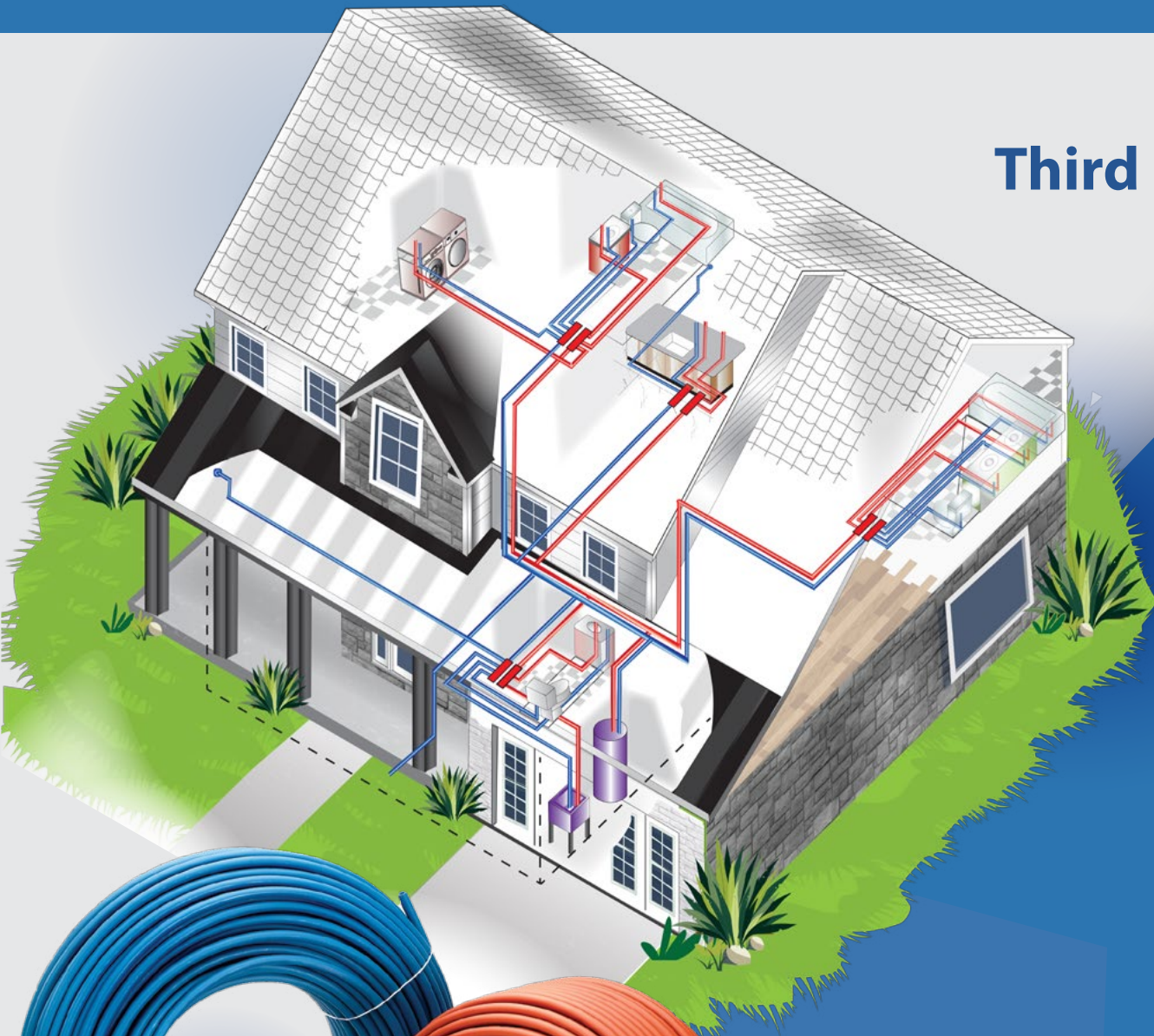


Third Edition



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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PEX Plumbing System Layouts & Design

6

The unique properties of PEX tubing allow it to be configured in a variety of plumbing system designs applicable to both residential and commercial plumbing systems. This chapter describes three popular layout options: trunk and branch, parallel (i.e., home-run), and zoned (i.e., remote manifolds). When used as described in this chapter or in various combinations, these three layouts can be configured to optimally serve almost any type of residential or commercial plumbing application.

By carefully choosing the right system for the application, the designer can produce a plumbing system that balances cost, installation time, resilience, and performance, including timely delivery of hot water with minimal water waste.

The unique features of PEX tubing allow for a great deal of system design freedom that can increase the performance and savings associated with the plumbing system. In today's high-performance homes, many designers recognize that the plumbing system can be designed to provide hot or cold water faster with greatly reduced energy loss. PEX plumbing systems can be designed to enhance these features but, like any plumbing system, PEX systems perform best and cost less to install when planned during the home's design phase. Advanced planning allows maximum performance, while limiting the lengths of pipe and number of fittings used.

When considered early enough in the house planning stage, a few simple room layout considerations can greatly improve the performance of the plumbing system. By consulting the codes and local inspectors in advance, builders and plumbers can also avoid costly time delays due to code issues arising during construction.

Note: Installers are recommended to take advantage of the flexibility of PEX tubing and to install directional fittings such as 90-degree elbows only when necessary, such as within tight cavities. The use of sweeps, usually installed with snap-on bend supports described in [Chapter 3 Material Properties](#), will typically reduce material cost, installation time, and pressure drop in the system.

This chapter describes a process that provides the guidance and tools needed to successfully lay out a PEX plumbing system in nearly any building.

Part I: Select Plumbing Layout

This section describes three popular layout options: trunk and branch, parallel (i.e., home-run), and zoned (i.e., remote manifolds) and the pros and cons of each.

Trunk and Branch (T&B)

Trunk and branch (T&B) piping systems have been used by plumbers for water distribution systems for decades. Installation of PEX tubing can be performed in a similar manner using a main trunk line to supply various branch take-offs to specific outlets. Typically, the trunk line services numerous outlets while the branch line services generally one to three closely grouped outlets, such as in a bathroom. Installation of PEX tubing in the T&B design follows the general design requirements established in plumbing codes.

As with rigid piping systems, use of tee fittings allows for the connection of branch take-offs from the main trunk. PEX tubing is available in long coils, reducing or eliminating the number of couplings that are required. Unlike rigid pipe systems, many elbows can be eliminated by bending the tubing to change direction

Specific features and advantages of the PEX trunk and branch design include:

- Simple system design
- PEX tubing provides opportunities to reduce the number of fittings thanks to flexibility of the tubing and long coils
- T&B systems will deliver hot water quicker during sequential flows with adjacent fixtures
- T&B systems will generally supply one fixture at a higher pressure as compared to a parallel (home-run) system using smaller diameter tubing

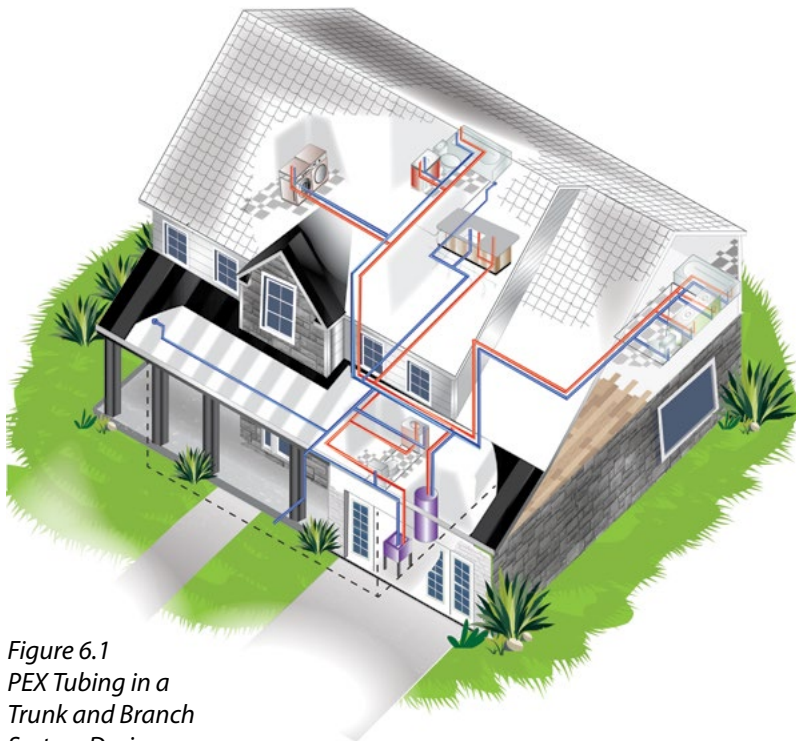


Figure 6.1
PEX Tubing in a
Trunk and Branch
System Design

Parallel (Home-run)

The unique features of PEX tubing make it ideal for use in centralized manifold-type system designs, commonly referred to as parallel or home-run plumbing systems. In this layout, each fixture is supplied with a dedicated line that runs directly from central hot- and cold-water manifolds. The hot water manifold should be located in close proximity to the hot water source to ensure fast and efficient delivery.

All outlets or fixtures are individually fed from a common manifold or two central manifolds (e.g., hot and cold). Because most, if not all, inline fittings are eliminated, pressure drop is minimized, potentially allowing the tubing size to be reduced for certain fixtures.

Depending on the hydraulic calculations and code allowance, nominal 3/8 tubing may be used for lower flow fixtures, with nominal 1/2 tubing recommended for longer lengths and higher flow fixtures. As demonstrated elsewhere in this Guide, nominal 3/8 PEX tubing has approximately 54% of the volume of nominal 1/2 tubing, so reducing tubing from 1/2 to 3/8 reduces the amount of water in a tube by 46%. This can allow for faster delivery of hot water with less wasted water.

The parallel system, sometimes referred to as “home-run” because of its similarity to home-run electrical wiring, often provides more consistent pressure when flowing water to multiple fixtures, since each fixture has its own dedicated supply line. Smaller diameter tubing also results in quicker delivery of hot water from the water heater because there is less volume of water to be flushed.

If the centralized manifolds are installed using valved outlets, it is not always required to install a second valve at the fixture (check local codes for specific requirements). An advantage of this system is the ability to shut off water for a specific fixture at the manifold without having to turn off water for the entire house at once.

Specific features and advantages of the PEX parallel design include:

- Smaller diameter tubing supplying each fixture
- Opportunity to eliminate most or all fittings between the manifold and the fixture
- Quicker delivery of hot and cold water to fixtures
- A more stable pressure to each fixture when operating simultaneous fixtures
- Ability to isolate individual fixtures from a central manifold

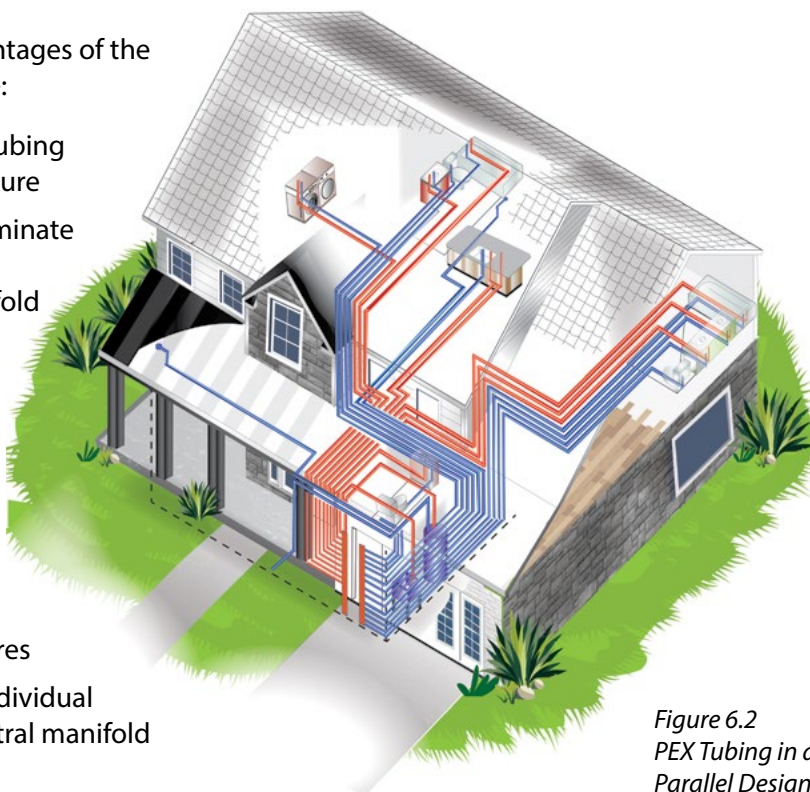


Figure 6.2
PEX Tubing in a
Parallel Design

Zoned (Remote Manifolds / Multi-port Tees)

A third method for installing PEX systems combines elements of the first two systems and is typically referred to as a zoned system design. The basic approach to this system is running hot and cold trunk lines to locations in close proximity to multiple fixtures, such as a kitchen or bathroom group. At this point, a small manifold or multi-port tee is installed on each trunk line, and individual branch lines, typically 3/8 or 1/2 tubing, are then run to each fixture.

The remote manifolds/multi-port tees typically do not have valves, unlike the centralized manifolds used in parallel plumbing. These manifolds are available as flow-through or closed end. Manifolds with valves must be installed in accessible locations; manifolds without valves or multi-port tees may be installed in enclosed spaces such as within floors or walls.

The zoned system combines advantages of the Trunk and Branch layout and the Parallel layout and simplifies installation due to the reduced number of fittings and joints that are required. This layout also uses less tubing than parallel plumbing, with fewer penetrations through studs, joists, etc.

Specific features and advantages of the zoned plumbing layout include:

- Relatively simple system design conversion from rigid piping to flexible PEX tubing
- Opportunities to reduce the number of fittings installed
- Quicker hot water delivery during sequential flows
- Easier to implement hot-water recirculation than with parallel layouts
- Opportunity to have centrally located individual shutoffs at each bathroom group when manifolds are accessible

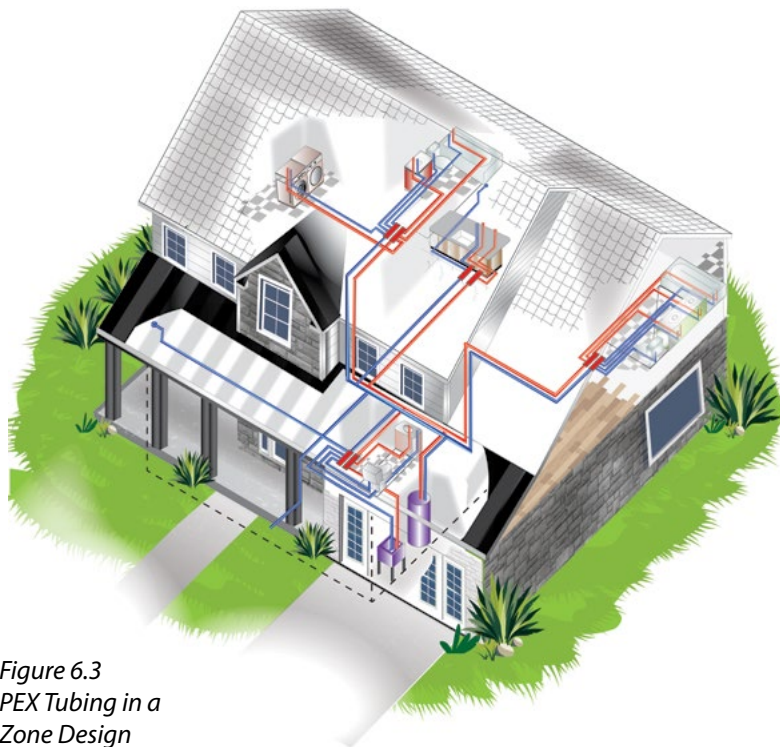


Figure 6.3
PEX Tubing in a
Zone Design

Part II: Design Recommendations

Optimize Plumbing Designs (fixture layouts)

Some of the most substantial problems with modern plumbing system designs relate not to the piping itself, but to the design and layout of the building. The materials that are chosen for framing, the location of rooms, the location of the water heater/s, and the point at which the water service line or building supply line enters the building can all have a significant impact on the performance of a hot- and cold-water distribution system. Often, the design of the plumbing system is left until the end of the design process when the building layout is largely determined. This can result in a poorly performing and costly system. By observing a number of guidelines early in the design process, PEX tubing systems can be installed in ways that minimize costs, ease installation, and increase occupant satisfaction.

One key to optimizing the design of any plumbing system is to minimize pipe lengths from the water heater to the fixtures. While this may seem intuitive, it cannot be stressed enough. Within the building, short piping runs result in shorter wait-times for hot water, better water quality due to reduced stagnation, potentially higher pressure, faster installation time, and lower material costs. This can be accomplished by the builder or designer early in the planning stage using several basic design principles:

1. **Group fixtures together** – Grouping plumbing fixtures around a common location can result in saving time, materials, water, and the energy required to heat the water. This can be done between floors as well, such as in the case of stacked bathrooms. Where possible, avoid locating bathrooms long distances from the water heater.
2. **Centrally located distribution point** – Centrally located water heaters and incoming water supplies can significantly improve the performance of a plumbing system. Water heater locations are typically not given a lot of thought, resulting in locations selected for convenience or placed in the utility room, commonly far from the fixture groups. This approach often leads to excessively long plumbing runs along with the resultant increase in materials, installation time, and water and energy use. Whenever feasible, locate the water heater as close as possible to the mid-point of the fixture groupings to keep tubing runs short.
3. **Create spaces for bundled pipe runs** – Particularly applicable to parallel (home-run) layouts, simultaneous installation of multiple tubing runs will reduce installation time. The flexibility of PEX tubing, available in coils, enables the simultaneous installation of multiple plumbing lines running in the same direction using common holes and chases. By utilizing space in interior soffits, bulkheads, and chases for tubing bundles, installation time can be reduced. However, cold and hot water lines should be bundled separately (i.e., cold with cold, hot with hot) and installers should follow local codes for pipe insulation requirements, especially for hot-water lines.
4. **Use building elements that ease tubing installation** – Using building construction elements such as open web floor trusses can dramatically speed up the process of installing plumbing tubing. This can also speed up the process of installation of other mechanicals including ducting and wiring.

Select Tubing System Layout and Design

The next step for the designer, plumber, and builder is to select the most appropriate plumbing system layout (e.g., trunk and branch, parallel, zoned) and design for the home or building. The unique properties of PEX tubing allow it to be configured in a number of different designs. All have been shown to work well in residential, multi-family, and commercial applications and all are code compliant. The selection of a system layout and design is generally based on a combination of key factors such as material cost, labor time, ease of installation, system performance, and installer preference.

The challenge for a plumbing designer is to select the layout that balances the unique needs of the installer, owner, and builder. This section of the Guide and [Chapter 7 Optimizing Design](#) will provide comparisons of the three most prevalent PEX plumbing layouts: trunk and branch, parallel, and zoned, and the guidance to select between layouts.

Selecting among the three layout options often involves a balance of the key factors since each project, installer, and circumstance is different. Selecting the best system for your project can reduce installation costs, minimize installation time, and lead to more satisfied owners. As demonstrated in [Chapter 8 Performance Data](#), all three system layouts can supply sufficient flow and pressure to the fixtures.

To aid in the decision-making process, several tools are provided:

1. **General Rankings of the layouts for Key Factors** – [Table 6.1](#) will provide a place to start and demonstrate how the layouts compare to each other based on specific priorities.
2. **Example Layouts** – In [Chapter 7](#), detailed designs of each layout are provided for four common residence types. By selecting the residence type that most closely resembles your project, you can see how the layouts compare for your building.
3. **Performance Testing** – The three layouts were compared and measured in comprehensive laboratory tests. By examining the test data shown in [Chapter 8](#), you can identify differences in the systems' performance in varying scenarios (e.g., low or high incoming pressure).
4. **Industry Technical Support** – Manufacturers and organizations offer a range of resources to assist PEX users. Available support ranges from general information to technical assistance on specific projects. For example, PPI's **Plastic Pipe Design Calculator** www.plasticpipecalculator.com can be used to estimate pressure drop through plumbing systems of various diameters.

General Rankings of the Layouts

The general characteristics of the three major layout options are ranked in [Table 6.1](#). Given the wide difference between building designs and preferences, they may not apply in every situation but are useful for general guidance as you design your building. The best way to use [Table 6.1](#) is to establish the relative priority of key factors, and then use the rankings of system designs to provide a starting point for the system to be selected.

Table 6.1 General Rankings of the System Characteristics

Factor	***	**	*
Minimize Tubing Used	Trunk and Branch	Zoned	Parallel
Minimize Fittings ^a and Joints	Parallel	Zoned	Trunk and Branch
Sequential Flow Hot Water Delivery Time	Trunk and Branch		
Zoned		Parallel	
Minimize Hot Water Wait Time	Parallel	Zoned	Trunk and Branch
Single Fixture Pressure	Trunk and Branch	Parallel Zoned	
Pressure Stability with Use of Multiple Fixtures	Parallel	Zoned	Trunk and Branch
Centralize Shut-off Valving	Parallel	Zoned	Trunk and Branch
Joint Accessibility During Installation	Parallel	Zoned	Trunk and Branch

*** Indicates the highest level of performance for that factor

* Indicates typical performance

^a A fitting is the device that allows the PEX tubing to change direction or size (i.e., tees, elbows, reducers). A joint is the connection of the PEX tubing to a fitting (i.e., a tee fitting has three joints).

For example, if a user determines that their top three factors are Minimizing Fittings and Joints, Centralized Shut-off Valving, and Pressure Stability with Use of Multiple Fixtures, then, given the fact that the parallel system ranks at the top of all three, it is a logical place to start.

However, if your top factors give you three different best designs, the right choice is not as obvious. You will then need to consider other factors and further explore the detailed design of your building to make a choice. The example layouts earlier in this chapter may then be helpful in making a choice.

Since local labor costs vary and there is variation between the fitting and tubing costs offered by different manufacturers, cost has been omitted as a factor in Table 6.1. This table simply provides information on the amount of tubing and fittings needed. Since the balance between material and labor cost varies across the country, the determination of actual cost estimates and total cost comparison between system designs is left to the designer or installer.

Plan Pipe Routing, Manifold/Multi-port Tee, and Valve Locations

Once the system layout and design are selected, the final step in the design process is to plan pipe routing, manifold/multi-port tee sizes and locations, and valve locations. There are several guidelines that can simplify this process. Bear in mind that PEX tubing is available in continuous coils as well as straight lengths. Consult local codes for specific installation requirements for your project.

Guidelines for optimizing the design of a PEX plumbing system include:

- **Minimize fittings** – The flexibility of smaller diameter PEX tubing (e.g., ≤NTS 1) enables it to be easily installed around obstructions and through framing members. Use of sweeps to change direction (i.e., bending the pipe in a gentle sweep rather than using elbow fittings) can result in quicker installations, fewer fittings, and potentially less pressure drop.

- **Group fixtures together** – If using trunk and branch or zoned layouts, use common trunk lines to feed multiple fixture groups. For example, if two bathrooms are stacked, use a single trunk line to supply both bathrooms groups, rather than two trunk lines.
- **Minimize pipe lengths** – Though this may seem intuitive, attention to this detail should lead to more efficiently installed plumbing systems plus benefits such as shorter wait for hot water.
- **Select appropriate tubing diameters** – Codes do not require changing the diameter or sizes of distribution tubing when switching from one tubing material to another. Performance data generated by Home Innovations and detailed in **Chapter 8 Performance Data** explains that PEX tubing can replace copper tubing on a size-for-size basis. Refer to local codes and the “Pipe Sizing” section below for specific recommendations.

Taking a short amount of time to plan the tubing sizes needed to supply the proper flow rates at the required pressure will result in the use of tube sizes that deliver the required fixture flow rate without being oversized. Oversized plumbing system designs result in wasted energy and water, as well as reduced customer satisfaction with the plumbing system operation.

1. **Bundle pipe runs** – Applicable particularly to PEX plumbing runs where few fittings are installed, installation of multiple tubing runs at the same time will reduce installation time. The flexibility of PEX tubing and the long unbroken lengths that can be easily fed from coils enables the simultaneous installation of multiple plumbing lines running in the same direction using common holes through framing members such as joists.
2. **Plan for solid attachment of transition points** – The flexibility of PEX tubing also requires that the transition to threaded fittings or rigid piping be performed correctly. As with most piping materials, solid connection points and attachment points are necessary when threading on valves and transition fittings to other materials. For example, drop-ear elbows, which include several tabs with holes for fastening to braces and supports, are available for installation of tub outlets and shower heads.
3. **Use color coding** – PEX tubing is often available in different colors. Using dedicated colors for hot, cold, and reclaimed water, where applicable, can be helpful for installers, owners, and future retrofits. However, it is not necessary to utilize PEX of different colors and this is not a requirement in any model code.
4. **Plan manifold locations** – Before selecting and locating manifolds, determine whether valves will be placed at end-points (e.g., at fixtures) or on central manifolds. Some jurisdictions require valves at all fixtures while others allow them to be located on central manifolds. In some cases, the homeowner, architect, or building owner may express a preference for the location of shut-off valves.

If valved manifolds are used, they must be situated to allow easy access and not concealed behind drywall, for example. This can be accomplished by placing them behind access panels or in open areas such as in basements, laundry rooms, mechanical rooms, or garages where no freezing potential exists. Just as with an electrical breaker panel, it is important to label each valve on the manifold to ensure easy identification of the distribution lines.

If manifolds without valves are used and local codes allow, the manifolds may be enclosed within walls or floors, similar to any other fitting such as a tee or elbow.

Pipe Sizing

Selecting appropriate pipe sizes or diameters can be a multi-faceted challenge. In many cases, the prevailing plumbing code dictates minimum pipe diameter based on predicted demand or flow rates, but some of those sizing tables are based on outdated expectations of fixture demands and unrealistic simultaneous usage. Current research has resulted in updated pipe sizing methods for certain types of construction, such as IAPMO's **Water Demand Calculator** (WDC), and further research will continue to update pipe sizing tables. This section discusses several aspects of pipe sizing for both residential and commercial design.

Oversized piping results in wasted energy and water since it takes longer to flush larger hot water lines to get hot water to fixtures. This can also lead to reduced customer satisfaction with the plumbing system. Oversized piping can result in stagnant water in which disinfectants such as chlorine decay, creating the possibility of growth of opportunistic pathogens such as Legionella. Oversized piping also reduces the velocity of water within the pipes, with the potential to allow greater biofilm growth¹. Finally, oversized piping wastes material and increases installation costs.

Undersized piping can result in excessive water velocities that could lead to erosion corrosion in metallic components or a higher probability of surge pressures and water hammer as a result of fast-closing valves. Undersized piping can also lead to excessive pressure drop and insufficient pressure at distal outlets. See **Table 6.2** for **Flow Velocity** through all diameters of PEX tubing and **Tables 6.3** and **6.4** for **Pressure Drop** of water through PEX tubing at 60°F (16°C) and 125°F (52°C), respectively.

High water velocities can also result in excessive surge pressures that can damage other plumbing system components and create audible water hammer when a fast-acting valve closes. Plastic pipe materials such as PEX, which is inherently more flexible than metallic materials and therefore able to absorb instantaneous surge pressures, will help to reduce surge pressures and water hammer (see **Chapter 3 Material Properties**).

The maximum recommended flow velocities through PEX tubing are **10 feet per second** (3.0 m/s) for cold water up to 80°F (26.5°C) and **8 feet per second** (2.4 m/s) for water temperatures above 80°F and up to 140°F (60°C).

Note: While PEX tubing can withstand flow velocities in **excess of 8 feet per second** for both hot and cold water without harm, the pressure drop through the tubing at such elevated velocities makes such flow rates impractical and inadvisable for most designs.

The Plastic Pipe Institute's **Plastic Pipe Design Calculator** can be used to select optimal pipe diameters to manage pressure drop and velocity. www.plasticpipecalculator.com.

¹ *Impact of Premise Plumbing Design, Velocity, and Operational Factors on Microbial Activity During Stagnation in Pipes*, P. Gurian, S. Samuel, N. Yadav, M. Krieger, R. Singh, T. Bartrand, 2025

Domestic Hot Water Recirculation (DHWR)

Since 2003, chlorine resistance testing according to ASTM Test Method F2023 is a mandatory requirement for all PEX tubing intended for potable water applications as per tubing standards ASTM F876 and CSA B137.5. Continuous recirculation, timed recirculation, and traditional domestic (i.e., intermittent) conditions are evaluated.

This test procedure is designed to extrapolate the life expectancy of a plumbing pipe when used at a hot-water temperature of 140°F (60°C) and a pressure of 80 psig (0.55 MPa), considered to be the normal operating limits of domestic hot-water plumbing systems. ASTM F2023 allows test laboratories to use reverse osmosis-purified water with a free chlorine concentration of 4 ppm (4 mg/L) and pH of 6.8, resulting in an ORP of 825 mV or higher. This represents a very aggressive water quality which gives conservative results in terms of service life of the pipe.

Note: Continuous recirculation of hot chlorinated water through PEX tubing at temperatures above 140°F (60°C) is beyond the intended application of the standard chlorine ratings as defined in those standards listed above. See **PPI TN-53 Guide to Chlorine Resistance Ratings of PEX Pipe and Tubing** for more information.

When selecting PEX tubing for a domestic hot water recirculation system (DHWR), ensure the tubing has the appropriate level of chlorine resistance for the application. This can be verified through the PEX Material Designation Code (e.g., PEX 5106) and by contacting the tubing manufacturer. See **Chapter 3 Material Properties** for details about chlorine resistance.

Where possible, it is recommended to utilize **intermittent recirculation systems**, such as circulating pumps on timers or activated by demand sensors, and to not run recirculation systems continuously (i.e., 24/7). This will help to save energy and comply with energy codes.

It is recommended that designers size tubing to achieve velocities that will deliver domestic hot water to distal points of the plumbing system and return to the source with a temperature drop of not more than 10°F (5.6°C), in accordance with *ASPE Plumbing Design Handbook Volume Two*. Pipe insulation is sometimes needed to help achieve consistent hot water temperatures throughout a domestic hot water recirculation (DHWR) piping loop for the purposes of faster delivery of hot water to distal points, as well as energy conservation.

Maintaining hot water temperatures between 125°F and 135°F (51°C to 57°C) will prevent the growth of pathogens (e.g., *Legionella*) while minimizing the risk of scalding and preventing excessive energy loss due to excessive water temperatures. However, the IAPMO Uniform Plumbing Code, Appendix N states that scalding (“second degree burn”) can occur in as little as 18 seconds when skin is exposed to 130°F (54°C) water. Installation of appropriate mixing devices is recommended to reduce outlet water temperatures to reduce the risk of scalding.

For the return piping of domestic hot water recirculation (DHWR) systems, according to **IAPMO IS-31(2023)**, the return piping flow velocity shall not exceed **2 feet per second** (0.6 m/s) for PEX tubing. This maximum flow velocity through return lines can be accommodated by controlling the flow rate via correct adjustment of DHWR circulation pumps (i.e., do not oversize pumps) or by increasing the diameter of the pipe return legs to reduce the flow velocity (e.g., increase from 1/2 to 3/4 tubing). See **Table 6.2** which shows the flow rate/volume per each nominal diameter of PEX tubing at a 2 ft/sec flow velocity.

Table 6.2 Flow Rate/Volume for PEX Tubing at 2 ft/sec Velocity

Nominal Tubing Size (NTS)	Flow Rate at 2 ft/sec GPM (L/min)
1/2	1.1 (4.2)
3/4	2.2 (8.3)
1	3.6 (13.6)
1 1/4	5.4 (20.4)
1 1/2	7.5 (28.4)
2	12.9 (48.8)
2 1/2	19.5 (74.0)
3	27.7 (105.0)
4	48.1 (182.0)

Other Design Considerations

If a pressure reducing valve (PRV) is installed in a plumbing system, an expansion tank or other form of thermal expansion relief is recommended. Consult the local code and the Authority Having Jurisdiction (AHJ).

Finally, for commercial plumbing systems, designers are recommended to review the following industry publications:

- ASPE Engineered Plumbing Design II
- ASPE Plumbing Engineering Design Handbook, Volume One: Fundamentals of Plumbing Engineering
- ASPE Plumbing Engineering Design Handbook, Volume Two: Plumbing Systems
- ASPE Engineering Methodologies to Reduce the Risk of Legionella in Premise Plumbing Systems
- ASHRAE Guideline 12 *Managing the Risk of Legionellosis Associated with Building Water Systems*
- ASHRAE 188 *Legionellosis: Risk Management for Building Water Systems*
- ASHRAE 514 *Risk Management for Building Water Systems: Physical, Chemical and Microbial Hazards*
- IAPMO Uniform Plumbing Code (UPC) Appendix N *Impact of Water Temperature on the Potential for Scalding and Legionella Growth*
- IAPMO Z1403 Water Demand Calculator

Part III: Flow Velocity and Pressure Drop Tables

The following tables provide detailed design information about sizing PEX tubing based on flow velocities and pressure drop:

- **Table 6.3 Flow Velocity in PEX Tubing**
- **Table 6.4 Pressure Drop through PEX Tubing with 60°F (16°C) Water**
- **Table 6.5 Pressure Drop through PEX Tubing with 125°F (52°C) Water**

The information in these tables was developed from the **PPI Plastic Pipe Design Calculator** which is a free online tool available at www.plasticpipe.org.

Notes to Tables 6.3, 6.4 and 6.5:

- All Flow Rates shown in this Guide are in US gallons (3.78 l) per minute (GPM).
- Values in **red** represent flow velocities above 10 fps (3.0 m/s) which are not recommended for PEX.
- Values in **blue** represent transition flow rates between laminar and turbulent flow for which precise pressure drop values cannot be calculated.

Table 6.3 Flow Velocity in PEX Tubing

Flow Rate GPM	Flow Velocity ft/sec									
	3/8	1/2	3/4	1	1 1/4	1 1/2	2	2 1/2	3	4
0.5	1.67	0.91	0.45	0.27	0.18	0.13	0.08	0.05	0.04	0.02
0.75	2.50	1.36	0.68	0.41	0.28	0.20	0.12	0.08	0.05	0.03
1.0	3.33	1.81	0.91	0.55	0.37	0.26	0.15	0.10	0.07	0.04
1.5	5.00	2.72	1.36	0.82	0.55	0.40	0.23	0.15	0.11	0.06
2.0	6.67	3.62	1.81	1.10	0.74	0.53	0.31	0.20	0.14	0.08
2.5	8.34	4.53	2.27	1.37	0.92	0.66	0.38	0.25	0.18	0.10
3.0	10.0	5.43	2.72	1.65	1.10	0.79	0.46	0.30	0.21	0.12
3.5	11.7	6.34	3.18	1.92	1.29	0.92	0.54	0.35	0.25	0.14
4.0	13.3	7.24	3.63	2.20	1.47	1.06	0.62	0.40	0.28	0.16
4.5		8.15	4.08	2.47	1.65	1.19	0.69	0.45	0.32	0.18
5.0		9.05	4.54	2.75	1.84	1.32	0.77	0.51	0.36	0.20
6.0		10.9	5.44	3.30	2.21	1.58	0.92	0.61	0.43	0.24
7.0		12.7	6.35	3.85	2.57	1.85	1.08	0.71	0.50	0.28
8.0			7.26	4.40	2.94	2.11	1.23	0.81	0.57	0.33
9.0			8.17	4.95	3.31	2.38	1.39	0.91	0.64	0.37
10.0			9.07	5.50	3.68	2.64	1.54	1.01	0.71	0.41
11.0			9.98	6.05	4.04	2.90	1.69	1.11	0.78	0.45
12.0			10.9	6.60	4.41	3.17	1.85	1.21	0.85	0.49
13.0			11.8	7.15	4.78	3.43	2.00	1.31	0.92	0.53
14.0				7.70	5.15	3.70	2.16	1.41	0.99	0.57

Table 6.3 Flow Velocity in PEX Tubing (Continued)

Flow Rate GPM	Flow Velocity ft/sec									
	3/8	1/2	3/4	1	1 1/4	1 1/2	2	2 1/2	3	4
15.0				8.25	5.52	3.96	2.31	1.52	1.07	0.61
16.0				8.80	5.88	4.22	2.46	1.62	1.14	0.65
17.0				9.35	6.25	4.49	2.62	1.72	1.21	0.69
18.0				9.90	6.62	4.75	2.77	1.82	1.28	0.73
19.0				10.4	6.99	5.02	2.92	1.92	1.35	0.77
20.0				11.0	7.35	5.28	3.08	2.02	1.42	0.81
25.0					9.19	6.60	3.85	2.53	1.78	1.02
30.0					11.0	7.92	4.62	3.03	2.13	1.22
35.0					12.9	9.24	5.39	3.54	2.49	1.42
40.0						10.6	6.16	4.04	2.84	1.63
45.0						11.9	6.93	4.55	3.20	1.83
50.0							7.70	5.05	3.55	2.03
55.0							8.47	5.56	3.91	2.24
60.0							9.24	6.06	4.26	2.44
65.0							10.0	6.57	4.62	2.64
70.0							10.8	7.07	4.97	2.85
75.0							11.5	7.58	5.33	3.05
80.0								8.08	5.68	3.25
85.0								8.59	6.04	3.46
90.0								9.09	6.39	3.66
95.0								9.60	6.75	3.86
100.0								10.1	7.10	4.07
110.0								11.1	7.81	4.47
120.0									8.52	4.88
130.0									9.23	5.29
140.0									9.95	5.69
150.0									10.7	6.10
160.0									11.4	6.51
170.0										6.92
180.0										7.32
190.0										7.73
200.0										8.14
220.0										8.95
240.0										9.76
260.0										10.6
280.0										11.4
300.0										12.2

Values in red represent flow velocities above 10 fps (3.0 m/s) which are not recommended for PEX.

Table 6.4 Pressure Drop through PEX Tubing with 60°F (16°C) Water

Flow Rate GPM	psi/100 ft of Pipe									
	3/8	1/2	3/4	1	1 1/4	1 1/2	2	2 1/2	3	4
0.5	1.0-2.6	0.3-0.6	0.08-0.1	0.03	0.01	0.01	0.00	0.00	0.00	0.00
0.75	5.15	1.22	0.1-0.2	0.05-0.1	0.02	0.01	0.00	0.00	0.00	0.00
1.0	8.46	1.99	0.39	0.08-0.12	0.05	0.01	0.00	0.00	0.00	0.00
1.5	17.1	4.02	0.78	0.24	0.10	0.05	0.00	0.00	0.00	0.00
2.0	28.3	6.63	1.29	0.39	0.15	0.07	0.00	0.00	0.00	0.00
2.5	42.0	9.79	1.90	0.58	0.22	0.10	0.03	0.00	0.00	0.00
3.0	57.9	13.5	2.61	0.79	0.31	0.14	0.04	0.01	0.00	0.00
3.5	76.1	17.7	3.41	1.04	0.40	0.18	0.05	0.02	0.01	0.00
4.0	96.5	22.4	4.31	1.31	0.50	0.23	0.06	0.02	0.01	0.00
4.5		27.6	5.30	1.61	0.62	0.28	0.08	0.03	0.01	0.00
5.0		33.2	6.38	1.94	0.74	0.34	0.09	0.03	0.02	0.00
6.0		45.9	8.80	2.67	1.02	0.47	0.13	0.05	0.02	0.01
7.0			11.6	3.50	1.34	0.61	0.17	0.06	0.03	0.01
8.0			14.7	4.43	1.70	0.77	0.21	0.08	0.03	0.01
9.0			18.1	5.45	2.09	0.95	0.26	0.10	0.04	0.01
10.0			21.8	6.57	2.52	1.14	0.32	0.12	0.05	0.01
11.0			25.8	7.78	2.98	1.35	0.37	0.14	0.06	0.02
12.0			30.2	9.08	3.47	1.57	0.44	0.16	0.07	0.02
13.0			34.8	10.5	4.00	1.81	0.50	0.18	0.08	0.02
14.0				11.9	4.56	2.07	0.57	0.21	0.09	0.02
15.0				13.5	5.16	2.34	0.65	0.24	0.10	0.03
16.0				15.2	5.79	2.62	0.72	0.26	0.11	0.03
17.0				16.9	6.44	2.92	0.80	0.29	0.13	0.03
18.0				18.7	7.14	3.23	0.89	0.33	0.14	0.04
19.0				20.6	7.86	3.55	0.98	0.36	0.16	0.04
20.0				22.6	8.61	3.89	1.07	0.39	0.17	0.05
25.0					12.8	5.79	1.59	0.58	0.25	0.07
30.0					17.8	8.03	2.20	0.80	0.35	0.09
35.0					23.5	10.6	2.90	1.06	0.46	0.12
40.0						13.4	3.68	1.34	0.58	0.15
45.0						16.6	4.55	1.66	0.71	0.19
50.0							5.50	2.00	0.86	0.23
55.0							6.52	2.37	1.02	0.27
60.0							7.63	2.77	1.19	0.31
65.0							8.81	3.20	1.38	0.36
70.0							10.1	3.66	1.57	0.41
75.0							11.4	4.14	1.78	0.47
80.0								4.65	2.00	0.52
85.0								5.18	2.23	0.58

Table 6.4 Pressure Drop through PEX Tubing with 60°F (16°C) Water (Continued)

Flow Rate GPM	psi/100 ft of Pipe									
	3/8	1/2	3/4	1	1 1/4	1 1/2	2	2 1/2	3	4
90.0								5.75	2.47	0.65
95.0								6.34	2.72	0.71
100.0								6.95	2.98	0.78
110.0								8.26	3.54	0.93
120.0									4.14	1.08
130.0									4.78	1.25
140.0									5.47	1.43
150.0									6.19	1.62
160.0									6.96	1.82
170.0										2.03
180.0										2.25
190.0										2.48
200.0										2.72
220.0										3.23
240.0										3.79
260.0										4.38
280.0										5.01
300.0										5.67

Values in red represent flow velocities above 10 fps (3.0 m/s) which are not recommended for PEX. Values in blue represent transition flow rates between laminar and turbulent flow for which precise pressure drop values cannot be calculated.

Table 6.5 Pressure Drop through PEX Tubing with 125°F (52°C) Water

Flow Rate GPM	psi/100 ft of Pipe									
	3/8	1/2	3/4	1	1 1/4	1 1/2	2	2 1/2	3	4
0.5	2.06	0.49	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.75	4.18	0.98	0.19	0.06	0.02	0.00	0.00	0.00	0.00	0.00
1.0	6.91	1.62	0.31	0.10	0.04	0.02	0.00	0.00	0.00	0.00
1.5	14.1	3.29	0.64	0.19	0.07	0.03	0.01	0.00	0.00	0.00
2.0	23.6	5.46	1.05	0.32	0.12	0.06	0.02	0.01	0.00	0.00
2.5	35.1	8.11	1.56	0.47	0.18	0.08	0.02	0.01	0.00	0.00
3.0	48.7	11.2	2.15	0.65	0.25	0.11	0.03	0.01	0.01	0.00
3.5	64.2	14.8	2.82	0.85	0.33	0.15	0.04	0.02	0.01	0.00
4.0	81.7	18.8	3.58	1.08	0.41	0.19	0.05	0.02	0.01	0.00
4.5		23.2	4.41	1.33	0.51	0.23	0.06	0.02	0.01	0.00
5.0		28.0	5.32	1.60	0.61	0.28	0.08	0.03	0.01	0.00
6.0		38.9	7.37	2.22	0.85	0.38	0.11	0.04	0.02	0.00
7.0		51.3	9.71	2.92	1.11	0.50	0.14	0.05	0.02	0.01
8.0			12.3	3.70	1.41	0.64	0.18	0.06	0.03	0.01
9.0			15.3	4.57	1.74	0.79	0.22	0.08	0.03	0.01
10.0			18.4	5.52	2.10	0.95	0.26	0.10	0.04	0.01
11.0			21.9	6.55	2.49	1.13	0.31	0.11	0.05	0.01
12.0			25.6	7.66	2.91	1.32	0.36	0.13	0.06	0.02
13.0			29.6	8.85	3.36	1.52	0.42	0.15	0.07	0.02
14.0				10.1	3.84	1.73	0.48	0.17	0.08	0.02
15.0				11.5	4.35	1.96	0.54	0.20	0.08	0.02
16.0				12.9	4.88	2.20	0.60	0.22	0.10	0.03
17.0				14.4	5.45	2.45	0.67	0.25	0.11	0.03
18.0				15.9	6.04	2.72	0.75	0.27	0.12	0.03
19.0				17.6	6.66	3.00	0.82	0.30	0.13	0.03
20.0				19.3	7.30	3.29	0.90	0.33	0.14	0.04
25.0					10.9	4.91	1.34	0.49	0.21	0.06
30.0					15.2	6.83	1.86	0.68	0.29	0.08
35.0					20.1	9.04	2.46	0.89	0.38	0.10
40.0						11.5	3.13	1.14	0.49	0.13
45.0						14.3	3.88	1.40	0.60	0.16
50.0							4.69	1.70	0.73	0.19
55.0							5.58	2.02	0.87	0.23
60.0							6.53	2.36	1.01	0.26
65.0							7.56	2.73	1.17	0.31
70.0							8.65	3.12	1.34	0.35
75.0							9.81	3.54	1.52	0.40
80.0								3.98	1.70	0.44
85.0								4.45	1.90	0.50

Table 6.5 Pressure Drop through PEX Tubing with 125°F (52°C) Water (Continued)

Flow Rate GPM	psi/100 ft of Pipe									
	3/8	1/2	3/4	1	1 1/4	1 1/2	2	2 1/2	3	4
90.0								4.93	2.11	0.55
95.0								5.45	2.33	0.61
100.0								5.98	2.55	0.67
110.0								7.12	3.04	0.79
120.0									3.56	0.93
130.0									4.12	1.07
140.0									4.71	1.22
150.0									5.35	1.39
160.0									6.02	1.56
170.0										1.74
180.0										1.93
190.0										2.14
200.0										2.34
220.0										2.79
240.0										3.27
260.0										3.79
280.0										4.34
300.0										4.92

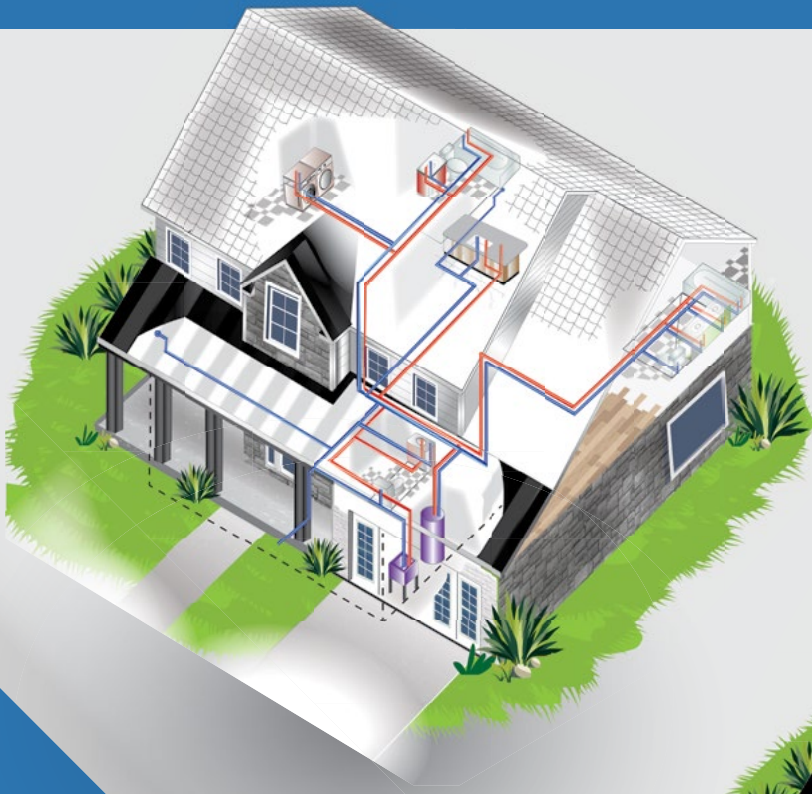
Values in red represent flow velocities above 10 fps (3.0 m/s) which are not recommended for PEX. Values in blue represent transition flow rates between laminar and turbulent flow for which precise pressure drop values cannot be calculated.

Part IV: Comparison of Flow Rates through PEX and Copper Tubing in a Plumbing System

To compare the actual pressure drop and flow rate performance of plumbing systems constructed in the same design using both PEX and Type L copper tubing, laboratory testing was performed on identical configurations of PEX and copper trunk and branch (T&B) plumbing systems serving standard residential plumbing fixtures supplied at source pressures of 40, 60, and 80 psi, with lengths of 60 and 100-feet of pipe to the furthest fixture. The measured flow rate at each plumbing fixture was virtually identical for both piping systems, except for minor differences in the water closet fill rate.

Even though PEX tubing has a slightly smaller inside diameter than copper tubing of the same nominal dimension, both tubing systems satisfied the farthest fixture demand, even with multiple fixtures flowing. **Table 6.6** compares the two piping systems with a minimum source pressure of 40 psi and a maximum tubing length of 100 ft, the most demanding scenario in the test. Results of flow tests using higher pressures were consistent.

This testing demonstrates that in a typical single-family residential plumbing system, both PEX and copper piping systems will deliver sufficient volumetric flow rates and pressures to



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