide (“Engel”); 1960’s
  2. PEXb: Silane (moisture cure); 1970’s
  3. PEXc: Electron Beam (radiation); 1970’s

- Each method is proven to make product that meets the strict requirements of standards by ASTM and other organizations
- More description of each method follows:

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# *High-Pressure Peroxide (Chemical Process)*

- Special high-pressure screw extruders
- Small amount of peroxide mixed to special PE resin before extrusion
- Crosslinking takes place in extruder/die, driven by temperature and high pressure
  - Pipe is crosslinked as it is extruded
  - Peroxide is consumed during crosslinking reaction

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# *Silane (Chemical Process)*

- Uses a conventional screw-type extruder
- Modified HDPE material is extruded
- Most crosslinking takes place after the material has left the extruder
- Crosslinking is driven by moisture and temperature through exposure to hot water or steam

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# *Electron Beam (Physical Process)*

- Uses a conventional screw-type extruder
- Normal HDPE pipe is extruded
- Crosslinking occurs in a secondary “beaming” operation - driven by the strength of the electron beam

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# *PEX Plumbing Products*

- PEX pipes are produced in nominal dimensions from 3/8” to 3” today in USA (even smaller sizes for special applications).
- PEX pipes are available in natural (white) or colors such as red, blue and terra cotta.
- PEX pipes are available in coils or straight lengths, depending on the application.

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# *Why is PEX a good material for plumbing? Engineering Reasons:*

1. Resistance to corrosion, erosion, water disinfectants
2. Freeze resistant
3. Water conservation
4. High temperature capability, pressure-rated up to 200° F
5. High pressure capability/stability (reduced creep)
6. Smooth wall, excellent flow characteristics
7. Quiet operation, absorbs pressure surges (reduced water hammer)
8. Flexibility for efficient design of piping layouts
9. Proven long life, rigorous certifications, highly tested
10. A sustainable product with green benefits

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# *Why is PEX a good material for plumbing? Engineering Reasons:*

- PEX is corrosion resistant (corrosion is simply not possible with PEX)
- No build-up of minerals inside the pipe, which could reduce flow over time

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# *Why is PEX a good material for plumbing? Engineering Reasons:*

- No pinhole problems as seen in metal pipes

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# *Why is PEX a good material for plumbing? Engineering Reasons:*

- No erosion corrosion issues with PEX pipes
- High velocities are tolerated by PEX pipes without damage

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# *Why is PEX a good material for plumbing? Engineering Reasons:*

- PEX pipes are freeze resistant
- PEX pipes withstand repeated freezing of water without damage

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# *Why is PEX a good material for plumbing? Installer Reasons:*

- Flexible pipe with reduced number of fittings allows faster installation
- Greater flexibility for design options
- Secure, reliable fittings reduce leaks
- Lightweight material, easy and safe to transport and handle
- Efficient to install, long coils reduce waste and number of joints
- Clean and safe to work with

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# *Why is PEX a good material for plumbing? Building Owner Reasons:*

- Excellent flow
- Proven long life
- Corrosion resistant
- Non-toxic, safe for hot and cold drinking water
- Quiet, dampens water hammer and pressure surges
- Lower thermal conductivity than copper reduces probability for condensation
- Freeze resistant
- Lower cost

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# *Standards for PEX and PEX Systems*

- ASTM F876 - Materials, Dimensions and Performance for Tube
- ASTM F877 - Performance Standard for Tube/Fitting Systems
- ASTM F2023 - Chlorine Resistance test method
- ASTM F2657 – UV Resistance test method
- AWWA C 904 – Standard for PEX service lines
- ANSI/NSF Standard 61 - Toxicological Evaluation for Materials in Contact with Drinking Water; “Health Effects”
- Multiple ASTM fitting standards

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# *PEX Pipe Requirements*

- ASTM F876 “Standard Specification for Crosslinked Polyethylene Tubing”
  - Pipes are CTS, SDR9, with tight tolerances on dimensions
  - Minimum Quick Burst Capability:
    - 475 psi @ 73.4°F, 210 psi @ 180°F, 180 psi @ 200°F
  - Long-term Pressure Ratings:
    - 160 psi @ 73.4°F, 100 psi @ 180°F, 80 psi @ 200°F
  - Sustained Pressure Tests
    - Up to 16,000 hours accelerated laboratory hydrostatic testing is required for PPI “Standard Grade” listings

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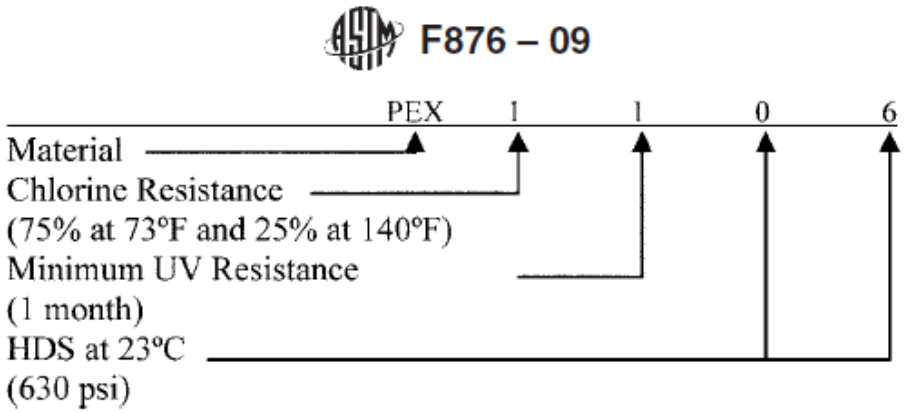
# *PEX Pipe Requirements*

- ASTM F876 has categories for performance in three key properties
- Performance categories are defined in the “Material Designation Code”
  - Example shown from ASTM F876




For example ASTM F876 PEX tubing marked with the material designation code PEX 1106 is a PEX tubing meeting the chlorine resistance requirement for 25% of the time at 140°F and 75% of the time at 73°F having a Minimum UV resistance of 1 month and having an HDS for water at 73°F of 630psi (HDB of 1250 psi).

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# *Chlorine Resistance*

- ASTM F2023 “Standard Method for Evaluating Resistance to Hot Chlorinated Water” is the test method
  - Minimum ORP 825 mV (typical of 4.0 ppm chlorine, pH 6.8)
  - 50 year minimum extrapolated life at 80 psig pressure
- ASTM F876 contains the actual performance requirements

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# *Chlorine Resistance*

- ASTM F876 has four categories for chlorine resistance, as part of the Material Designation Code:

**0:** Not tested or not rated
**1**: 25% of time at 140°F, 75% of time at 73.4°F
**3**: 50% of time at 140°F, 50% of time at 73.4°F
**5**: 100% of time at 140°F,  0% of time at 73.4°F

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# *Chloramines Resistance*

- See PPI Statement A: “Relative Oxidativeness of Chloramines and Free Chlorine Disinfectants…on PEX Pipe”
- “Jana Laboratories, an accredited laboratory, examined the relative oxidative aggressiveness of the common potable water disinfectants free chlorine and chloramines on crosslinked polyethylene (PEX) pipes.”
- “Based on these results, it is the position of PPI [BCD] that chloramines are less aggressive than free chlorine to PEX pipes, and that testing using free chlorine, in accordance with ASTM F2023, will conservatively estimate the time-to-failure for PEX pipes when used with the disinfectant chloramines.”

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# *UV Resistance*

- ASTM F2657 “Standard Method for Outdoor Weathering Exposure of Crosslinked Polyethylene” is the test method
  - Pipes are exposed in desert near Phoenix, AZ for natural UV radiation exposure for specified time periods
  - Exposed pipes are then re-tested for F2023 chlorine resistance to show no significant reduction in pipe lifetime
  - Manufacturer reports acceptable UV exposure limits based on this testing, in accordance with ASTM F876

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# *UV Resistance*

- ASTM F876 has four categories for UV resistance, as part of the Material Designation Code:

  **0:** Not tested or not rated
  **1**: 1 month
  **2:** 3 months
  **3:** 6 months

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# *PEX System Requirements:*

- ASTM F877 “Standard Specification for Crosslinked Polyethylene Plastic Hot- and Cold- Water Distribution Systems”
  - Applies to pipes with fittings and/or manifolds, tested as systems
  - Quick burst capabilities, sustained pressure requirements
  - Excessive Temperature and Pressure test:
    - 150 psi @ 210°F for 720 Hrs. (30 days)
  - Thermocycle Test:
    - Pressurize with 100 psi Nitrogen gas
    - 2 Minutes in 60°F water, 2 Minutes in air, 2 Minutes in 180°F water
    - Repeat 1,000 times with no leaks

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# *Joining: Mechanical Fitting Systems*

- Most common ASTM standard specifications for PEX fittings:
  - ASTM F1807: Brass or Copper Insert Fittings with Copper Crimp Rings
  - ASTM F1960: Cold Expansion Fittings with PEX Reinforcing Rings
  - ASTM F2080: Cold Expansion Fittings with Metal Compression-Sleeves
  - ASTM F2098: Stainless Steel Clamps for Use with F1807 Insert Fittings
  - ASTM F2159: Plastic Insert Fittings using Copper Crimp Rings

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# *Codes Acceptance*

- PEX is listed as an acceptable material in all national model plumbing codes:
  - International Plumbing Code published by ICC
  - Uniform Plumbing Code published by IAPMO
  - Standard Plumbing Code published by NAPHCC
- Accepted in every state.
- Check with the local Building or Plumbing Official to determine if they are permitting the use of PEX.
  - PPI can assist with local approvals

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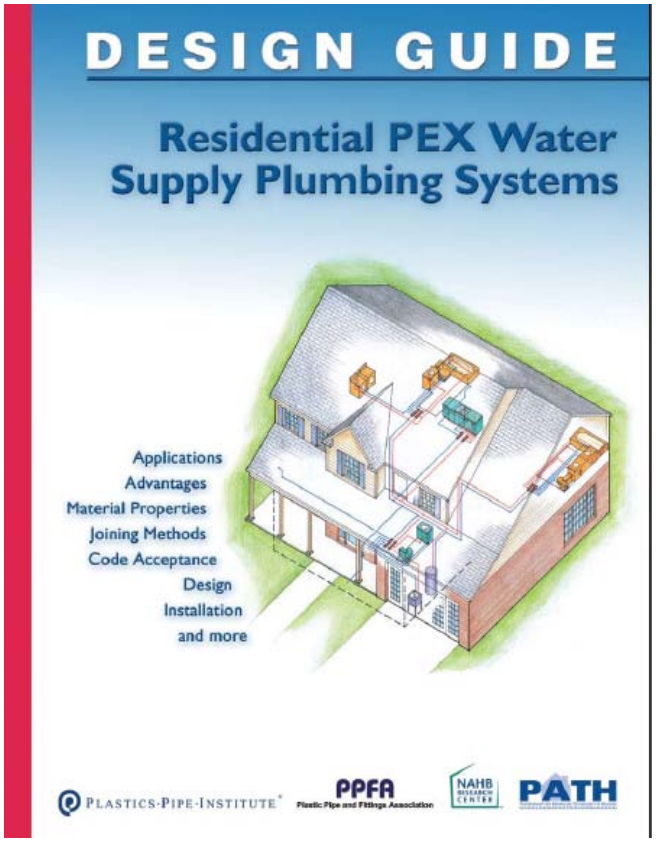
# *Designing PEX Plumbing Systems*

- PEX can be used in a traditional Main and Branch System
- PEX can be used in a manifold or Home-Run System
- PEX can be combined with Remote Manifolds
- "PEX Design Guide" available from PPI or at www.ToolBase.org
  - Contains pressure loss tables



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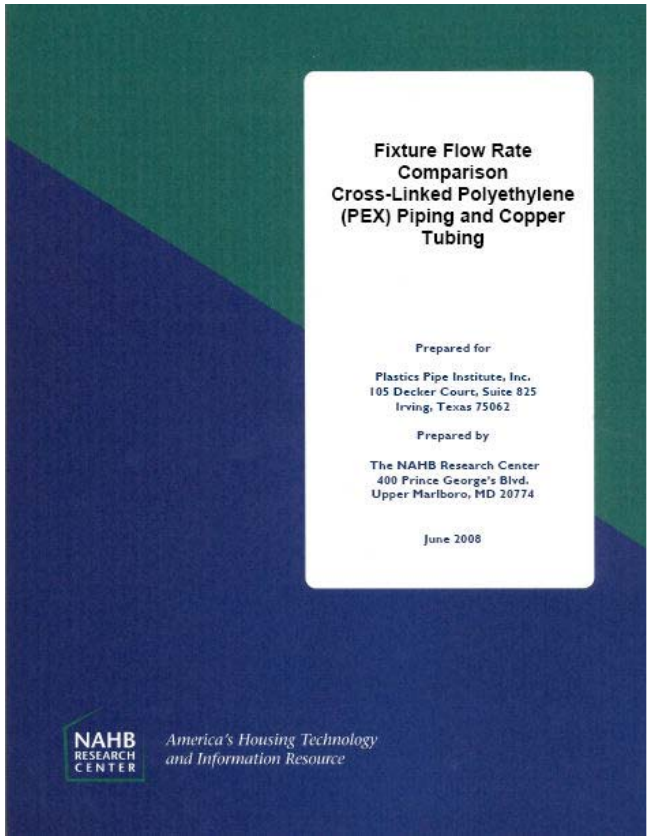
# *Designing PEX Plumbing Systems*

- PEX typically can be installed in place of rigid pipes on a size-for-size basis because of smooth wall and elimination of most elbows.
  - See NAHB study “Fixture Flow Rate Comparison…”
- Codes allow size-for-size replacement, unless alternate system designs may reduce pipe diameter requirements



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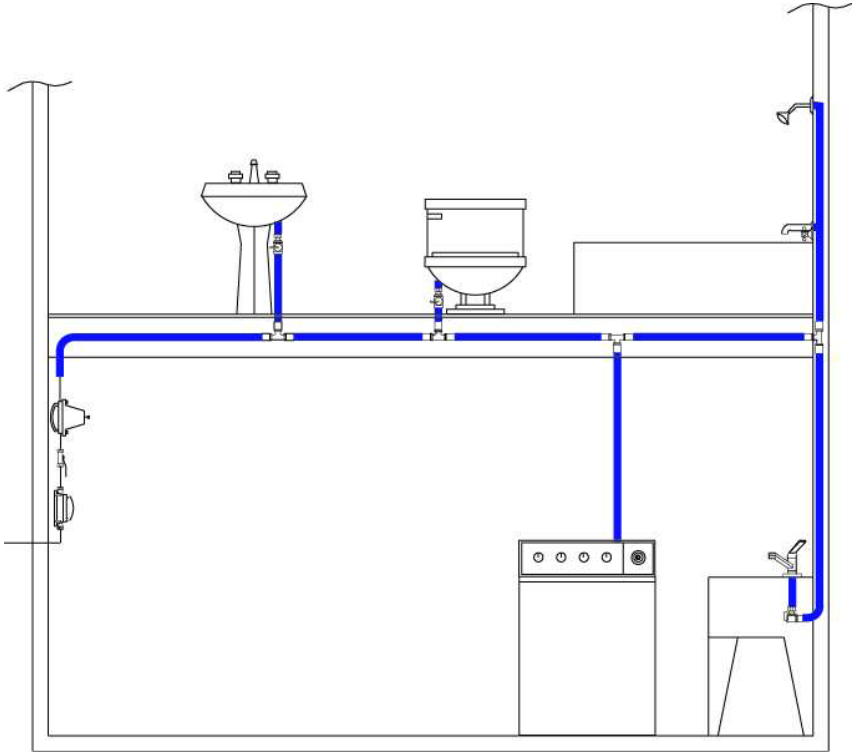
# *Designing PEX Plumbing Systems*

- PEX can be used in a Traditional Main and Branch System



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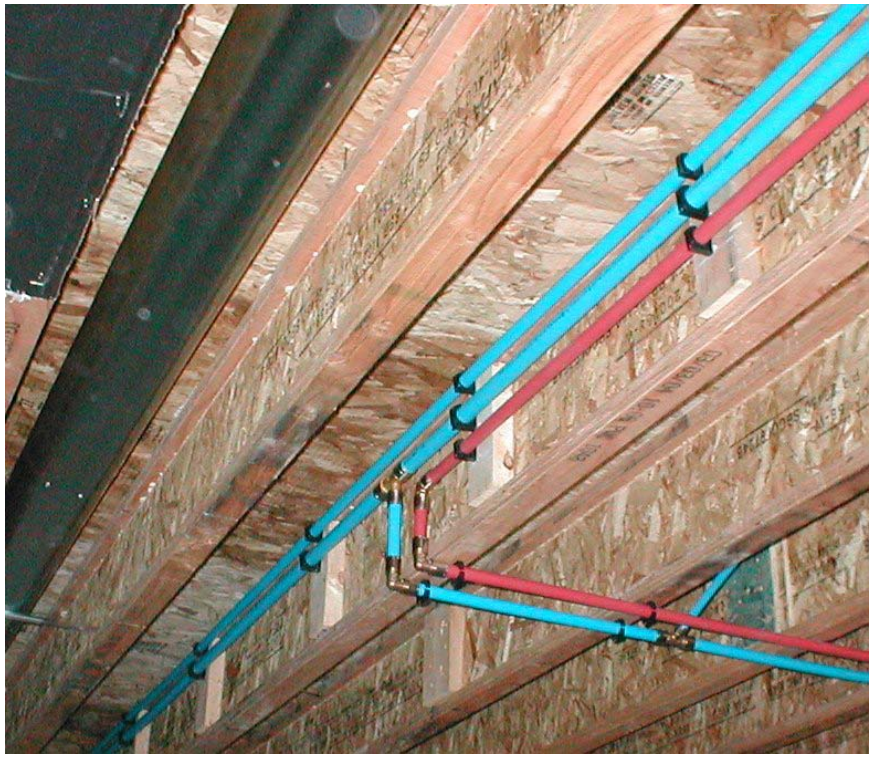
# *Designing PEX Plumbing Systems*

- Traditional Main and Branch System
- Traditional installation technique, but faster
- Normal use of reducing tees and elbows
- Pipe sizes up to 3”



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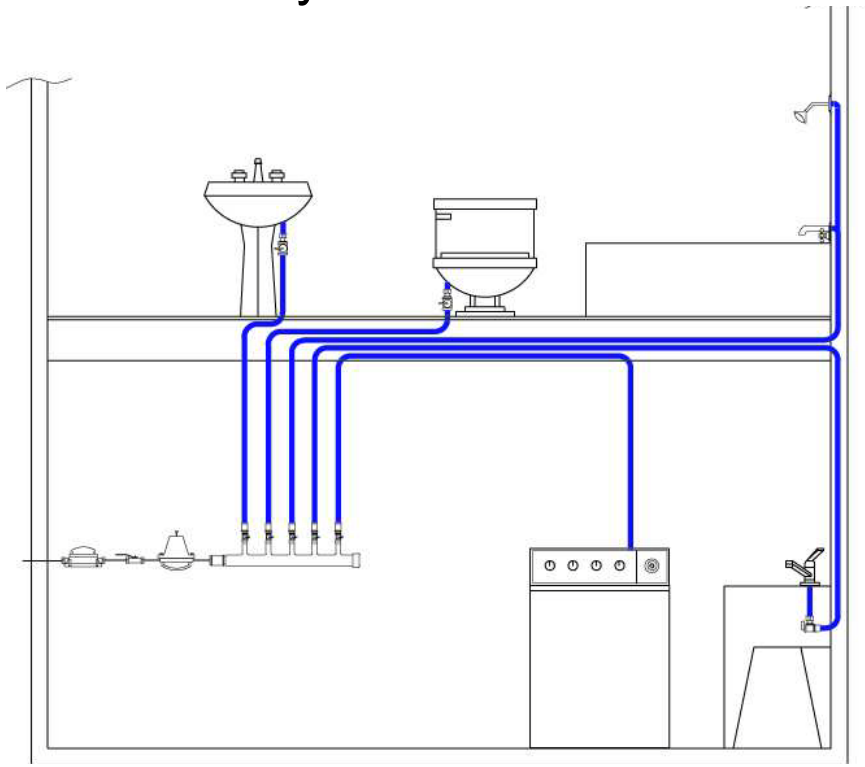
# *Designing PEX Plumbing Systems*

- PEX can be used in a Manifold or Home Run System



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# *Designing PEX Plumbing Systems*

- Manifold or Home Run System
- 3/8” or 1/2” pipes home-run to each fixture
- Central manifolds
- Fewer fittings
- Balanced pressure
- Copper or polymer manifolds are available

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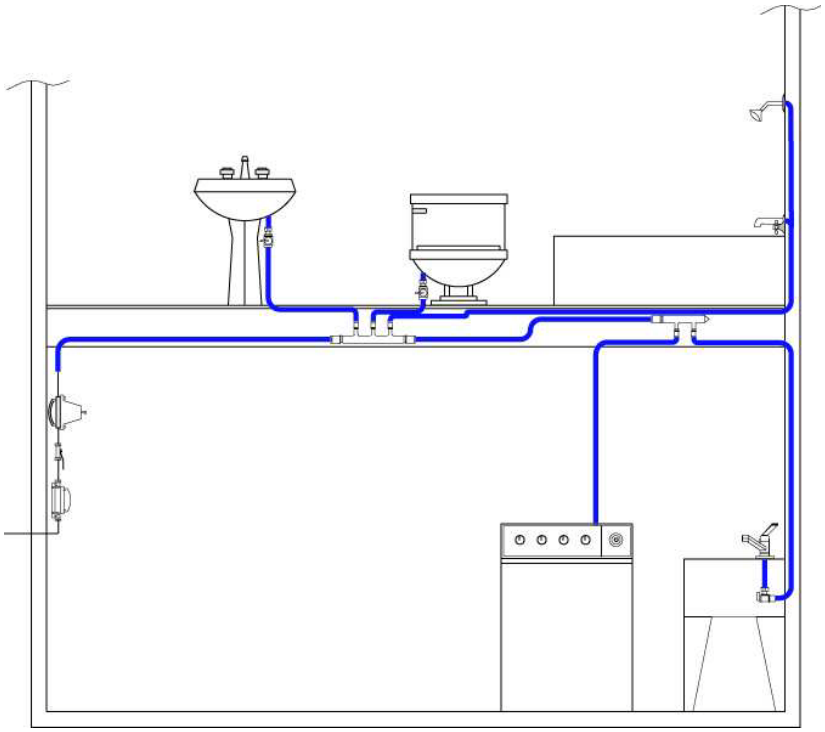
# *Designing PEX Plumbing Systems*

- PEX can be combined with Remote Manifolds



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# *Designing PEX Plumbing Systems*

- Remote Manifolds are smaller manifolds installed remotely
- Manifolds may be fed with 3/4”, 1”, 1 1/4” pipe
- 3/8” or 1/2” pipes home-run to each fixture
- Reduced fittings
- Balanced flow
- Copper or polymer manifolds are available

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# *Designing PEX Plumbing Systems*

- Copper “stub ells” are often used outside the walls for appearance and durability
- Standard end-point shut- off valves are used

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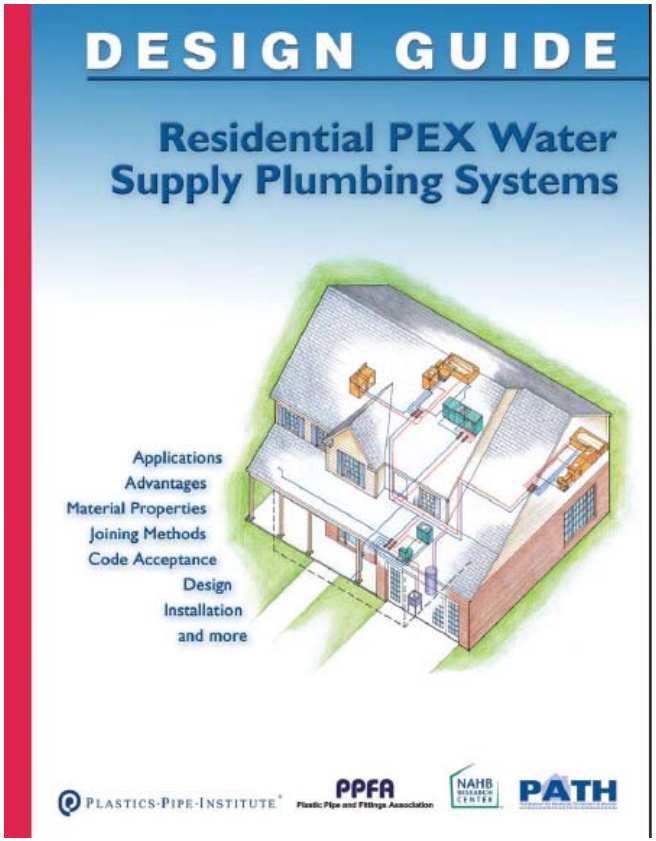
# *PEX Installation Basics*

- PEX is flexible, so an installation may look different than an installation with rigid pipe.
- Refer to “PEX Design Guide”



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# *PEX Installation Basics*

- Minimum Bending Radius is 5-6 times the Outside Diameter of the tube.
- Horizontal runs should be supported every 32 inches for sizes ≤1”
  - Manufacturers will allow up to 48” on larger diameters.
- Vertical runs should be supported every 60 inches.

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# *PEX Installation Basics*

- Protect PEX from abrasion
  - Use sleeves or plastic isolaters through metal studs (not required in wood studs)
- Use hangers that are smooth without sharp edges - plastic is preferred
- Hangers should not pinch the tube
- Use protective nail plates where PEX passes within 2” of a nailing surface on a stud

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# *Linear Expansion and Contraction*

- Linear expansion rate of PEX: 1 inch per 10°F per 100 ft. length
- Example: Hot water pipe 50 ft. long, 50°F rise will lengthen pipe by 2.5 inches
- Installers must allow for movement with correct installation
- In systems with wide temperature swings using larger diameters of PEX (≥ 1”) deflection legs may be required to accommodate expansion/contraction of pipes without excessive force on fittings and fixed brackets

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# *Piping through floor joists and wooden studs*

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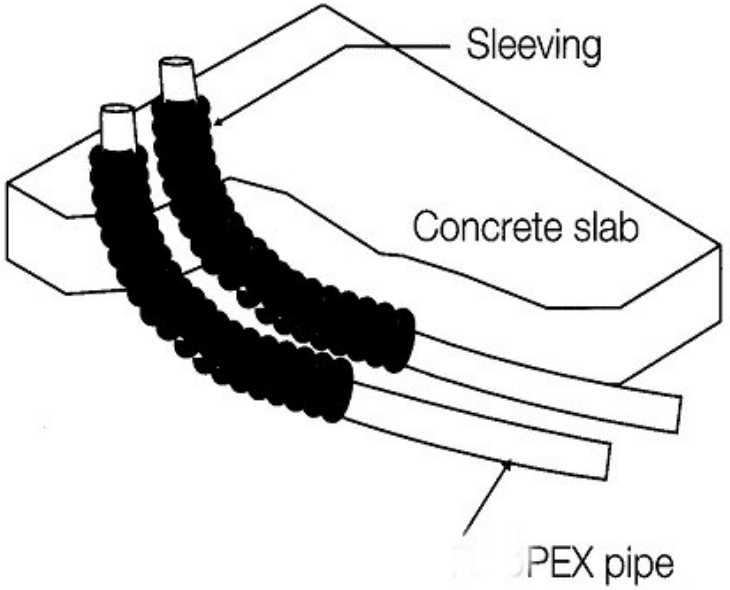
# *Under Slab Installation*

- PEX is recommended for use under slabs in most applications
- Protect PEX from abrasion
  - Sleeve pipe where it passes through concrete to protect against abrasion.



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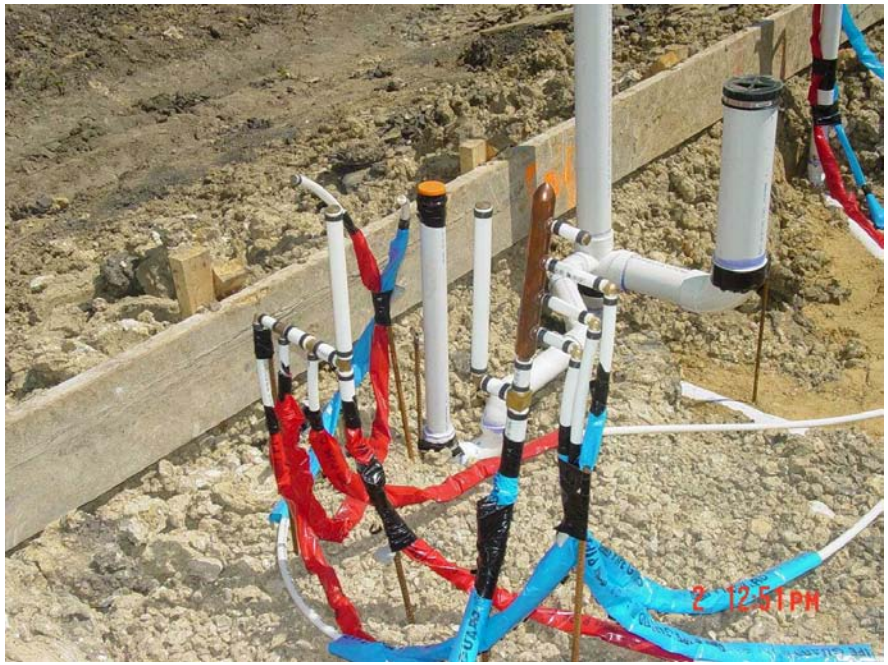


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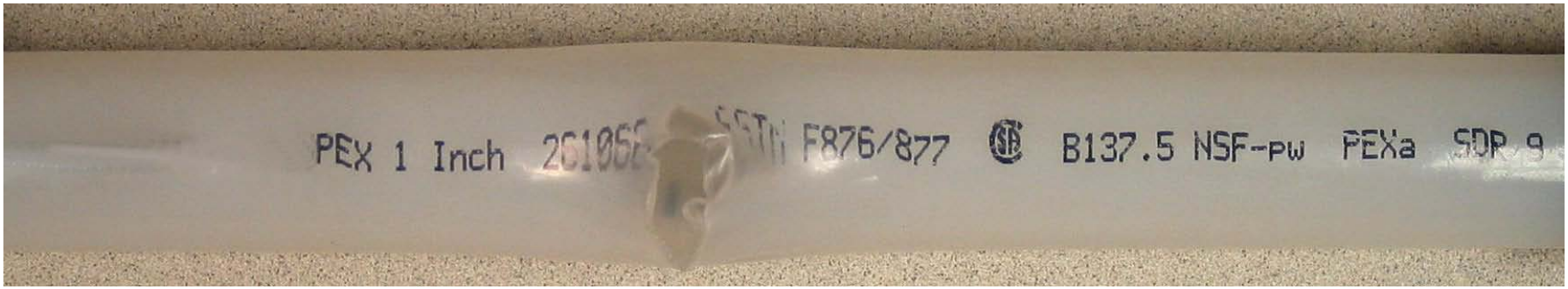
# *PEX Pressure Testing*

- Pressure test as required by manufacturer or code*
- Air *or* water test acceptable
  - Minimum burst pressure is 475 psig
  - PEX is ductile, will not shatter if burst
  - No shards will break away from pipe
- Maximum test pressure up to 200 psig



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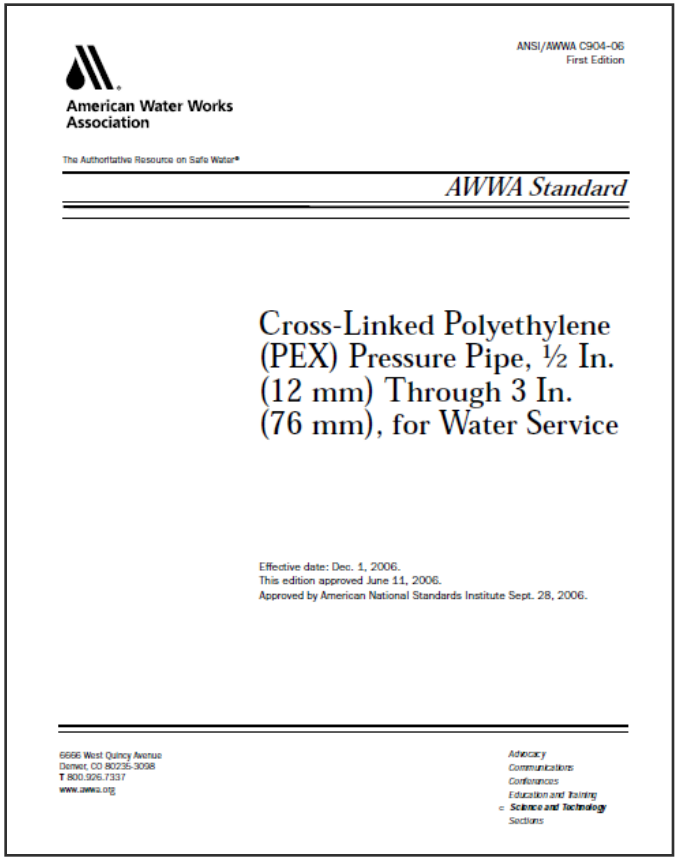
# *PEX Water Service Line*

- AWWA C904 recognizes PEX for this application.
- PEX is already approved in model codes for service line applications.
- PEX works with CTS compression-joint fittings according to AWWA C-800, using stainless steel inserts at connections.



ANSI/AWWA C904-06
First Edition

American Water Works Association

The Authoritative Resource on Safe Water®

*AWWA Standard*

Cross-Linked Polyethylene (PEX) Pressure Pipe, ½ In. (12 mm) Through 3 In. (76 mm), for Water Service

Effective date: Dec. 1, 2006.
This edition approved June 11, 2006.
Approved by American National Standards Institute Sept. 28, 2006.

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# *PEX Water Service Line*

- Advantages of PEX pipes as compared with HDPE pipes, from PPI Technical Note-17:

| Property | From PE to PEX |
|---|---|
| Density | Unchanged or Decreases |
| Tensile Strength @ 73°F (23°C) | Unchanged |
| Elongation at Break | Unchanged or Decreases |
| Environmental Stress Crack Resistance | Increases |
| Resistance to Slow Crack Growth | Increases |
| Creep Resistance | Increases |
| Hydrostatic Design Basis (HDB)<br>• HDB @ 73°F (23°C)<br>• HDB @ 180°F (82°C) | <br>Unchanged<br>Increases |
| Hydrocarbon Permeation | Unchanged |
| Chemical Resistance * | Increases |
| *. The chemical resistance of thermoplastics is complex and is generally a function of the polymer's resistance to applied load, temperature and environment | |

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# *Case Studies and Other Publications*

- Many case studies are available from PPI at:
  www.plasticpipe.org
- PPI Statement A: “Relative Oxidativeness of Chloramines and Free Chlorine…”
- PPI Technical Note 17: “Crosslinked Polyethylene Pipe and Tubing”
- PPI Technical Note 39: “Recommended Practices Regarding Application of Pesticides and Termiticides Near PEX Pipes”

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# *PEX Pipes for Plumbing - Summary*

- Clean, safe water
- Corrosion resistance
- Reliable pipes and fittings
- Flexibility in design and installation
- More than 30 years of experience
- PEX pipes now available up to 3” diameter
- A sustainable product with green benefits

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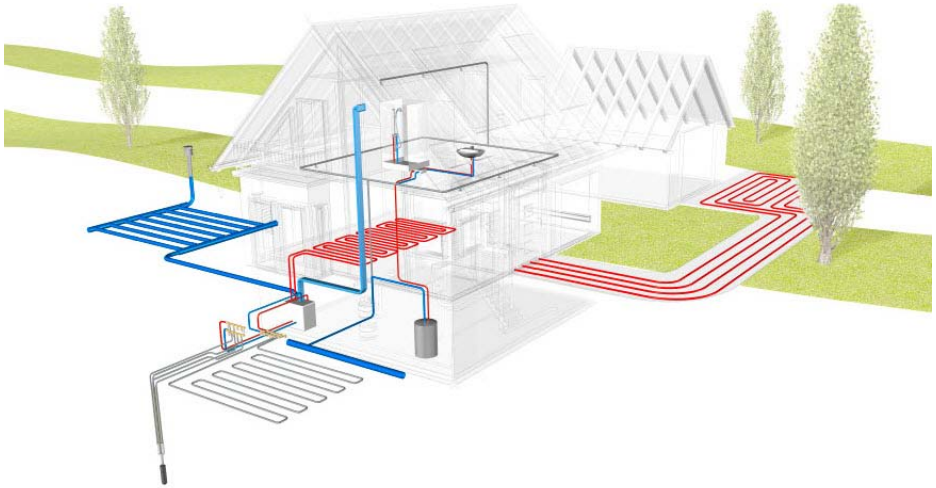
# *Other Applications for PEX Pipes*

- Radiant heating and cooling
- Residential fire protection (as per NFPA 13D)
- Hydronic (hot-water) building services piping (as per ASME B31.9)
- Outdoor snow and ice melting
- Renewable energy
- Insulated energy transfer pipes



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*Thank You for your attention!*

*Questions?*

*For more info, please visit us at:*

www.plasticpipe.org