the construction specifier

Plumbing with PEX

by David Nickelson and Jon Bittenbender

All images courtesy REHAU

CROSSLINKED POLYETHYLENE (PEX) TUBING IS WIDELY EMPLOYED ACROSS PLUMBING AND HEATING TRADES IN RESIDENTIAL APPLICATIONS, BUT MANY SPECIFIERS HAVE YET TO CONSIDER ITS USE IN COMMERCIAL PLUMBING SYSTEMS. BASED ON DECADES OF SUCCESSFUL INSTALLATIONS AND GROWING CONFIDENCE IN THE TRADE, PEX IS GAINING GROUND AS A HIGH-PERFORMANCE, COST-EFFECTIVE ALTERNATIVE TO COPPER AND CHLORINATED POLYVINYL CHLORIDE (CPVC) PIPING ON LARGE-SCALE COMMERCIAL PLUMBING PROJECTS.

With more than 50 years of testing and quantifiable performance in applications all over the world, PEX tubing has proven to be a durable material that does not suffer from corrosion, electrolysis, filming, mineral buildup, or water velocity wear—problems plaguing copper and other metal piping systems.[1]

PEX tubing is manufactured by extrusion in sizes from 6 to 102-mm (¼ to 4-in.) nominal diameter. It is controlled to outside diameter (OD) dimensions in what is commonly called copper tube size (CTS). The ratio of the OD to the wall thickness of PEX tubing is 9:1 (based on the standard dimension ratio [SDR] of 9).

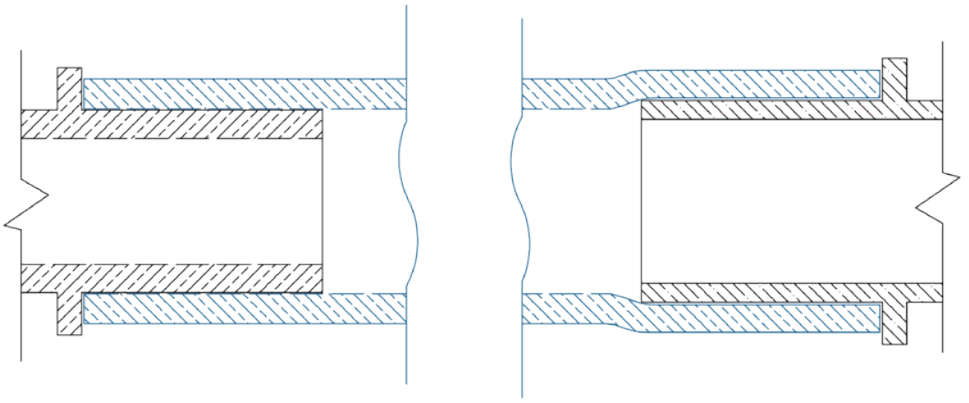
Advantages of PEX as stated in the design guides of manufacturers include:

- minimization of fittings;
- freeze-break resistance;
- stress corrosion and pitting resistance;
- scale and deposit buildup resistance;
- minimization of noise (water hammer); and
- notching damage and abrasion resistance.

Flexibility matters

The primary advantage of PEX tubing—also available in coils and straight lengths—over copper and CPVC rigid pipe is its flexibility. Installers can route it through walls, floors, and ceilings with minimal fittings. The need for fewer fittings means less resistance leading to reduced pressure loss.

The flexibility of PEX leads to yet another advantage over rigid pipe: freeze-break resistance. PEX tubing expands if it accidentally freezes and returns to its original size when the



Cross-sectional comparison of insert fitting (left) versus cold-expansion with crosslinked polyethylene (PEX) compression-sleeve fitting (right) showing minimal reduction in inside diameter (ID) with negligible impact on flow rate.

ice thaws. When water freezes in a rigid pipe, it breaks open the piping and causes leaks and flooding, resulting in a financial headache for the building owner.

Pressure loss and flow rates

To meet standardized pressure ratings, plastic piping requires thicker walls than copper and CPVC, resulting in a slightly smaller inside diameter (ID). The flexibility of PEX offsets this potential ID impact on pressure loss by requiring fewer fittings. As mentioned earlier, fewer points of resistance mean less pressure loss.

Additionally, the development of cold-expansion fittings has helped dispel the myth PEX tubing causes a loss of pressure due to its smaller ID and the use of insert fittings.

Fittings for PEX plumbing systems are available in lead-free brass and polymers in two main styles—cold-expansion and insert. All fitting types must meet the performance requirements of ASTM F877, *Standard Specification for Crosslinked Polyethylene (PEX) Hot- and Cold-Water Distribution Systems*.

There are two proven technologies for cold-expansion-style fittings, one under ASTM F1960, *Standard Specification for Cold Expansion Fittings with PEX Reinforcing Rings for Use with Crosslinked Polyethylene (PEX) and Polyethylene of Raised Temperature (PE-RT) Tubing*, and the other referred to as cold-expansion with PEX compression sleeve.

For insert-style fittings, standards include:

- ASTM F1807, *Standard Specification for Metal Insert Fittings Utilizing a Copper Crimp Ring, or Alternate Stainless Steel Clamps, for SDR9 Crosslinked Polyethylene (PEX) Tubing and SDR9 Polyethylene of Raised Temperature (PE-RT) Tubing*, brass;
- ASTM F2159, *Standard Specification for Plastic Insert Fittings Utilizing a Copper Crimp Ring, or Alternate Stainless Steel Clamps for SDR9 Crosslinked Polyethylene (PEX) Tubing and SDR9 Polyethylene of Raised Temperature (PE-RT) Tubing*, polymer;
- ASTM F3347, *Standard Specification for Metal Press Insert Fittings with Factory Assembled Stainless Steel Press Sleeve for SDR9 Crosslinked Polyethylene (PEX) Tubing*, brass; and
- ASTM F3348, *Standard Specification for Plastic Press Insert Fittings with Factory Assembled Stainless Steel Press Sleeve for SDR9 Crosslinked Polyethylene (PEX) Tubing*, polymer.

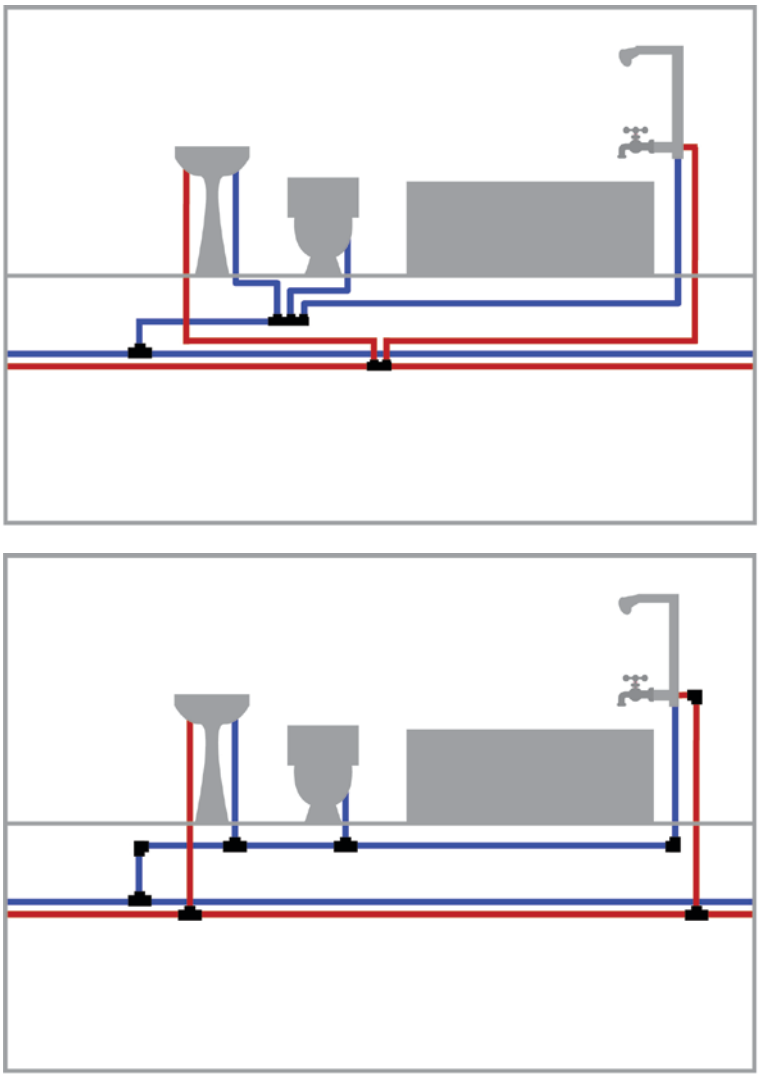
There are three crosslinking production methodologies for PEX (known as a, b, and c). PEXa is the most flexible, enabling the use of cold-expansion fittings as well as a tighter bend radius. Compared to insert fittings, cold-expansion fittings produce a more consistent connection due to the inherent shape memory of PEXa pipe.[2]

To use cold-expansion fittings, an expander tool is placed inside the tubing to enlarge the PEX. The tool is turned multiple times until the tubing is expanded to the manufacturer's specifications. With the ASTM F1960 design, the expanded tubing end is allowed to retract onto the fitting to form the seal with the aid of a ring. The connection is enhanced by the memory effect of the tubing, thereby not solely relying on the crimping mechanism for its security.

The latest generation of PEX fittings—cold-expansion with PEX compression sleeve—takes this connection security up a notch and speeds the formation of the connection by actively compressing a PEX sleeve over the expanded tubing and fitting.

Fixture flow rates of PEX and copper pipe were compared in a June 2008 study conducted by the National Association of Home Builders (NAHB) for the Plastics Pipe Institute (PPI).

It concluded, "PEX and copper piping systems will deliver sufficient volumetric flow rates to the plumbing fixtures when using the same nominal size tubing. While PEX tubing has a smaller inside



Tee and branch piping layout (above) and multiport tee piping layout (top). By taking advantage of the flexibility of PEX in piping layout design, the multiport tee configuration significantly reduces the number of fittings required.

Plumber using PEX expansion/compression tool to form secure connections in commercial project. Also shown are galvanized steel support channels and support hangers.

diameter than copper tubing, both tubing systems meet the farthest fixture demand, even with multiple fixtures flowing."[3]

Over time, corrosion and other buildup can reduce the ID of copper pipe, thus reducing flow and pressure, and its effectiveness, in a commercial plumbing system.

Pipe sizing, layout options

When sizing pipe, a good practice is to look at the pressure loss tables of the manufacturer. One must not assume the PEX system should be upsized. Doing the math ensures the client is happier due to potential savings in material and energy costs.

The water supply fixture unit (WSFU) method helps determine the required load (gpm) and the resulting pipe size as defined by local governing plumbing code. Alternatively, particularly for larger buildings, the uniform friction head loss method can be used. It is also advisable to consider the maximum velocity of water flow. Once the flow rate is determined, the pipe can be sized based on the maximum allowable velocities, according to the prevailing local codes.

PEX has two piping layout options (tee and branch and remote multiport tee) while copper and CPVC have only one (tee and branch). A PEX tee-and-branch system uses the same layout as rigid pipe but with faster installation. When possible, installers should use bend supports instead of fittings to maximize the benefit of this method.

A remote multiport tee offers a variety of plumbing design possibilities due to the minimal amount of connections required. Fewer fittings means less leak potential and pressure loss as well as reduced installation time, which saves money for the building owner.

Codes and standards

All major model plumbing and building codes recognize PEX tubing as acceptable for water distribution piping.

Nationally accredited, third-party certification agencies, such as the International Code Council (ICC) and NSF International, require strenuous quality control (QC) testing, including random plant inspections and annual monitoring. Long-term hydrostatic pressure ratings as well as standardized chlorine resistance testing to ensure the piping will withstand the most aggressive drinking water conditions are also required.

Many commercial buildings require plumbing systems to be installed within return air plenums or fire-rated assemblies.

Bend Radius PEXa mm (in)

Pipe Size (in)	Typical 8X OD	Min. Cold 5X OD	Min. Heated 3X OD
3/8	102 (4.0)	64 (2.500)	38 (1.500)
1/2	127 (5.0)	79 (3.125)	48 (1.875)
5/8	152 (6.0)	95 (3.750)	57 (2.250)
3/4	178 (7.0)	111 (4.375)	67 (2.625)
1	229 (9.0)	143 (5.625)	86 (3.375)
1 1/4	279 (11.0)	15 (6.875)	105 (4.125)
1 1/2	330 (13.0)		
2	432 (17.0)		

PEXa tubing can be bent as much as five times the outside diameter (OD) when cold and three times the OD after heating with a heat gun. (The bend radius of PEXb and PEXc is slightly less.) The superior flexibility of PEX compared to chlorinated polyvinyl chloride (CPVC) and copper pipes significantly reduces the need for fittings in plumbing systems.

When placing PEX in a plenum, design professionals use ASTM E84, *Standard Test Method for Surface Burning Characteristics of Building Materials*, to evaluate whether materials will help spread a fire or create smoke when burned. Individual PEX manufacturers obtain their listings and certifications for plenum applications using different installation methods such as half-inch fiberglass insulation or galvanized support channels.

Underwriters Laboratories (UL)-listings are required when combustible material is installed in fire-rated assemblies, such as reinforced concrete slabs, wood-framed floor/ceiling assemblies, and framed bearing and nonbearing walls.

Since all potable water in the United States is disinfected using chlorine, all PEX tubing must be tested and certified by qualified third-party certification agencies to meet the requirements of ASTM F876, *Standard Specification for Crosslinked Polyethylene (PEX) Tubing*, including chlorine resistance.

"PEX pipe has shown itself to be resistant to attack from chlorine and chloramines under a wide range of conditions, and has performed reliably in all regions of North America," the ICC said in its design guide.[4]

Plumbing professionals must also consider ultraviolet (UV) resistance when specifying PEX tubing for commercial plumbing. Most PEX has some UV resistance, but prolonged exposure to direct or indirect sunlight can damage the tubing. PEX should not be stored outdoors or used in outdoor applications unless buried in the ground or protected in some other way.

It is advisable to check with the manufacturer to find out the maximum recommended UV exposure time limit of the PEX, based on the UV resistance.[5]

Installation considerations

When installing PEX tubing, proper support spacing must be observed per code. PEX expands and contracts when heated and cooled, so it is important to keep this in mind when designing and specifying pathways and supports. It is recommended to choose supports that will not cut, scratch, or damage the tubing.

Standard CTS hangers can be used to support suspended sections of PEX tubing. Fixed support points will hold PEX in place and minimize the movement of the tubing during expansion or contraction, thus mitigating any damage to the pipe. Isolating suspension clamps allow the tubing to slide within the support.

To increase the spacing between support hangers, specifying engineers can choose galvanized steel support channels, into which the PEX tubing is placed. These support channels also minimize expansion and contraction that occurs when the tubing is heated and cooled.

Designers and specifiers must consider an approved through-penetration firestop system when PEX tubing will penetrate floors, ceilings, and walls. The most common firestop system standards are ASTM E814, *Fire Tests of Through-Penetration Firestops,* and UL 1479, *Fire Tests of Through-Penetration Firestops*. It is important to ensure the firestop system meets all local code requirements before installation.

Incorporating proper controls into the PEX plumbing system is crucial, as failure to follow pressure and temperature limits may damage the tubing, resulting in leaks and possible breakdown of the system. The maximum temperature and pressure ratings of PEX plumbing systems are in accordance with ASTM F876 and PPI TR-3, *Policies and Procedures for Developing Hydrostatic Design Basis, Hydrostatic Design Stresses, Pressure Design Basis, Strength Design Basis, Minimum Required Strength Ratings and Categorized Required Strength for Thermoplastic Piping Materials or Pipe*.

Installation advantages

PEX tubing provides building owners reliability, durability, and cost savings, and makes plumbing installation easier and safer. CPVC plumbing systems require glue to join fittings. It

is a time-consuming process, as the CPVC pipe ends must be primed, glued, and then held together while the adhesive dries.

Even more time-consuming is soldering and brazing, which is still used to install copper tubing. As this process requires a fire source, it can be a safety issue for the contractor and a liability for the building owner. Other methods to join copper are available, such as press-connect and push-connect fittings, both of which tend to be less reliable.

CAN LEGIONNAIRES' DISEASE BE MITIGATED?

Legionnaires' disease is a severe form of pneumonia caused by the bacterium *Legionella pneumophila*. The Centers for Disease Control and Prevention (CDC) notes health professionals diagnosed almost 7500 cases in 2017, and the number of cases reported has been on the rise since 2000.* The first case of the disease occurred in 1976 at an American Legion convention at a Philadelphia hotel. Of the more than 200 people who contracted the disease, 29 died.

While Legionella is found naturally in freshwater sources such as lakes and streams, most humans contract Legionnaires' disease by inhaling contaminated water droplets, water vapor, steam, or mist. Legionella thrives in warm, stagnant water (20 to 50C [68 to 122 F]).

Mitigating Legionella in plumbing systems requires maintaining sufficient hot-water temperatures and minimizing dead legs—the volume of water between either a hot water storage tank or a recirculation line and the fixture.

CDC recommends maintaining hot water at the return at the highest temperature allowable by state regulations or codes, preferably greater than 51 C (124 F), while using preset thermostatic valves in point-of-use fixtures to help minimize the risk of scalding.**

Similarly, the Occupational Safety and Health Administration (OSHA) recommends maintaining water heaters at 60 C (140 F) and delivering hot water to all outlets at a minimum of 50 C (122 F). Further recommendations include frequently flushing lines, especially dead legs, and running hot water recirculation pumps continuously to avoid stagnation.***

A hot water recirculation system can help control Legionella growth by circulating hot water at regular intervals throughout the plumbing system. These systems were initially designed to conserve water by reducing hot water wait times for occupants. However, a drawback of these systems is that continuous recirculation may consume unnecessary amounts of energy, particularly during the times of day when a building is unoccupied. To address this trade-off between water and energy waste, the plumbing industry has introduced controls such as timers, aquastat controls, and occupant sensors. Use of these controls in hot water recirculation systems is required by current model plumbing codes. **CS**

** For more information, read "Legionella: History, Burden and Trends" by the Centers for Disease Control and Prevention (CDC) at www.cdc.gov/legionella/about/history.html.*

*** Read "Legionella: Guidance for Monitoring Building Water" by CDC at www.cdc.gov/legionella/wmp/monitor-water-guidance.html.*

**** Consult "Legionellosis: Control and Prevention" by the Occupational Safety and Health Administration (OSHA) at www.osha.gov/SLTC/legionnairesdisease/control_prevention.html, Accessed 22 Mar. 2019.*

With PEX, installers have a flexible, easy-to-maneuver material requiring fewer fittings, which speeds up installation and reduces cost. A commercial installation time study performed by the Home Innovations Research Lab set up an experiment with two 15-year veterans of commercial plumbing in side-by-side timed installations of copper and PEX systems.

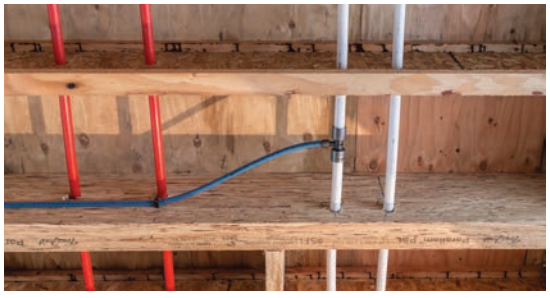
The study concluded the PEX plumbing systems installed up to 65 percent faster than copper systems. For plumbers, PEX won over copper installations because fewer fittings are needed and measuring, cutting, and attaching fittings to the pipe takes less time.

Conclusion

A versatile material, PEX is suitable for commercial plumbing applications because it is flexible, reliable, and durable. The pliable nature of PEX allows contractors to bend and position the tubing where needed, requiring fewer fittings than rigid piping systems, thereby reducing installation time and saving building owners money.

Cold-expansion fittings help enlarge the ID of PEX tubing while providing a tight seal and virtually leak-proof connection. Further, PEX does not corrode or degrade like metal plumbing systems and, therefore, assures longevity.

Given the data and conclusions from industry sources and experience from installers, there is evidence to consider the advantages of specifying PEX in commercial plumbing projects. **CS**



PEX plumbing installation in a multifamily project.

Notes

[1] Read *Design Guide: Residential PEX Water Supply Plumbing Systems, Second Edition*, (November 2013) from the Plastic Pipe and Fittings Association (PPFA)/International Code Council (ICC)/Plastics Pipe Institute (PPI)/Home Innovation Research Labs.

[2] For more, read "How Do Expander Fittings Work on PEX?" in the *San Francisco Chronicle*. Access it at homeguides.sfgate.com/expander-fittings-work-pex-74898.html.

[3] Consult *Fixture Flow Rate Comparison: Crosslinked Polyethylene (PEX) Piping and Copper Tubing* (June 2008) by the National Association of Home Builders (NAHB) and PPI.

[4] See Note 1.

[5] See Note 1.

ADDITIONAL **INFORMATION**

Authors

David Nickelson is a technical team leader in the building solutions division at REHAU's North American headquarters in Leesburg, Virginia. His responsibilities include product development, codes and certifications, industry standardization work, and crosslinked polyethylene (PEX) production support. Nickelson is the secretary of ASTM F17.10 subcommittee and represents REHAU on all voting matters in standards development organizations such as ASTM, NSF International, the Canadian Standards Association (CSA), Underwriters Laboratories (UL), and the National Fire Protection Association (NFPA). Nickelson is also the chair of Plastics Pipe Institute's (PPI's) technical committee. He received a bachelor's degree in mechanical engineering from Pensacola Christian College. He can be reached at david.nickelson@rehau.com.

Jon Bittenbender is the director of engineering for the building solutions division of REHAU. He has been involved in the engineering of the company's PEX-based applications, including plumbing, radiant heating and cooling, hydronic piping, turf conditioning, and snow- and ice-melting since 1999. Bittenbender holds a bachelor's degree in mechanical engineering from the Pennsylvania State University. He can be reached at jonathan.bittenbender@rehau.com.

Abstract

Crosslinked polyethylene (PEX) tubing is widely used across plumbing and heating trades in residential applications, but many specifiers have yet to consider its use in commercial plumbing systems. Based on decades of successful installations and growing confidence in the trade, PEX is gaining ground as a high-performance, cost-effective alternative to copper and chlorinated polyvinyl chloride (CPVC) piping on large-scale commercial projects.

MasterFormat No.

22 10 00–Plumbing Piping

UniFormat No.

D20–Plumbing

Key Words

Division 22
Crosslinked polyethylene tubing
Piping systems
Plumbing