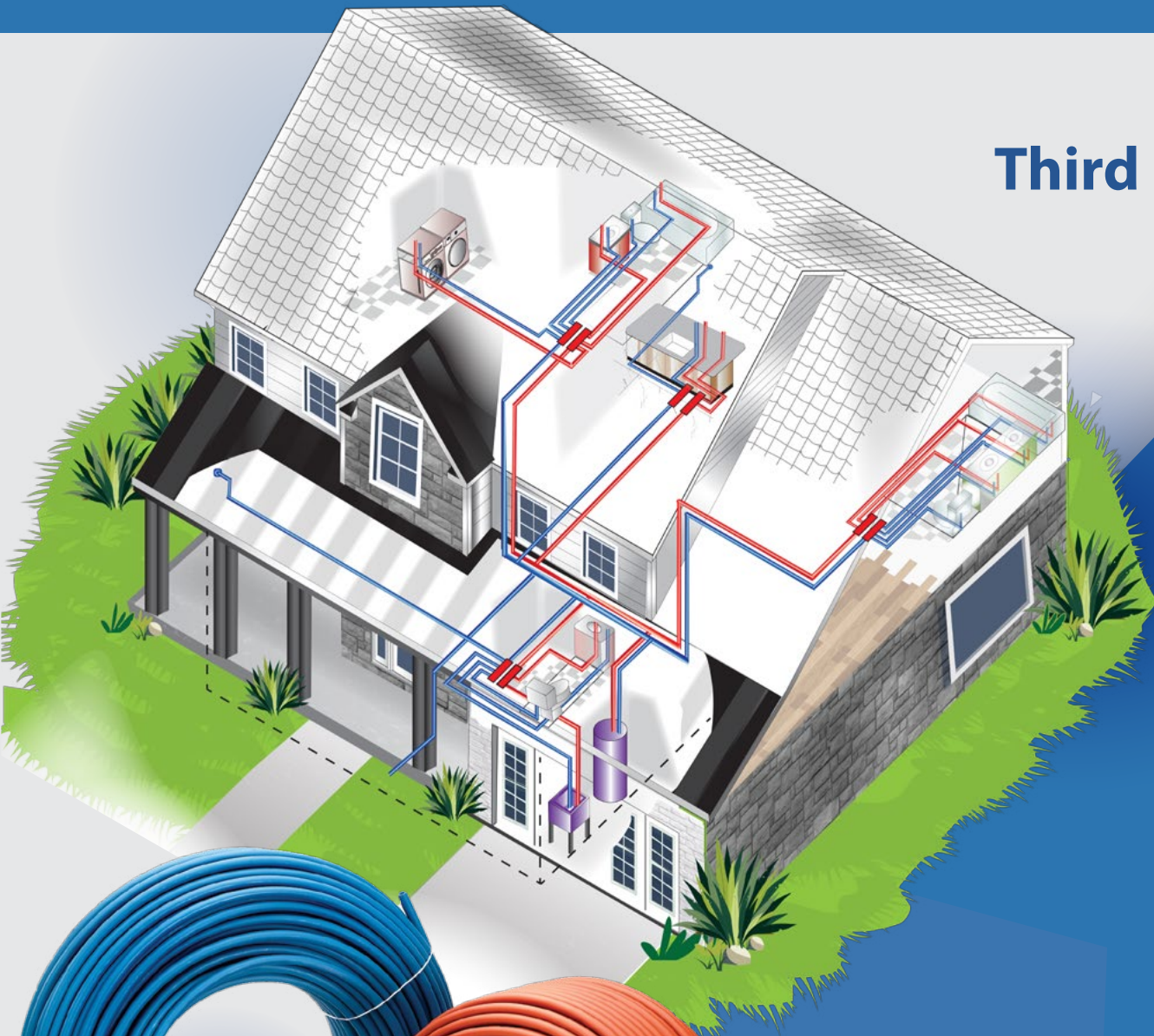


Third Edition



# PEX

## Plumbing Distribution Systems Design and Installation Guide

Advantages

Material Properties

Codes & Standards

Joining Methods

PEX Plumbing Layouts

Optimizing Design

Installation Guidelines

Water Service Line

Other Applications





# PEX

## Plumbing Distribution Systems Design and Installation Guide

### Third Edition

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# Water Service Lines / Building Supply Lines



# 10

A water service line delivers potable water from the water main, typically a community water system (CWS) or public water supply (PWS), to the property line and into a building. Some codes define the portion of this pipe within the property as the building supply line.

Crosslinked polyethylene (PEX) tubing is an ideal piping material for buried water service lines and building supply lines in practically all applications because it is a strong, tough, reliable material with exceptional resistance to chlorine and chloramines. It is both sustainable, with lower costs to the environment for production and usage, and resilient, thanks to excellent resistance to corrosion, water disinfectants, seismic events, and other types of external damage.

PEX tubing has been used successfully for water service line and building supply line applications in North America for over 25 years, providing safe delivery of potable water and protecting the health of building occupants in both new construction and rehabilitation work, such as lead service line (LSL) replacements.

## Background on PEX Tubing for Water Service Line

Crosslinked polyethylene is a high-temperature, flexible pressure piping system with exceptional resistance to slow crack growth (SCG), pressure cycling, seismic movements, and potable water disinfectants like chlorine and chloramines. In North America, PEX tubing systems are used for water service lines, building supply lines, hot- and cold-water distribution, residential fire protection, hydronic distribution, radiant heating and cooling, outdoor snow and ice melting, district energy piping, geothermal ground heat exchangers, and other demanding applications.

Most of the properties and characteristics of PEX tubing and joining systems are thoroughly described [Chapter 2 Advantages](#), [Chapter 3 Material Properties](#), and [Chapter 5 Joining Methods](#), so this chapter will focus on the use of PEX tubing for water service line and building supply line applications.

## Advantages of PEX Water Service Line Tubing

There are numerous advantages of PEX water service line tubing as compared with alternative materials such as Type K soft copper tubing.

### Corrosion Resistance

Unlike buried metal pipes, plastic water service and building supply lines are non-metallic and will not corrode either due to aggressive soil or water. PEX water service tubing will not suffer mineral build-up, scaling or internal deposits, nor will it contribute dissolved metals into drinking water.

### Water Velocity

The maximum recommended flow velocity through PEX water service tubing is 10 feet per second (3.0 m/s) for cold water up to 80°F (26.5°C). For required velocities beyond 10 fps, contact the tubing manufacturer.

### Light Weight and Longer Coils

PEX tubing weighs five to six times less than Type K copper per equivalent length. The lighter weight can reduce shipping costs and allow the product to be handled more easily on jobsites, with the potential to improve worker safety (see **Figure 10.1**).

The lighter weight also allows PEX tubing to be handled in longer coil lengths (e.g., 300 ft/91 m) than copper, reducing the need for couplings in certain installations (see **Figure 10.2**).

### Continuous Footage Markings

PEX tubing is marked at least every five feet showing the footage mark, and this can reduce waste by identifying coil lengths, potentially reducing installation time and scrap by allowing installers to easily select the right coil for each installation. See **Figure 10.3** for an example of a footage marking.



Figure 10.1 Worker Carrying PEX Tubing



Figure 10.2 PEX Tubing in Long Coil



Figure 10.3 Footage Marking on PEX

### Low Thermal Conductivity

As an advanced polymer material, PEX tubing has a significantly lower thermal conductivity than metallic water service line. As reported in **PPI TR-48 R-Value and Thermal Conductivity of PEX and PE-RT**, the PEX k-value = 2.86 (BTU·in)/(ft<sup>2</sup>·hr·°F) or 0.41 W/(m·°K), while the copper k-value = 196 (BTU·in)/(ft<sup>2</sup>·hr·°F) or 28 W/(m·°K). This data indicates that copper is 68 times more conductive than PEX, transferring heat through the tubing wall more rapidly.

The benefit of this property is that PEX tubing can resist heat transfer and can delay the freezing of water within tubing, providing reliable delivery of water even in extremely cold weather (see **Table 10.1**).

**Table 10.1 Thermal Conductivity of PEX and Copper Tubing**

Material	Thermal Conductivity	
	BTU·in/(ft <sup>2</sup> ·hr·°F)	W/(m·°K)
PEX	2.86	0.41
Copper	196	28

### Freeze-Break Resistance

PEX tubing is less susceptible to the effects of cold temperatures, retaining its flexibility even below freezing (i.e., does not become brittle). If water-filled PEX tubing freezes, the elasticity of the material typically allows it to expand without cracking or splitting, and then it will return to its original size upon thawing. This applies when PEX tubing has room to expand evenly along its length, as is typical when installed in the ground. However, since the insulating properties (i.e., lower thermal conductivity) of PEX tubing slows heat transfer through the tubing wall, there is less chance of water freezing within PEX tubing in cold environments.

See **PPI TR-52 Resistance of PEX Pipe and Tubing to Breakage When Frozen (Freeze-break Resistance)** and consult with tubing manufacturer for more information.

## PEX Water Service Line Requirements

According to plumbing codes, the requirements for PEX tubing to be used as a water service line or building supply line are the same as for indoor potable water applications. For example, PEX tubing and fittings intended for potable (drinking) water shall meet the requirements of **NSF/ANSI/CAN 61 Drinking Water System Components - Health Effects**, **NSF/ANSI/CAN 372 Drinking Water System Components, Lead Content**, and **ASTM F876 Standard Specification for Crosslinked Polyethylene (PEX) Tubing** or **CSA B137.5 Crosslinked Polyethylene (PEX) Tubing Systems for Pressure Applications**.

For water service line applications outside of the property line and the jurisdiction of the plumbing code, **AWWA C904 Crosslinked Polyethylene (PEX) Pressure Tube, 1/2 Inch Through 3 Inch for Water Service**, is the ANSI-approved standard for PEX tubing intended to deliver potable water into homes and buildings and is the standard typically required by water utilities for this application. AWWA C904 was first published in 2006 and contains requirements including dimensions, degree of crosslinking, quick burst pressures, design factor, long-term hydrostatic strength (LTHS), pressure ratings, chlorine resistance, UV resistance, excessive pressure-temperature capability, hot-bend and cold-bend tests, marking requirements, quality control, and more.

Some important examples of the requirements of AWWA C904 are listed below. AWWA C904 also contains information regarding the proper installation of underground PEX potable water service lines that is appropriate for these installations.

### **Long-Term Hydrostatic Strength**

AWWA C904 requires PEX tubing to demonstrate long-term hydrostatic strength resulting in a pressure rating for PEX tubing of 160 psig at 73°F (1103 kPa at 23°C). This is also known as the *Pressure Class* or *Pressure Rating*.

### **Chlorine Resistance**

PEX water service tubing is highly resistant to elevated levels of free chlorine, up to 4.0 ppm, and is also highly resistant to elevated levels of chloramines. AWWA C904 requires that all PEX tubing must have a minimum extrapolated lifetime of 50 years when tested in accordance with **ASTM Test Method F2023 Standard Test Method for Evaluating the Oxidative Resistance of Crosslinked Polyethylene (PEX) Pipe, Tubing and Systems to Hot Chlorinated Water** based on class 1 conditions of 25% of the time hot at 140°F and 75% of the time at 73°F operating at 80 psig (e.g., intermittent hot water, ≤ 6 hours/day). This is a very conservative approach for water service line applications, which typically operate at an annual average water temperature of 73°F (23°C) or less.

At the typical water service line end-use operating condition of 160 psig at 73°F (1103 kPa at 23°C), the extrapolated time-to-failure for PEX tubing meeting the requirements of AWWA C904 is in excess of 100 years, with regards to resistance to chlorine.

**PPI Statement A Relative Oxidative Aggressiveness of Chloramines and Free Chlorine Disinfectants on Crosslinked Polyethylene (PEX) Pipe and Tubing used in Treated Potable Water** reports on laboratory testing that was performed to evaluate the resistance of PEX tubing to water containing chloramines. According to PPI Statement A, "Based on these results, it is the position of PPI that chloramines are less aggressive than free chlorine to PEX pipes. Testing of oxidative resistance using free chlorine, in accordance with ASTM F2023, will provide a conservative estimate of the time-to-failure for PEX pipes when used with the disinfectant chloramines."

For information on the use of chlorine dioxide (ClO<sub>2</sub>) and PEX tubing, please see **PPI TN-67 Chlorine Dioxide and Plastic Hot- And Cold- Water Plumbing Distribution Pipes**.

### **Ultraviolet (UV) Resistance**

AWWA C904 requires that all PEX tubing must have a minimum ultraviolet (UV) resistance performance categorized by a digit '3' in the material designation code for PEX tubing, which is based on a minimum of 6 months of UV resistance when tested in accordance with **ASTM Test Method F2657 Standard Test Method for Outdoor Weathering Exposure of Crosslinked Polyethylene (PEX) Tubing**, which uses natural outdoor exposure for the tubing at exposure levels based on worst-case North American location near Phoenix, AZ, and evaluated in accordance with ASTM F876.

### **PEX Material Designation Code**

The performance requirements of AWWA C904 are comprehensive and robust. Based on the above-listed chlorine and UV resistance requirements, the minimum Material Designation

Code for PEX tubing according to AWWA C904 is "**PEX 1306**" (see **Figure 10.4**). PEX Material Designation Codes such as "PEX 3306" or "PEX 5306" exceed the minimum requirements and, therefore, also comply.

See **Chapter 3 Material Properties** for details about the four-digit PEX Material Designation Code.



Figure 10.4 PEX Markings

### Joining PEX Water Service Line

There are several types of joining techniques and fittings approved for use with PEX water service tubing. The primary type of fitting or valve is a compression-joint fitting produced according to AWWA C800, typically produced of lead-free brass. These are the same valves and fittings designed for use with Type K copper tubing and high-density polyethylene (HDPE) water service tubing (see **Figure 10.5**).



Figure 10.5 AWWA C800 Compression Joint Valve

Stainless steel or plastic insert stiffeners are required when using these fittings with HDPE or PEX to ensure long-term security of the connection (see **Figures 10.6** and **10.7**). These inserts are very thin and have a negligible effect on pressure loss.



Figure 10.6 Stainless Steel Insert Stiffener



Figure 10.7 PEX with Stainless Steel Insert Stiffener

In addition, several types of metal and polymer fittings which are designed specifically for PEX tubing may be approved for water service and building supply line applications. This includes fittings produced to nationally-accredited standards such as ASTM F1807, F1960, F2080, F2159, F3347, and F3348 as well as ASSE 1061 for push-fit fittings (see **Figure 10.8**). See **Chapter 5 Joining Methods** for details about each of these fitting options.

As stated in AWWA C904, "Each such fitting should be qualified before use by investigation and by tests when necessary to determine that the fitting is suitable and safe for the intended service." This includes specific approvals from fitting manufacturers for buried water service and building supply line applications.



Figure 10.8 Collection of Various PEX Fitting Systems

## PEX Water Service Line Installation

PEX water service line installs much the same as HDPE and copper tubing. For reliable installations, follow the installation requirements listed below as well as the requirements in AWWA C904 and those of the tubing manufacturer.

### Handling on the Jobsite

The following handling procedures are recommended:

- Store tubing to protect against damage from crushing, excessive heat, harmful chemicals, or overexposure to sunlight
- Prevent cuts, scratches, nicks, and gouges in the tubing
- Do not drag tubing over rough ground or pull through bored holes containing sharp-edged material, to prevent abrasion
- Unroll and uncoil tubing carefully to avoid kinking

### Bending and Flexibility

The minimum bending radius for PEX water service line is **8 times** the Outside Diameter of the tube. See **Table 10.2** and **Figure 10.9** for details about the bending radius for each diameter.

Bending the tubing too tightly may cause kinking, which could damage the tubing and/or restrict the flow of water. See **Figure 10.10** for an example of installing PEX tubing as a lead service line replacement while following the minimum bending radius.

**Table 10.2 Minimum Bending Radius for PEX Water Service Tubing**

Tube Size (nominal)	Tube OD (actual) in.	8X Minimum Bend Radius in.
3/4	0.875	7.0
1	1.125	9.0
1 1/4	1.375	11.0
1 1/2	1.625	13.0
2	2.125	17.0
3	3.125	25.0

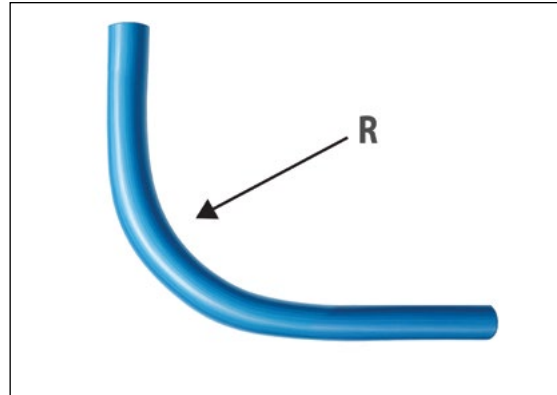


Figure 10.9 Bending Radius for PEX



Figure 10.10 Installing PEX Tubing as an LSL Replacement

### Bend Supports

Bend supports or bend guides may be used to replace most elbow fittings for 90-degree changes in direction when using PEX as water service line tubing (see **Figure 10.11**).

Bends in PEX tubing are not permitted closer than 10 pipe diameters from any fitting or valve connection.

For example, with NTS 1 PEX tubing with an outside diameter (OD) of 1.125 in., the minimum length between the bend and fitting is  $10 \times 1.125 \text{ in.} = 11.25 \text{ in.}$  (28.57 cm).



Figure 10.11 Bend Support on PEX Tubing

## Connections

There are several important steps to follow when connecting PEX water service line to valves or fittings.



Figure 10.12 Cutting PEX Tubing

- It is critical to use a proper tubing cutter, because PEX tubing must be cut squarely and cleanly before any connection (see **Figure 10.12**)
- When compression joint fittings are used, be sure to install an insert stiffener (see **Figure 10.7**)
- Insert tubing into fitting or valve ends, then tighten the fitting nuts per instructions
- For other PEX fittings, follow AWWA C904 and the manufacturer's instructions for assembly



Figure 10.13 PEX Tubing Installed with 10- to 20-Degree Gooseneck

### Gooseneck

PEX water service tubing should leave the water main at a 10- to 20-degree angle above the horizontal to prevent stress on the connection. It is not required to use the 45-degree gooseneck common with copper service line (see **Figure 10.13**).

### Thermal Expansion

The longitudinal (i.e., linear) expansion rate of PEX tubing is 1.1 inch per 10°F per 100 ft. length.

For example, if a 60 ft. (18.3 m) PEX service line is installed at an ambient air temperature of 90°F (32°C), and then the service water temperature is 60°F (16°C), this will be a 30°F (16.6°C) temperature reduction that will result in a tubing length reduction of  $1.1 \times 3 [30^\circ\text{F}/10^\circ\text{F}] \times 0.6 [60 \text{ ft}/100 \text{ ft}] = 2 \text{ in. (50.8 mm)}$ .

It is recommended that installers allow a slight curve while laying PEX tubing in a trench to accommodate for changes in length when put into service (see **Figure 10.14**).

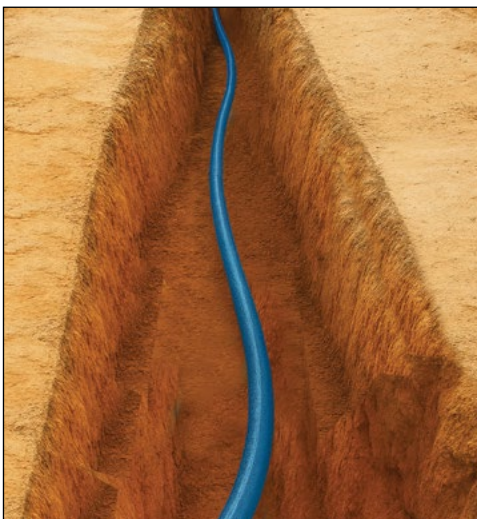


Figure 10.14 PEX Tubing in Trench with Slight Curve

### Horizontal Directional Drilling (HDD)

Horizontal Directional Drilling (HDD) uses trenchless techniques to drill a bore path through the ground which can be guided around obstacles or under streams, for example. The HDD process begins with boring a small, horizontal hole (pilot hole) under the crossing obstacle (e.g., a driveway) with a continuous string of steel drill rod. When the bore head and rod emerge on the opposite side of the crossing, a special cutter, called a back reamer, is attached and pulled back through the pilot hole. The reamer bores out the pilot hole so that the pipe can be pulled through. The pipe is usually pulled through from the side of the crossing opposite the drill rig.

PEX water service line is approved for installation using established HDD techniques. Care should be taken to prevent significant external damage to PEX tubing when installed using HDD methods, such as gouging by sharp rocks. See **Chapter 12 Horizontal Directional Drilling (HDD)** of the Plastics Pipe Institute's *Handbook of Polyethylene Pipe* for more information on this installation procedure.

### Pressure Testing

AWWA C904 requires that "test pressure shall be at least equal to the expected working pressure (main pressure), but not less than 40 psi and not greater than 1.25 times working pressure at 73°F (23°C) for a minimum duration of 15 minutes and maximum of 2 hours."

Do not allow the water in system to freeze during testing. Suitable precautions should be taken to eliminate hazards to personnel in the proximity of lines being tested in the event of tubing system rupture.

### Backfill and Embedment of PEX Tubing According to AWWA C904

AWWA C904 provides guidance with regards to backfill and embedment of PEX water service tubing.

- To prevent freezing water, water service tubing should be installed below the frost line
- PEX tubing should be installed in trench bottoms that provide continuous support and are free from rocks, stones, and debris, as per **ASTM D2774 Standard Practice for Underground Installation of Thermoplastic Pressure Piping** (see **Figure 10.15**)
- The initial backfill, from 3 in. (76 mm) below the pipeline to 4 in. to 6 in. (10 cm to 15 cm) above the tubing, should be sand or other materials, as allowed in ASTM D2774 or as approved by the tubing manufacturer
- If the installation will be subject to surface traffic, a minimum cover of 24 in. (61 cm) should be provided and trench backfill in the tubing zone should be compacted to at least 90% of the laboratory maximum density of the backfill soil



Figure 10.15 PEX Water Service Tubing in Trench

## Permeation through Buried Pipes

Certain organic (e.g., hydrocarbon) compounds such as fuels, solvents, or other possible contaminants may permeate through plastic pipes, potentially contaminating the drinking water and damaging the pipe's integrity. This issue affects all types of buried pipes, including iron, copper, PVC, HDPE, or PEX.

Metal pipes use gaskets made of elastomeric materials, which may be susceptible to permeation by light hydrocarbons with smaller molecular sizes. Therefore, piping engineers must take special care when installing potable water lines through contaminated soil, regardless of the type of pipe material. If contamination is suspected, a chemical analysis of the soil or groundwater must be performed to determine the contaminant and its compatibility with PEX tubing.

The plastic piping industry provides the following techniques for dealing with suspected contamination of soil or groundwater:

- Surround the pipe with good clean soil of Class I or Class II material to allow the suspected contaminants to dissipate into the envelope of the surrounding soil; U.S. EPA guidelines prohibit the reuse of excavated hydrocarbon contaminated soil in the envelope of bedding or backfill material, or
- Sleeve the tubing in suspected areas, or
- Reroute the tubing around the contaminated area.

## Locating Buried PEX Water Service Tubing

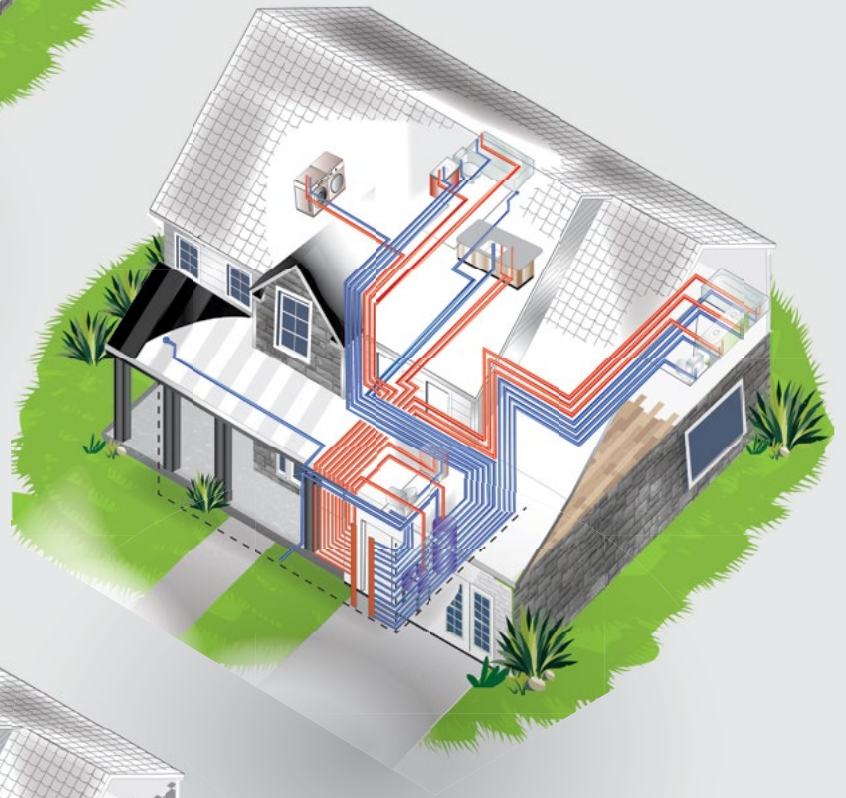
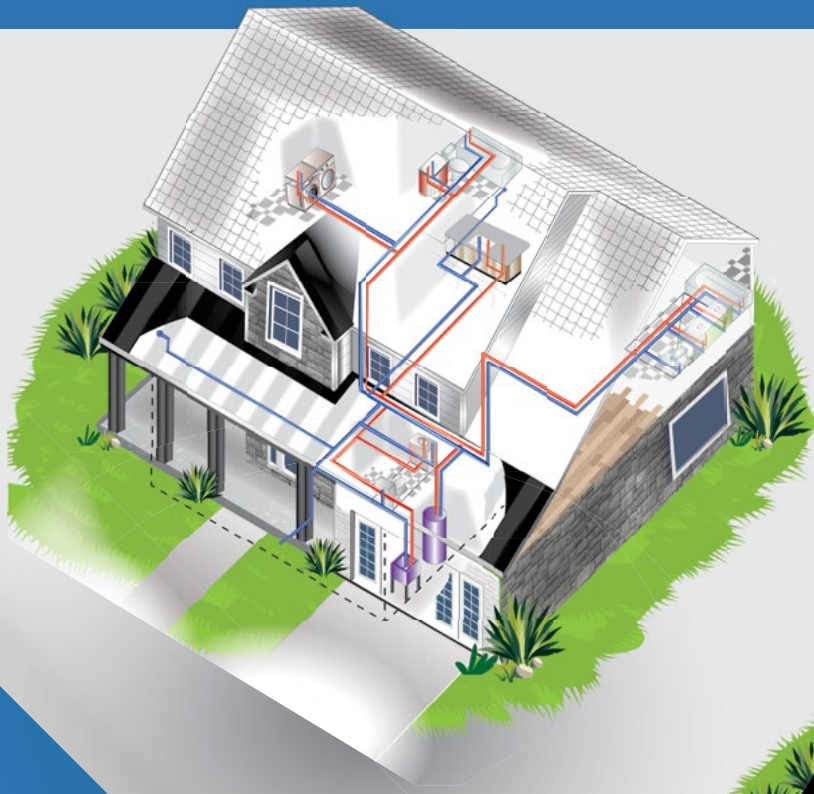
Available methods for locating buried PEX pipes include metallic detection tape, copper tracing wire, or electronic locating beacons, as required by the local codes or the project owner. Tracer wire may be secured to PEX tubing with nylon ties. Do not use adhesive tape to attach a tracer wire to the tubing.

## Thawing Frozen PEX

In the unlikely event of a freeze, several suitable methods exist to thaw frozen water inside PEX tubing:

- Use a commercial hot-water injection system that pumps heated water through the tubing to the ice blockage and returns the cooled water for reheating
- Expose the buried tubing and apply wet hot towels to frozen area
- Expose the buried tubing and apply hot water to frozen area
- Expose the buried tubing and use a hand-held hair dryer or electric heat gun
- Expose the buried tubing and apply low-wattage electrical heating tape

In all cases, do not apply open flame directly to PEX tubing, as this could cause permanent damage.



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