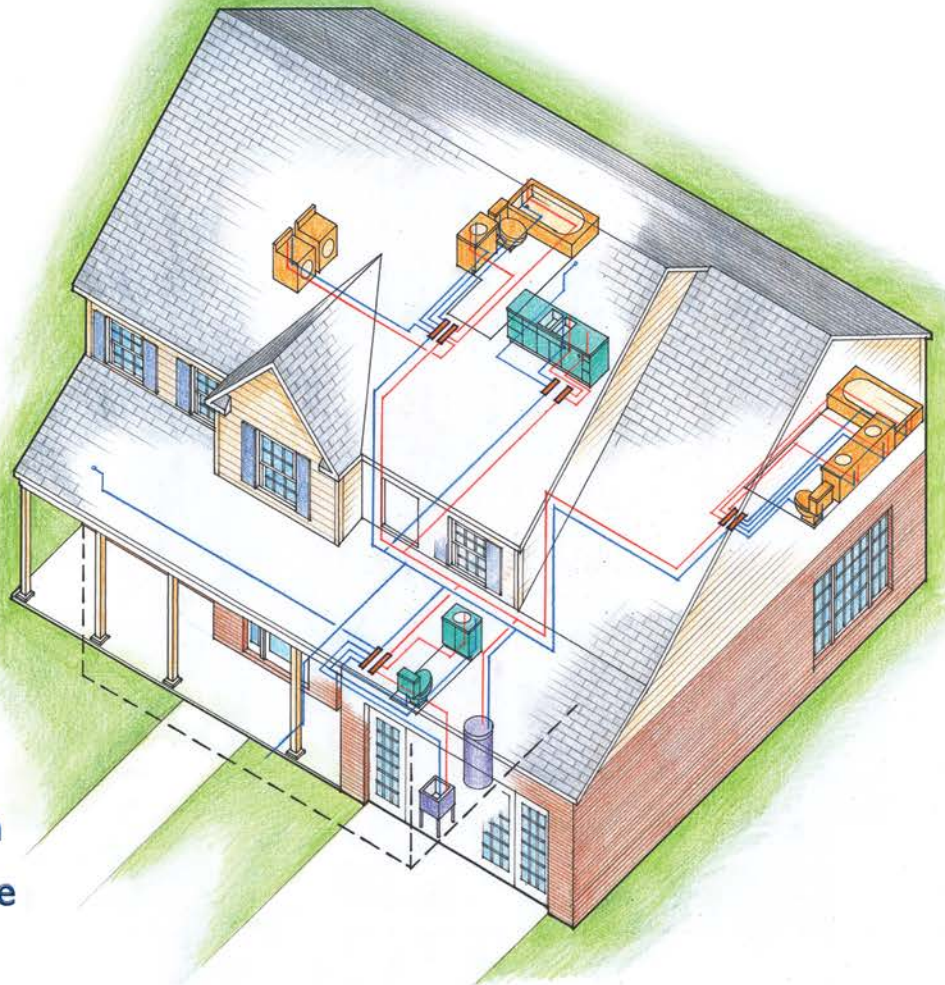


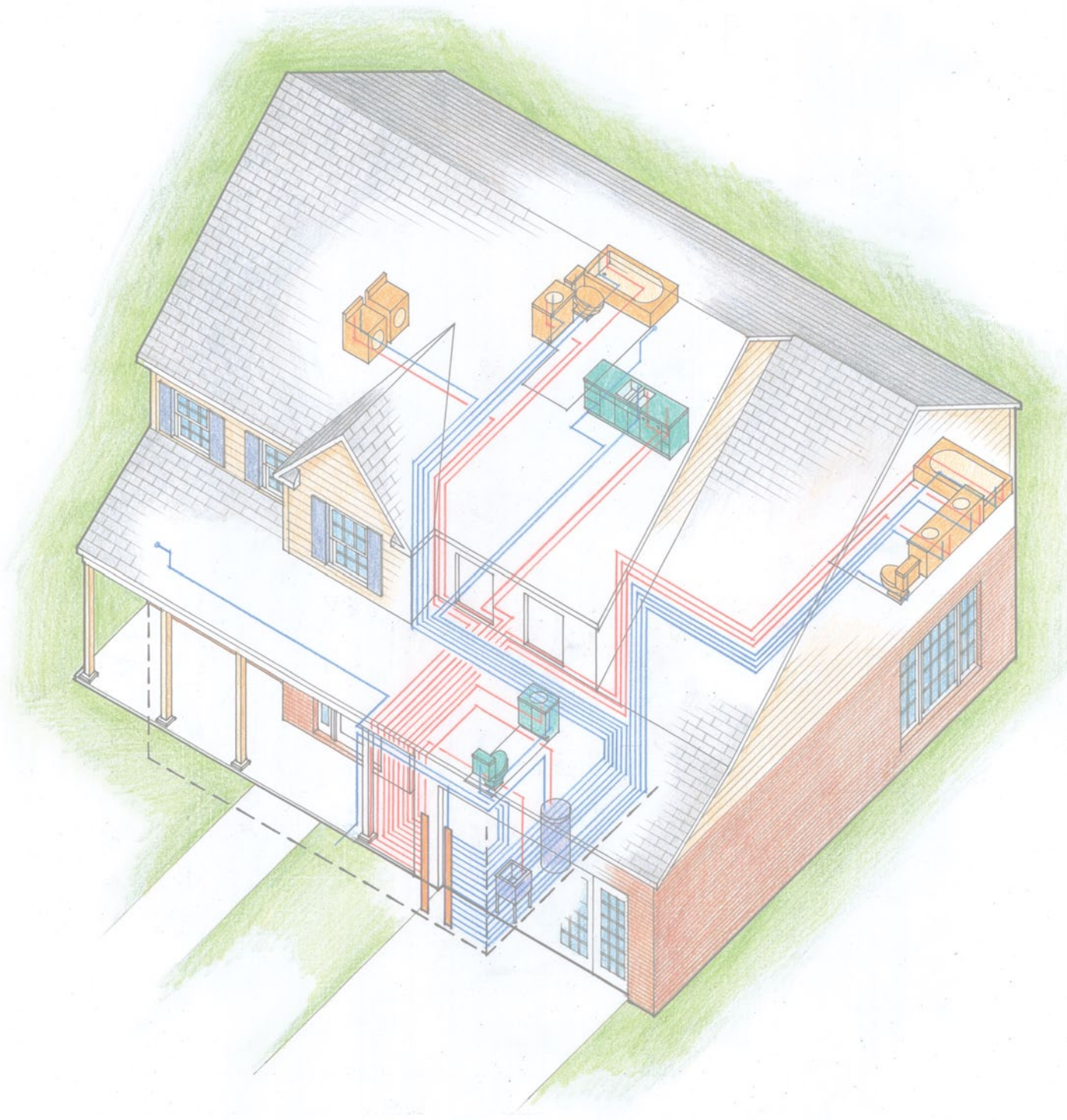
# DESIGN GUIDE

## Residential PEX Water Supply Plumbing Systems

Second Edition

Applications  
Advantages  
Material Properties  
Joining Methods  
Code Acceptance  
System Design  
Installation  
and more





# DESIGN GUIDE

## Residential PEX Water Supply Plumbing Systems

Second Edition

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# INTRODUCTION

## The Second Edition

We are proud to publish the 2<sup>nd</sup> Edition of the PEX Design Guide. This edition includes many updates to reflect the increased usage of PEX systems in a variety of residential applications like water reuse and retrofit applications. New information has been added to almost every chapter including: standards updates in Chapter 3; updates to all applicable national plumbing, mechanical, and building codes in Chapter 4 including new green construction codes; updates to fitting systems in Chapter 5; and new design information on fixture flow rates and water hammer in Chapter 8. There have been many changes to national green building standards over the past few years. Many of those changes are captured throughout the document. In addition to the many updates, we are pleased to note the participation of third party certification bodies in the creation of this guide. It is believed that this new level of cooperation will make this guide easier to use and provide more value to installers and inspectors alike. Thank you for taking the time to download this PPI document.

## Objective

This Design Guide provides the information and resources necessary to design and install cross-linked polyethylene (PEX) water supply systems in residential buildings. It includes comprehensive design concepts and installation guidelines to increase the acceptance and proper use of PEX. This document is targeted to meet the needs of home builders, designers, and trade contractors. Its purpose is to introduce potential users to PEX and to enable current users to optimize their PEX plumbing and fire sprinkler systems, and to minimize system costs. In addition, it will allow code inspectors and homeowners to become familiar with the applications, performance characteristics, and benefits of PEX water supply systems.



### Background

Cross-linked polyethylene (PEX) is a high-temperature, flexible, polymer pipe. Cross-linking technology was first developed in Europe and has since come into use around the world for a variety of applications. PEX has a 30-year history of successful use in the European market with extensive testing for durability and material performance. It was first introduced in North America in 1984 where it has been primarily used for radiant floor heating, and more recently, for domestic water distribution systems. It is approved for potable hot and cold water supply systems as well as hydronic heating systems in all model plumbing and mechanical codes across the United States and Canada. In addition, PEX is approved for use in multi-family NFPA 13D sprinkler systems.

Not all plastics are the same, just as not all metals are the same. A result of modern polymer technology, PEX piping performs in ways that provide superior reliability, durability, and safety. Also, current testing requirements for PEX are much more stringent than any other time in history.

The PEX piping industry is highly regulated. Standards, specifications, and code requirements define tight material and production quality controls. Continuous-use temperature ratings as high as 200°F (93°C) are required as well as standardized chlorine resistance testing to ensure that the piping will withstand the most aggressive drinking water conditions. Nationally accredited, third-party certification agencies require strenuous quality control testing, including random plant inspections and annual monitoring testing.

There are numerous opportunities for more widespread use of PEX pipe in the U.S. residential market. The development of manifolds and parallel plumbing systems for flexible piping has helped to advance its use. All major residential building codes permit the use of PEX piping, but obstacles to its acceptance still remain. There is anecdotal and research information that shows:

- Some plumbers are reluctant to use PEX piping due to a lack of experience with installation methods and design requirements
- Some jurisdictions prohibit the use of PEX piping for water supply plumbing even though PEX pipe is approved for use in all model codes
- Codes were originally written for rigid trunk and branch systems; while they have now been amended to include PEX piping systems, they do not provide many system design details

Although these hurdles exist, the following are among the many benefits of PEX piping systems.

- **Ease of Installation** – PEX pipe uses mechanical connections eliminating the need for solders, flames, and chemicals. Its flexible nature allows it to bend around obstructions. Use of manifolds can speed installation and improve performance.
- **Corrosion Resistance** – PEX piping will not pit or stress corrode.
- **Scaling Resistance** – PEX pipe's smooth interior walls and chemical properties make it resistant to mineral build-up.
- **Cost Effectiveness** – PEX plumbing systems are less labor intensive and can optimize system performance.

- **Availability of Pipe Sizes** – PEX piping is available in a wide range of diameters.
- **Energy Efficiency** – PEX piping minimizes heat transmission through the pipe wall.
- **Resistance to Freeze Damage** – Under most circumstances, water in the pipe can be frozen and thawed without damaging the pipe.
- **Water Conservation** – Well designed PEX plumbing systems can reduce the wait time for hot water to reach the fixture.
- **Environmentally Sound** – PEX is an inert material and does not contain volatile organic compounds (VOCs).
- **Certification** – PEX pipes and fittings must meet strict performance requirements.

Although general research on hot water systems has been performed on various aspects of plumbing systems, a literature search by the Home Innovation Research Labs indicated that specific system design information for flexible water supply plumbing is sparse. Documents relied more on “standard practice” than on engineered or designed systems. Using these approaches often leads to system designs that either supply more water than is needed at the fixture, or do not take advantage of the characteristics of a flexible plumbing system to reduce cost and improve performance.

This Design Guide provides the information and resources necessary to design and install efficient and cost-effective PEX water supply systems in residential buildings. It illustrates various plumbing configurations for a variety of house types as well as installation guidelines for each method. Properly designed and installed PEX piping systems are beneficial for plumbing designers, installers, and homeowners.

### Applications

PEX piping can be used in a wide variety of applications in residential construction. This Design Guide is focused on the design and installation of PEX hot and cold water supply systems, which can be used for both new construction and remodeling or retrofit projects.

Other applications for PEX are described in a separate section of this guide and include:

- Fire suppression systems (residential fire sprinklers)
- Municipal water service pipe in underground applications
- Radiant floor heating systems for suspended floor systems or in slab construction
- Snow and ice melt systems for sidewalks, driveways, entrances, and ramps
- Turf conditioning for greenhouses, golf courses, and sports field surfaces
- Water reuse and reclamation systems

Available in sizes from 1/4 to 4 inches, PEX piping can generally be installed in place of rigid piping on a size-for-size basis. Parallel installations with central manifolds can be used to balance pressures at the outlets and minimize hot water delivery wait time, reducing wasted water and energy. Manifolds can be installed that reduce the amount of piping and fittings, speed-up installation, and balance pressures throughout the system.

### How to Use the Design Guide

This PEX Design Guide can be used by anyone considering the installation of a new or retrofit PEX piping system for residential plumbing applications. It can be used by the novice as an introduction to PEX piping or by the experienced plumber to optimize his/her approach. Building code officials can use this Guide as a consolidated source of information on the application of PEX piping in residential buildings. Builders can use this guide to learn about the advantages, installation issues, and expected performance of PEX plumbing systems for discussions with sales staff and homeowners.

Each section of this guide focuses on various aspects of using PEX piping.

- **Chapter 1 – Introduction:** Background information to educate the user about the history and uses of PEX piping
- **Chapter 2 – Advantages:** Various advantages to using PEX piping in residential buildings
- **Chapter 3 – Material Properties:** Unique properties of PEX piping
- **Chapter 4 – Joining Methods:** Explanations of the various types of fittings and their joining methods
- **Chapter 5 – Types of PEX Plumbing Systems:** Descriptions of the three types of PEX piping system designs
- **Chapter 6 – Code Acceptance:** Information on major plumbing codes and relevant jurisdictional code provisions for PEX piping
- **Chapter 7 – Design:** Designs and performance details of the three basic plumbing layouts for four common house configurations to assist in evaluating which system provides the best balance of performance, ease of installation, and cost for a particular house
- **Chapter 8 – Lab Testing and Performance Data:** System performance comparison of three plumbing systems
- **Chapter 9 – Installation:** Detailed instructions for installing PEX piping
- **Chapter 10 – Testimonials:** Quotes from plumbers and home builders on their experiences with PEX piping
- **Chapter 11 – Other Applications:** Other uses of PEX piping
- **Appendix A:** Additional lab testing data
- **Appendix B:** New Installation Checklist to aid plumbers with the process of installing PEX piping
- **Appendix C:** Resources for additional information beyond this Design Guide
- **Glossary:** List of terms and acronyms used in this Design Guide

There are three main ways to use this guide:

- **Introductory Overview:** The guide can be read in its entirety as an introduction for those who have little or no exposure to PEX piping.
- **Planning Tool:** The Code Acceptance and Design chapters, in particular, can be used to optimize system designs and building layouts during the planning stage while the home design is being finalized.
- **Reference Guide:** Certain sections can be extracted and read as needed. For example, plumbers may want to reference the Installation section, or building inspectors may want to reference the Code Acceptance section.



# GLOSSARY

**ASTM:** American Society for Testing and Materials

**Corrosion:** deterioration in metals caused by oxidation or chemical action

**Crosslinked polyethylene:** 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.

**Elasticity:** a measure of material stiffness or the ability of the material to stretch or deform temporarily under a load

**Fitting:** a device or connection that allows the PEX pipe to change direction or size, such as a tee, elbow, or coupling

**Fixture:** a device or appliance at the end of a water supply distribution pipe line. Example: lavatory, water closet, tub/shower, dishwasher

**IAPMO:** International Association of Plumbing and Mechanical Officials

**ICC:** International Code Council

**IPC:** International Plumbing Code

**IRC:** International Residential Code

**Joint:** the connection of the PEX pipe to a fitting, fixture, or manifold

**Manifold:** a device having a series of ports that are used to connect distribution lines for several fixtures

**NSPC:** National Standard Plumbing Code





**Outlet:** see fixture

**Parallel:** a plumbing design that utilizes a central manifold and distribution piping to each hot and cold water fixture

**pH:** a scale ranging from 0 to 14 that ranks how acidic or alkaline a liquid is; water with a pH below 7 is considered acidic and water with a pH above 7 is considered alkaline

**PPFA:** Plastic Pipe and Fittings Association

**PPI:** Plastics Pipe Institute

**Scaling:** process of mineral buildup on the interior of a pipe

**Test fixture:** the tub-shower unit farthest from the water source that was instrumented to measure flow rate, flowing pressure, and mixed water temperature in the lab tests

**Thermoplastic:** having the property of becoming soft when heated and hard when cooled

**Thermoset:** having the property of becoming permanently hard and rigid when heated or cured

**Trunk and branch:** a plumbing design that has a large main line that feeds smaller pipes to each fixture

**Ultraviolet:** high energy light waves found in sunlight that lead to the degradation of many plastics and materials (UV)

**UPC:** Uniform Plumbing Code

**Wait time:** the time it takes for hot water to be delivered to the Test Fixture; delivery time

**Water hammer:** a banging noise heard in a water pipe following an abrupt alteration of the flow with resultant pressure surges

**Zone:** a plumbing system that uses trunk lines from the water source to small manifolds at grouped fixtures, such as a bathroom; can be flow-through or closed end

