

uponor

PEX Piping Systems Design and Installation Manual

Moving plumbing and mechanical piping forward



PEX Piping Systems Design and Installation Manual
is published by

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Uponor has used reasonable efforts in collecting, preparing, and providing quality information and material in this manual. However, system enhancements may result in modification of features or specifications without notice.

Uponor is not liable for installation practices that deviate from this manual or are not acceptable practices within the mechanical trades.

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Foreword

This design and installation manual is published for architects, building officials, engineers, plumbers, and mechanical contractors interested in Uponor PEX plumbing and hydronic piping systems. It describes general installation recommendations that use Uponor PEX piping products. Refer to local codes for additional requirements.

Uponor made reasonable efforts to collect, prepare and provide quality information and material in this manual. However, system enhancements may result in modification of features or specifications without notice.

Uponor is not liable for installation practices that deviate from this manual or are not acceptable practices within the mechanical trades, codes or standards of practice.

Refer to the Uponor AquaSAFE™ Installation Guide to install a combination plumbing and fire safety system using Uponor products.

Direct any questions regarding the suitability of an application or a specific design to a local Uponor representative by calling 888.594.7726.

Note that this manual is available in English, Spanish, and French at no charge. To order additional copies, visit the Uponor website at uponor.com.

Throughout this document, there will be multiple references to the requirements of Local or National codes. Uponor recognizes the importance of consistent regulations and works closely with industry associations and code development bodies to ensure transparency, consistency and safety. It is important to understand the difference between a manufacturer's (Uponor) recommendation and the code requirement as it applies. If there are differences between Uponor's recommendations and design parameters and the enforceable code language, it is critically

important that the more restrictive criteria be followed. Where Uponor's recommendations are more restrictive than the adopted code, our limitations must be followed to ensure the product(s) perform as expected and remain covered under Uponor's Limited Warranty. Uponor always recommends confirming that the products, design and intended installation are acceptable to the local Authority Having Jurisdiction (AHJ) and comply with all local codes, ordinances and regulations prior to installation.



Chapter 1

Uponor PEX Properties

Uponor PEX properties

PEX is an acronym for crosslinked polyethylene. The “PE” refers to the raw material used to make polyethylene; the “X” refers to the crosslinking of the polyethylene across its molecular chains. The molecular chains are linked into a three-dimensional network that makes PEX remarkably durable within a wide range of temperatures and pressures.

Currently, three methods exist for producing PEX:

- Engel or peroxide method (PEX-a)
- Silane method (PEX-b)
- Electron beam (e-beam) or radiation method (PEX-c)

All three processes generate pipe that is crosslinked to various degrees according to ASTM

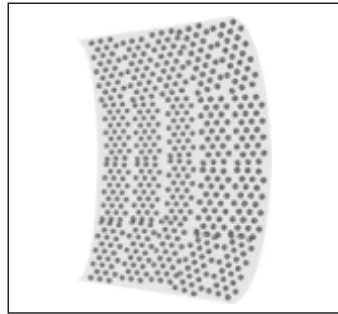


Figure 1-1: PEX-a (Engel) 80%+ crosslinked

F876 and F877 standards.

Uponor manufactures Engel-method PEX-a pipe. The PEX industry considers this pipe superior because the crosslinking is done during the manufacturing process when the polyethylene is in its amorphous state (above the crystalline melting point). Accordingly, the degree of crosslinking reaches more than 80%, resulting in a more uniform product with no weak links in the molecular chain.

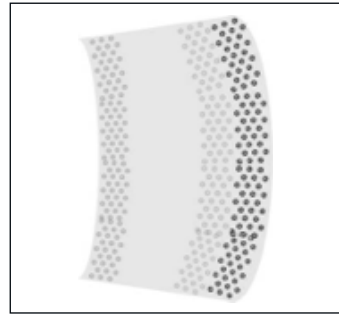


Figure 1-2: PEX-b (Silane) 65-70% crosslinked

PEX-a distinctions

The properties of PEX-a pipe make it the most flexible PEX on the market. This flexibility allows the tightest bend radius available — six times the outside diameter of the pipe. Its flexibility also greatly reduces instances of kinked pipe. And in the rare instance of a kink, the thermal memory of PEX-a allows kink repair with a simple shot of heat from a heat gun.

The pipe’s shape memory also offers the unique

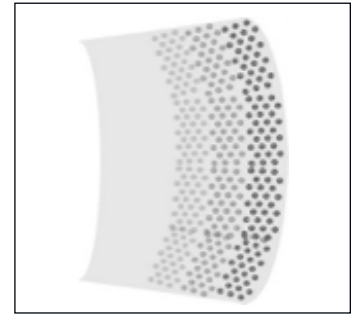


Figure 1-3: PEX-c (Radiation) 70-75% crosslinked

opportunity for ProPEX fitting connections. Shape memory allows PEX-a to expand and then shrink back to normal size — creating strong, durable and reliable fitting connections.

Finally, PEX-a pipe offers more resistance to crack propagation (how a crack grows) than PEX-b or PEX-c pipe. A crack that occurs in PEX-a pipe is the least likely to grow over time and cause leaks or damage.

Stress resistance

Pipe installed in commercial applications must be capable of withstanding the stresses that result from installation within commercial buildings. Typical stresses include:

- Expansion and contraction that result from repeated heating and subsequent cooling of the heat-transfer fluid
- Mechanical abrasion, shearing and stretching that occurs as a result of installation, normal structural movement, and heating and cooling from seasonal weather changes

Property	English units	SI units
Approximate modulus of elasticity (Secant at 1% and 73°F/22.8°C)	91,350 psi	630 N/mm ²
Tensile yield strength at 68°F (20°C) per DIN 53455	2.76-3.77 psi	19-26 N/mm ²
Piping density	59 lbs./ft ³	936 Kg/m ³
Impact strength	Will not fail under impact at temperatures of -284°F/-140°C	
Water absorption	Room temperature = 0.01% Boiling for 40 days = 0.07%	
Coefficient of friction (surface-roughness factor)	0.000019 inches	0.0005 mm
Surface tension	0.00014 lbs./inches	25 dyne/cm
Coefficient of linear expansion at 135°F/57°C	Avg. = 9.2*10 ⁻⁵ in/in•°F	Avg. = 1.7*10 ⁻⁴ m/m•°C
Softening temperature	264°F to 268°F	129°C to 131°C
Specific heat	0.55 Btu/lb•°F	2302.3 J/kg•°C
Coefficient of thermal conductivity	0.219 Btu/(hr•ft•°F)	0.38 W/(m•°K)
Degree of crosslinking	70 to 89% (per ASTM F876)	
Minimum bend radius	Six times the outside diameter	

Table 1-1: Material properties of Uponor PEX piping

- Uponor PEX provides the durability and reliability that is needed for these applications and currently holds the unofficial world record for long-term testing at elevated temperature and pressure. From 1973 to 2009, the pipe was subjected to ongoing testing at 203°F (95°C) at 175 psi (12 bar) by Studvik in Sweden and BASF in Germany.

Chemical resistance

PEX has very good resistance to chemical-dissolving agents. The unique molecular structure is stable and inert, and it is virtually unaffected by chemicals (organic or inorganic) commonly found in plumbing and hydronic systems. Contact Uponor Technical Support for specific chemical

Dimensions and physical characteristics of SDR9 Uponor PEX pipe					
Nominal pipe size	Pipe O.D. (in)	Pipe I.D. (in)	Weight of pipe only lbs/ft (kg/m)	Contents of pipe gal/ft (l/m)	Weight of pipe and water lbs/ft (kg/m)
¼"	0.375	0.241	0.04 (0.018)	0.0024 (0.009)	0.06 (0.027)
⅜"	0.50	0.350	0.05 (0.022)	0.005 (0.018)	0.09 (0.040)
½"	0.625	0.475	0.06 (0.027)	0.0092 (0.034)	0.14 (0.063)
⅝"	0.750	0.574	0.08 (0.036)	0.0134 (0.050)	0.19 (0.086)
¾"	0.875	0.671	0.1 (0.045)	0.0184 (0.069)	0.25 (0.113)
1"	1.125	0.862	0.2 (0.090)	0.0303 (0.114)	0.45 (0.204)
1¼"	1.375	1.054	0.34 (0.154)	0.0453 (0.171)	0.72 (0.326)
1½"	1.625	1.244	0.44 (0.199)	0.0632 (0.239)	0.96 (0.435)
2"	2.125	1.629	0.682 (0.309)	0.1083 (0.409)	1.58 (0.716)
2½"	2.625	2.011	0.93 (0.421)	0.1649 (0.624)	2.3 (1.043)
3"	3.125	2.4	1.28 (0.580)	0.2351 (0.889)	3.24 (1.469)
4"	4.125	3.17	2.29 (1.03)	0.4097 (1.550)	5.703 (2.586)

Table 1-2: Dimensions and physical characteristics of SDR9 PEX pipe

compatibility verification. Review the Plastics Pipe Institute (PPI) Technical Report 19 *Chemical*

Resistance of Plastic Piping Materials for more information about the transport of chemicals.

Uponor AquaPEX® pipe

Uponor AquaPEX® piping is intended for use in domestic-water potable plumbing systems. It is also available for reclaimed water systems, as well. While it may also be used in hydronic heating and cooling applications, it does not feature an oxygen barrier, meaning additional equipment will be required to manage the hydronic system's oxygen levels.

Product	Marking	UV resistance
Uponor AquaPEX White	5106	1 month
Uponor AquaPEX White with Blue Print	5106	1 month
Uponor AquaPEX White with Red Print	5106	1 month
Uponor AquaPEX Purple	5106	1 month
Uponor AquaPEX Blue	5306	6 months
Uponor AquaPEX Red	5306	6 months

Table 1-3: Uponor AquaPEX UV resistance ratings

Cleanliness of Uponor AquaPEX

The quality materials and exacting process used in manufacturing Uponor AquaPEX yield remarkably clean water-distribution piping. Uponor PEX piping is made by crosslinking high-density, high-molecular weight, 100% virgin polyethylene material. It is subject to the highest testing, codes, listings, and standards.

In addition to testing and certification at NSF International, Canadian Standards Association

(CSA), and Underwriters Laboratories (UL), Uponor PEX piping has been tested and approved for potable-water applications by the most demanding agencies in the world, including DVWG-Germany, KIWA-Netherlands, CTSB-France, and BSI-Great Britain.

Toxicity extraction testing performed in accordance with ANSI/NSF 61 *Drinking Water System Components – Health Effects* verifies Uponor PEX piping does not leach potentially harmful substances into the drinking water.

Ultraviolet (UV) resistance

The test method for evaluating UV resistance as required by ASTM F876 is ASTM F2657 *Test Method for Outdoor Weathering Exposure of Cross-linked Polyethylene (PEX)*. According to ASTM F876, PEX piping must bear a four-digit code to signify the requirements it meets. The second digit in the code references the minimum ultraviolet (UV) resistance of the piping. For example, piping with a 5106 marking has a “1” as the second digit, which indicates the piping meets minimum UV resistance requirements for a period of 1 month. Piping with a “2” as the second digit indicates a resistance period of 3 months, and piping with a “3” indicates a resistance period of 6 months.

For the minimum UV resistance of all Uponor AquaPEX products, refer to **Table 1-3**.

Note: See **page 91** for handling guidelines regarding light fixtures.

Oxidative resistance

The test method for evaluating oxidative resistance as required by ASTM F876 is ASTM F2023 *Test Method for Evaluating the Oxidative Resistance of Cross-linked Polyethylene (PEX) Piping and Systems to Hot Chlorinated Water*. According to ASTM F876, PEX piping must bear a four-digit code to signify the requirements it meets. The first digit in the code references the minimum chlorine resistance at end-use conditions.

Uponor AquaPEX was evaluated according to the ASTM F2023 test method for evaluating oxidative resistance to hot, chlorinated water. This is the most stringent test method in the industry. Uponor AquaPEX piping exceeds the minimum life expectancy requirement of 50 years when operating with end-use conditions 100% of the time (including recirculation) at 140°F/60°C at up to 80 psi for potable water. Refer to **page 69** for proper hot-water system design.

Uponor ServicePEX™ pipe

Uponor ServicePEX™ pipe is manufactured and designed for use in water service applications. The pipe is certified to the AWWA C904 Standard and is listed to IPC, IRC, and UPC requirements.

Like Uponor AquaPEX, ServicePEX is manufactured to yield remarkably clean water-distribution piping, made by crosslinking

high-density, high-molecular weight, 100% virgin polyethylene material and is subject to the highest testing, codes, listings, and standards.

The pipe has the following hydrostatic **ratings** per **PPI TR-4**:

- 160 psi at 73°F (11 bar at 23°C)
- 100 psi at 180°F (6.9 bar at 82°C)

Note: ServicePEX can satisfy the **performance requirements** of section F.7 of **PPI TR-3** for polyethylene (PE) materials to qualify for a **higher 0.63 design factor** resulting in a hydrostatic temperature/pressure rating of **200 psi at 73.4°F (13.8 bar at 23°C)**.

Note that while the pipe features a PEX 5306 marking for six months of UV resistance, the pipe has been tested and proven to withstand 12 months of UV exposure.

Product	Marking	UV resistance
Uponor ServicePEX	5306	Listed for 6 months, but tested and proven to withstand 12 months

Table 1-4: Uponor ServicePEX UV resistance rating

Wirsbo hePEX™ pipe

Wirsbo hePEX™ features an oxygen barrier that conforms to DIN 4726 for use in closed-loop hydronic piping and radiant heating and cooling applications. It is compatible with Uponor ProPEX and QS-style fittings and is manufactured in full compliance to ASTM F876 and F877. It is also listed to NSF 61 for potable-water applications. For UV resistance refer to **Table 1-5** below.

Oxygen diffusion

All non-metallic (plastic or rubber) pipe is permeable to the passage of dissolved oxygen molecules through the material walls. This permeability allows dissolved oxygen molecules to enter a closed system. Having excessive oxygen molecules in a heating system may cause corrosion problems with the system's ferrous components.

In any new hydronic heating installation, dissolved oxygen molecules exist in the new, fresh water. The large bubbles are purged from the system prior to initial startup. The dissolved oxygen, however, remains. This dissolved oxygen is not visible in the form of bubbles, and cannot be eliminated by the use of an air vent or scoop.

As the heating system brings the water up to temperature, these dissolved oxygen molecules increasingly bond with ferrous components in the system. The result is corrosion or rust. After a few years of operation, a layer of rust on all ferrous components becomes apparent.

In a typical hydronic system using metallic pipe, almost all dissolved oxygen molecules are used up and cause a non-aggressive rust usually called "ferrous oxide" usually within the first 72 hours, and that is the end of the corrosion process.

In a non-metallic system, using plastic or rubber pipe, oxygen continues to enter the system through the permeable pipe, and the corrosion process continues. Left unchecked, this corrosion will cause considerable damage to the ferrous components of the heating system.

Damage may include:

- Circulator failures
- Pinhole leaks at expansion tanks
- A red, sludgy build-up inside the system pipe (reducing flow)
- Eventual boiler failure (if using a cast-iron or steel boiler)

Product	Marking	UV resistance
Wirsbo hePEX	5106	1 month

Table 1-5: Wirsbo hePEX UV resistance rating

Using PEX in hydronic piping systems

Refer to the following options when using PEX in hydronic piping systems.

- Option 1:** Use Wirsbo hePEX pipe which limits the oxygen diffusion into the heat-transfer fluid to a level consistent with established standards.
- Option 2:** Isolate the heat-transfer fluid from components likely to corrode (e.g., cast-iron pumps, boilers, expansion tanks, etc.) with a non-ferrous heat exchanger. Uponor AquaPEX pipe, which does not have an oxygen-diffusion barrier, is available for systems that isolate the heating loops from the heat plant and circulator components. All other components (e.g., expansion tanks, circulators and piping) on the floor-heating side of the heat exchanger must be made of a non-ferrous material as well.
- Option 3:** Use Uponor AquaPEX pipe and eliminate all corrosive ferrous components from the system (e.g., use bronze pumps, copper tube boilers with bronze headers, etc.).
- Option 4:** Treat all heat-transfer fluid with corrosion inhibitors. Corrosion inhibitors require regular maintenance from the heat plant manager to maintain the correct inhibitor level. In the event the system mixture is allowed to lapse, corrosion damage may occur. For these reasons, Uponor does not recommend the use of corrosion inhibitors to counter the effects of oxygen diffusion. Refer to "Water additive guidelines" on **page 89** for more information about corrosion inhibitors.

Standards, codes, and listings

Uponor PEX piping is manufactured to meet the following requirements. Refer to product submittals for details.

Standards

ASTM International

- ASTM F876 Standard Specification for Cross-linked Polyethylene (PEX) Piping
- ASTM F877 Standard Specification for Cross-linked Polyethylene (PEX) Plastic Hot- and Cold-Water Distribution Systems
- ASTM F1960 Standard Specification for Cold Expansion Fittings with PEX Reinforcing Rings for Use with Cross-linked Polyethylene (PEX) Piping
- ASTM F2023 Standard Test Method Evaluating the Oxidative Resistance of Cross-linked Polyethylene (PEX) Piping and Systems to Hot Chlorinated Water
- ASTM F2657 Standard Test Method for Outdoor Weathering Exposure of Cross-linked Polyethylene (PEX) Piping
- ASTM E84 Standard Test Method for Surface Burning Characteristics of Building Materials
- ASTM E119 Standard Test Methods for Fire Tests of Building Construction and Materials
- ASTM E814 Standard Test Method for Fire Tests of Through-Penetration Firestop Systems

NSF International

- ANSI/NSF Standard 14 Plastics Piping System Components and Related Materials
- ANSI/NSF Standard 61 Drinking Water System Components — Health Effects
- ANSI/NSF Standard 359 Valves for Crosslinked Polyethylene (PEX) Water Distribution Systems

American Water Works Association (AWWA)*

- AWWA C904 Cross-Linked Polyethylene (PEX) Pressure Pipe, ½" (12 mm) through 3" (76 mm) for Water Service

*Uponor ServicePEX™ pipe only

Underwriters Laboratories, Inc. (UL)

- ANSI/UL 263 Standard for Safety for Fire Tests of Building Construction and Materials
- UL 1821 Standard for Safety for Thermoplastic Sprinkler Pipe and Fittings for Fire Protection Service (NFPA 13D applications only)
- UL 2846 Standard for Safety for Fire Test of Plastic Water Distribution Plumbing Pipe for Visible Flame and Smoke Characteristics

CSA Group (Canadian Standards Association)

- CAN/CSA B137.5 Crosslinked Polyethylene (PEX) Piping Systems for Pressure Applications
- CAN/CSA B214 Installation Code for Hydronic Heating Systems

Underwriters Laboratories of Canada (ULC)

- CAN/ULC-S102.2 Standard Method of Test for Surface Burning Characteristics of Flooring, Floor Covering and Miscellaneous Materials and Assemblies
- CAN/ULC-S101 Standard Methods of Fire Endurance Tests of Building Construction and Materials
- CAN/ULC-S115 Standard Method of Fire Tests of Firestop Systems

Plastics Pipe Institute (PPI)

- PPI Technical Report TR-4

German National Standard (DIN)

- DIN 4726 Warm Water Surface Heating Systems and Radiator Connecting Systems — Plastics Piping Systems and Multilayer Piping Systems

Codes

- IECC
- IPC
- IMC
- IRC
- UPC
- UMC
- NSPC
- HUD
- UFGS
- NPC of Canada
- NBC of Canada

Listings

- cNSFus-fs
- cNSFus-rfh
- cNSFus-pw
- cQAlus
- UL
- CSA
- WH
- ETL
- PPI TR-4
- ICC-ES-PMG
- IAPMO
- BMEC
- CCMC

Figure 1-4: Uponor PEX pipe coils



ProPEX fittings

Uponor ProPEX fittings are available in engineered polymer (EP), lead-free (LF) brass, and brass and are tested and listed to:

- ASTM F1960 *Standard Specification for Cold Expansion Fittings with PEX Reinforcing Rings for Use with Cross-linked Polyethylene (PEX) Piping*
- CAN/CSA B137.5 *Crosslinked Polyethylene (PEX) Piping Systems for Pressure Applications*

Uponor ProPEX EP fittings

Accessibility

ProPEX fitting connections (i.e., ASTM F1960 and CAN/CSA B137.5) do not require o-rings or are considered a mechanical connection and therefore may be directly buried in soil or placed directly behind a wall covering without the need for direct access to the fittings or connection. This includes multiport tees. However, codes require that mechanical or operating components must be accessible for operating, maintenance, and repair. An operating component that incorporates Uponor ProPEX connections must be accessible.

Note: This information is based on Uponor's review of the most current model codes to this manual's published date.

Performance

EP is a high-performance thermoplastic material that has superior mechanical, chemical and thermal properties which provide dimensional stability in demanding applications, including areas of high stress, heat and moisture.

Uponor EP fittings comply with NSF/ANSI 61 health effects requirements when tested at temperatures up to and including 180°F/82.2°C (i.e., commercial hot water).

Durability

Resistant to corrosion, pitting and scaling, Uponor EP products are designed for any residential and commercial plumbing and/or heating application.

Note: Do not expose EP fittings to direct sunlight for more than 30 days.

Additionally, EP fittings are the ideal solution to lead-free requirements and are even approved for direct burial in soil, making installation options endless.

Cost effectiveness

Uponor EP is a more cost-effective option because it offers a stable material cost and is not subject to the wide price fluctuations of metal.



Couplings



Opposing-port tees



Tees



Elbows



Multiport tees



Plugs

Figure 1-5: ProPEX EP offering

Uponor EP strength

Uponor EP is made from UDEL® polysulfone, Acudel® modified polyphenylsulfone, and Radel R® polyphenylsulfone. These materials are part of a family of polymers that have been used successfully in the demanding environments of medical appliance, aerospace and plumbing for many years.

In fact, lab tests prove that Uponor's ProPEX EP tee and ProPEX connection are able to withstand up to 2,900 lbs. of pull force without failure.



Figure 1-6: Beginning of test using a 2" ProPEX EP tee



Figure 1-7: At approximately 2,900 lbs. of pull force



Figure 1-8: ProPEX LF brass fittings

Uponor ProPEX LF brass fittings for potable applications

Uponor offers a complete line of LF brass transition fittings, valves, stub outs, and water-heater connectors for domestic water plumbing applications.

- All Uponor LF brass products comply with NSF/ANSI 61 Annex G, NSF/ANSI 372 and conform to the lead-content requirements for "lead-free" plumbing as defined by various state laws as well as the U.S. Safe Drinking Water Act.
- All Uponor LF brass fittings marked as NSFus-pw-G comply with the dezincification resistance (DZR) and stress-corrosion cracking (SCC) requirements of Sections 5.8.1 and 5.8.2 per the current NSF 14 Standard.
- Uponor's LF brass is approved for direct burial in soil per NSF/ANSI Standard 14 testing which established minimum performance criteria for DZR/SCC resistance for PEX fittings intended for potable water.

Note: Uponor's LF brass copper press adapters are not recommended for direct burial.

Soldering

When soldering LF brass fittings, Uponor recommends using a lead-free flux and solder which meet the requirements of NSF/ANSI 372 or NSF/ANSI 61 Annex G. Please refer to the solder and flux manufacturer for details on properly soldering LF brass materials.

Uponor ProPEX brass fittings for hydronic applications

Uponor offers a complete line of brass transition fittings and valves for closed-loop heating and cooling applications.

All Uponor brass transition fittings and valves comply with surface burning characteristics required in CAN/CSA B137.5 and ASTM E84, are code-approved per IMC, UMC, IBC, and IRC for use in residential and commercial applications, and are listed to ANSI/NSF 14, cNSFus-rfh, and cQALus through QAI and NSF.

Note: Uponor non-LF brass fittings are not for potable applications and are not recommended for direct burial.

Fittings by others

Uponor PEX piping can be used with any type of SDR9 PEX fitting, including compression fittings. Compression fittings must be installed with an insert stiffener to ensure the pipe wall doesn't collapse under compression, compromising the connection.

Note that Uponor cautions the use of other manufacturer's PEX pipe with Uponor ProPEX rings as well as using other's expansion rings with Uponor PEX pipe. Because of the lower degree and uniformity of crosslinking in PEX-b and PEX-c pipe, stress cracking of the PEX-b and PEX-c pipe wall can occur during expansion, compromising the strength of the fitting connection.

Additionally, mixing Uponor ProPEX products with other manufacturers' PEX pipe, rings, and/or fittings will limit the Uponor 25-year transferable limited system warranty. For complete warranty details, refer to the Uponor website at uponor.com.

When transitioning from copper to PEX, Uponor recommends the use of ProPEX LF brass copper press adapters, LF sweat adapters, or brass sweat adapters.

Note: Standard Uponor LF brass sweat adapters cannot be pressed as they are a different material.

Chapter 2

Making ProPEX Connections

Uponor ProPEX ASTM F1960 (CAN/CSA B137.5) cold-expansion fittings make solid, permanent, manufactured connections without the need for torches, glues, solder, flux, or gauges. The unique shape memory of Uponor PEX piping forms a tight seal around the fitting, creating a strong, reliable connection. This chapter shows how to make proper ProPEX connections using one of the following tools.

- Milwaukee M12, M12 FUEL, M18, and M18 FUEL 2" ProPEX expansion tools
- Milwaukee M18 FORCE LOGIC ProPEX Expansion Tool
- ProPEX 201 Corded Expander Tool
- ProPEX Hand Expander Tool

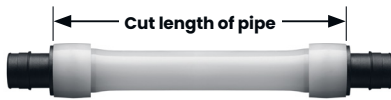


Figure 2-1: Distance between fittings

Distance between fittings

Uponor requires a minimum distance between ProPEX fittings to avoid damaging the fittings during installation and to protect against elevated stress on the pipe and fittings. Refer to **Table 2-1** for the minimum distance between fittings, which is expressed as cut length of pipe.

Nominal fitting size	Cut length of pipe
½"	2"
¾"	3"
1"	3½"
1¼"	4½"
1½"	4½"
2"	6" or 6¾"
2½"	7½"
3"	9"

Table 2-1: Minimum distance between ProPEX fittings

*6¾" for Milwaukee M18 FUEL 2" ProPEX Expansion Tool.

Pipe size	Milwaukee ProPEX expansion tools					Uponor ProPEX expander tools		
	M12 with standard heads (2432)	M12 FUEL with RAPID SEAL™ heads (2532)	M18 (2632)	M18 FUEL 2" (2932)	M18 FORCE LOGIC (2633)	Manual	100/150	201
¾"	6-7	6-10	5	5-7	—	5	7	—
½"	7-8	5-8	9	7-9	—	4	4	—
⅝"	9-10	6-10	9	8-9	—	9	9H	—
¾"	11-12	7-12	10	9-11	—	14	7H	—
1"	17-18	12-18	19	12-13 (or 7-8H)	—	—	7H	—
1¼"	—	—	9	9-10H	—	—	8H	—
1½"	—	—	10	8-9H	—	—	—	—
2"	—	—	—	9-10	4	—	—	5H
2½"	—	—	—	—	5	—	—	—
3"	—	—	—	—	7	—	—	—

Table 2-2: Recommended number of expansions for ¾" to 3" piping at 73.4°F (23°C)

Note: "H" in the table refers to Uponor H-series expander heads.



General ProPEX connection tips

- If the fitting does not slide into the piping all the way to the stop, immediately remove it from the piping and expand the piping one final time.

Note: To avoid over-expanding the piping, do not hold the piping in the expanded position.

- **Table 2-2** shows the recommended number of expansions. Experience, technique, and weather conditions influence the actual number of expansions. Fewer expansions may be necessary under certain conditions. The correct number of expansions is the amount necessary for the piping and the shoulder of the fitting to fit snugly together.

- Ensure the ProPEX ring rests snugly against the fitting shoulder. If there is more than ⅛" (1 mm) between the ring and the shoulder of the fitting, the connection must be replaced. Square cut the piping 2" away from the fitting for ¾" to 1" pipe, 3" away for 1¼" to 2" pipe, and 5" away for 2½" and 3" pipe prior to making the new connection.

- Brass ProPEX fittings can be disconnected and reused. EP fittings must be discarded. Be sure to follow the recommended minimum distance between ProPEX fittings shown in **Table 2-1**.

Making ProPEX connections with Milwaukee M12, M12 FUEL, M18, or M18 FUEL 2" ProPEX expansion tools

Note: All standard Uponor expander heads are compatible with the M12 and M18 tools. Uponor expander heads will not auto-rotate on the Milwaukee tools (only Milwaukee expansion heads will auto-rotate on the M12 and M18). H-heads are not compatible with

Milwaukee tools and Milwaukee heads are not compatible with Uponor tools. Milwaukee heads are easily distinguished by color coding and the Milwaukee logo.

Important! Making expansions are slightly different when using a tool that features auto rotation. When making a ProPEX connection, be sure to follow the guidelines for the tool you are using in your application.

1. Square cut the PEX piping perpendicular to the length of the piping. Remove all excess material or burrs that might affect the fitting connection.
2. Slide the ProPEX ring over the end of the piping until it reaches the stop edge. If using a ProPEX ring without a stop edge, extend the ring over the end of the piping no more than 1/16" (1mm).

Important! If making a 3/8" ProPEX connection, first expand each side of the ring before placing it on the piping. Refer to the "Making

3/8" ProPEX connections" instructions on **page 15** for further information.

With auto rotation (standard Milwaukee heads)

3. Milwaukee ProPEX expansion tools come with built-in auto rotation. If using a Milwaukee expansion head, simply hold the piping and tool in place while holding the trigger to expand the piping. The head will automatically rotate to ensure the piping is evenly expanded. Continue expanding and rotating until the piping and ring are snug against the shoulder on the expander head. See **Table 2-2** for the recommended number of expansions for each piping size.

Note: Do not force the pipe onto the expander head. Ensure the expander head is rotating during each expansion.

Without auto rotation (standard Uponor heads)

4. Press the trigger to expand the piping.
5. Release the trigger, remove the head from the piping, rotate it 1/8 turn and slide the head back into the piping. Continue expanding and rotating until the piping and ring are snug against the shoulder on the expander head. See **Table 2-2** for the recommended number of expansions.

Important! Rotating the tool between expansions will provide smooth, even expansion of the piping. Failure to rotate the tool will cause deep grooves in the piping which can result in potential leak paths.



Figure 2-2: 3/8" and 1/2" Milwaukee expansion heads

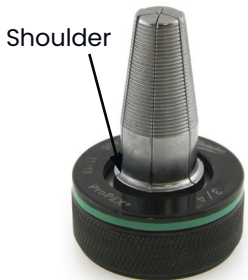


Figure 2-3: 3/4" to 3" Milwaukee expansion heads

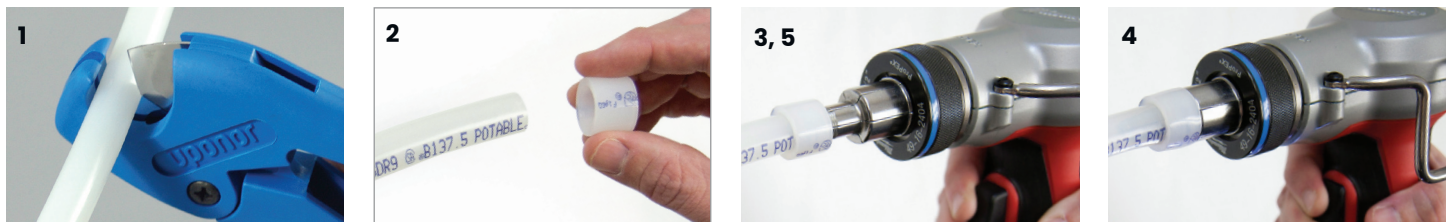


Figure 2-4: Expansion with Milwaukee M12, M12 FUEL, M18, and M18 FUEL 2" ProPEX expansion tools



Figure 2-5: Inserting ProPEX fitting into 1/2" Uponor PEX piping



Figure 2-6: ProPEX coupling

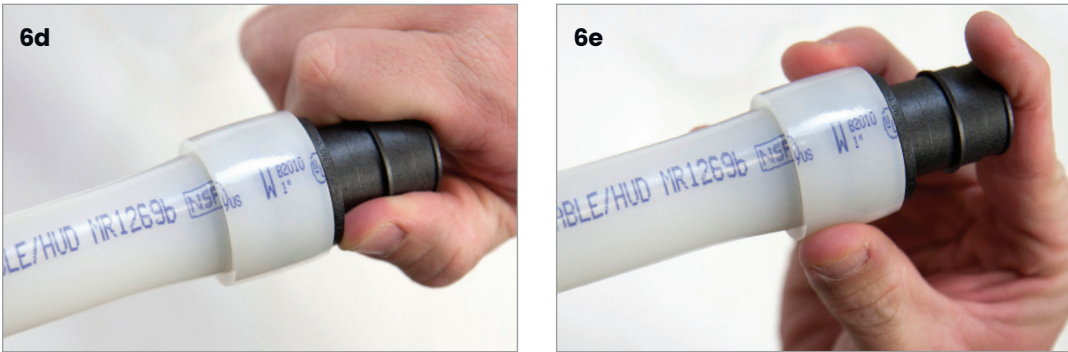


Figure 2-7: Inserting ProPEX fitting into 1" Uponor PEX piping



Figure 2-8: ProPEX tee

6. After the final expansion, immediately remove the tool and insert the fitting. Ensure the piping and ring seat against the shoulder of the fitting.

Important! Only perform the necessary number of expansions. DO NOT over expand the pipe. You should feel some resistance as the fitting goes into the piping. If you do not feel any resistance, the piping may be over expanded and will require additional time to shrink over the fitting.



Figure 2-9: Expansion with Milwaukee M18 ProPEX Expansion Tool

Making ProPEX connections with Milwaukee M18 FORCE LOGIC ProPEX expansion tools

FORCE LOGIC expansion head installation

The Milwaukee FORCE LOGIC ProPEX Expansion Tool for 2", 2½", and 3" Uponor PEX pipe features an auto-rotating head with specially designed alignment cogs. This requires slightly different head installation than the M12 and M18 ProPEX expansion tools for ¾" to 1½" pipe sizes.

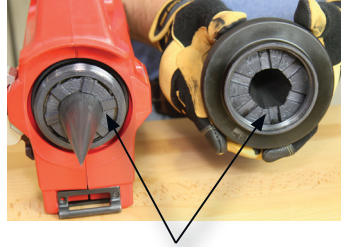
1. Remove the battery pack and place the FORCE LOGIC tool in the upright position (cone up).



Figure 2-10: FORCE LOGIC expansion head installation

2. Verify the expansion cone is fully retracted.

3. Screw the head onto the tool (clockwise). Hand-tighten securely. Do not over tighten. Ensure the expansion head fits flush against the tool.



Auto-rotate teeth

Figure 2-11: FORCE LOGIC expansion head auto-rotate teeth

4. Check the installation.
 - a. Ensure the head segments do not "flower".



Figure 2-12: Incorrect expansion head "flowering"

- b. If the head flowers, correct the installation by loosening the head slightly and rotating the segments until they engage in the cogs. Re-tighten the head.



Figure 2-13: Correct expansion head alignment

- c. Rotate the six expansion segments in the clockwise direction. They will rotate freely. They should not rotate counter clockwise.
- d. The expansion head collar will fit flush against the tool.

Making a ProPEX connection

1. Square cut the pipe perpendicular to the length, and remove all excess material or burrs.



Figure 2-14: Cut pipe

2. Slide the ProPEX ring over the end of the piping until it reaches the stop edge.



Figure 2-15: Add ring



Figure 2-16: Ensure ring reaches stop edge

3. The tool features auto rotation so the head will automatically rotate to ensure the piping is evenly expanded.

Note: To cancel the expansion process quickly, pull and release the trigger.

4. Press the trigger to initiate the rotation of the head. A green light will turn on and the work light will blink. Insert the pipe and ring and release the trigger. When the expansion head has reached its maximum diameter, it will retract.

Important! Do not force the pipe and ring on the head during any expansion.

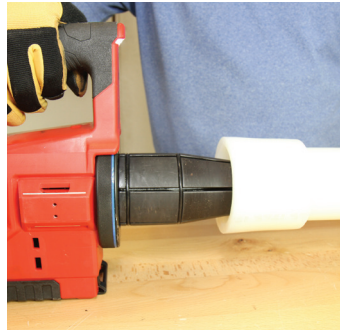


Figure 2-17: Begin expanding

5. After the tool has retracted, the green indicator light blinks three times. Press the trigger and repeat the expansion process.

6. Repeat the process until the pipe and ring are snug against the shoulder of the expansion head. Repeat the expansion one or two more times depending on the ambient temperature.

Note: Colder temperatures require fewer expansions.



Figure 2-18: Expand to shoulder

7. After final expansion, immediately remove the tool and insert the fitting.



Figure 2-19: Insert fitting

Making ProPEX connections with ProPEX 201 corded expander tools

1. Square cut the PEX piping perpendicular to the length of the piping. Remove all excess material or burrs that might affect the fitting connection.



Figure 2-20: Cut pipe

2. Slide the ProPEX ring over the end of the piping until it reaches the stop edge. If using a ProPEX ring without a stop edge, extend the ring over the end of the piping no more than $\frac{1}{16}$ " (1 mm).



Figure 2-21: Add ring

3. Slide the expander head into the piping until it stops. Full expansions are necessary to make a proper connection.



Figure 2-22: Slide head into piping

4. Press the trigger to expand the piping.



Figure 2-23: Begin expanding

5. Release the trigger, remove the head from the piping, rotate it $\frac{1}{8}$ turn and slide the head back into the piping. Continue expanding and rotating until the piping and ring are snug against the shoulder on the expander head. See **Table 2-2**.



Figure 2-24: Rotate head

Important! Rotating the tool between expansions will provide smooth, even expansion of the piping. Failure to rotate the tool will cause deep grooves in the piping which can result in potential leak paths.

6. After the final expansion, immediately remove the tool and insert the fitting. Ensure the piping and ring seat against the shoulder of the fitting.

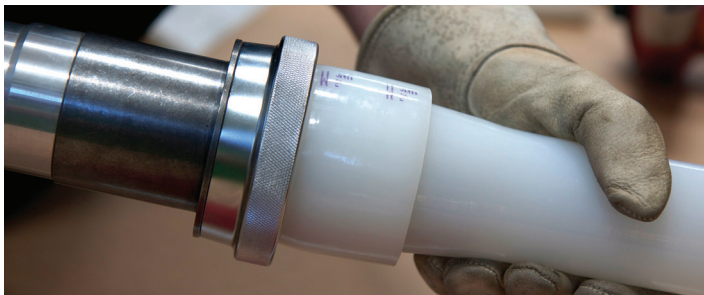


Figure 2-25: Expand to shoulder



Figure 2-26: Insert fitting



Figure 2-27: Ensure piping and ring seat against shoulder of fitting



Figure 2-28: ProPEX EP tee connected to pipe

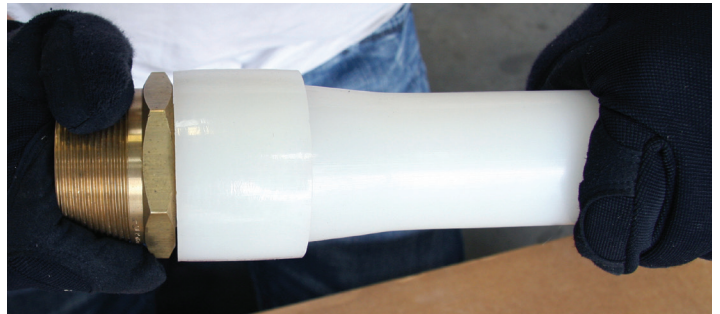


Figure 2-29: ProPEX brass fitting connected to pipe

Making 3/8" ProPEX connections

When making a 3/8" ProPEX connection, expand the ring once on each side to properly fit over the piping. Refer to the following instructions to make a 3/8" ProPEX connection.

1. Square cut the PEX piping perpendicular to the length of the piping. Remove all excess material or burrs that might affect the fitting connection.



Figure 2-30: E6081128 pipe cutter (plastic)

2. Expand each side of the ring once.

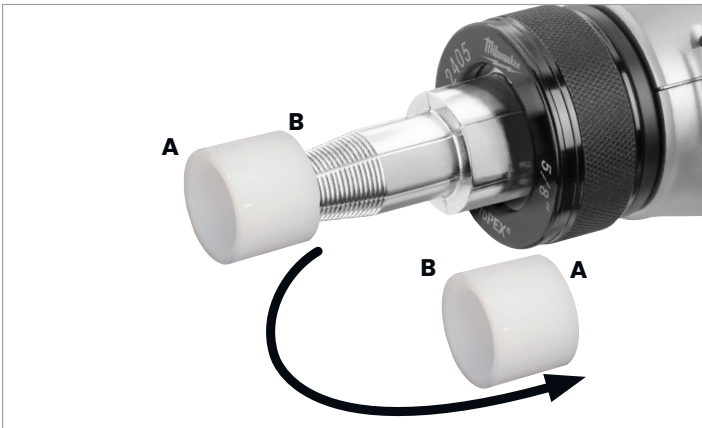


Figure 2-31: Expand each side of the ring

3. Slide the expanded ring over the end of the piping. Extend the end of the ring over the end of the piping no more than 1/16" (1 mm).

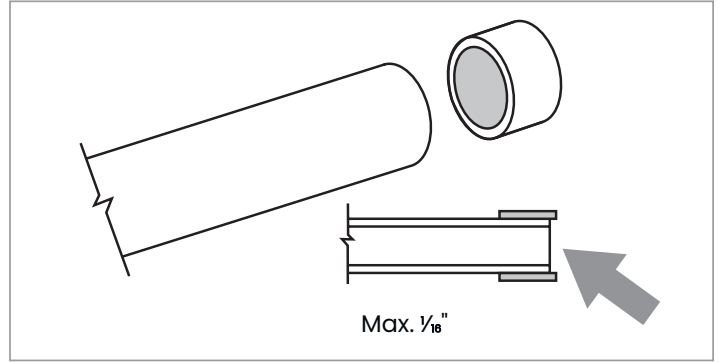


Figure 2-32: Slide the expanded ring over the end of the piping

4. After the ring is on the piping, continue with the regular steps for making a proper connection with your specific tool.

Important tips for a proper 3/8" ProPEX connection

- The thicker 3/8" ProPEX Ring shrinks over the fitting faster than larger-sized rings.
- When the temperature is below 40°F (4.4°C), fewer expansions are required.

Proper expander tool and head maintenance

- Use a lint-free cloth to apply a light coat of lubricant to the cone prior to making any ProPEX connections.
- If used regularly, apply the lubricant daily to the cone of the ProPEX expander tool. Failure to keep the tool lubricated may result in improper connections.



- **Caution:** Excessive lubrication may result in improper connections. Only use a small amount of lubrication to keep the tool working properly.
- Keep all other parts of the tool free from lubricant.
- Once a month, soak the heads in degreasing agent to remove any grease from between the segments. Clean the cone using a clean, dry cloth.

Disconnecting a ProPEX brass fitting

ProPEX brass and EP fittings are manufactured connections that can be concealed in walls, ceilings, and floors. When necessary, ProPEX brass fittings can be disconnected.

Important! EP fittings cannot be reclaimed.

Refer to the following guidelines for disconnecting a ProPEX brass fitting.

1. Ensure the system is not pressurized.
2. Use a utility knife to carefully cut through the ProPEX ring.

Important! Do not heat the ring prior to cutting it. Take care to cut only the ring and not the piping or fitting. Gouges in the fitting may result in leaks. If you accidentally damage the fitting, you must discard it.



Figure 2-33: Cut ring

3. Remove the ProPEX ring from the piping.



Figure 2-34: Remove ring

4. After removing the ring, apply heat directly around the fitting and piping connection. **Do not use open flame.** Gently work the piping back and forth while pulling slightly away from the fitting until the piping separates from the fitting.



Figure 2-35: Heat connection



Figure 2-36: Work piping back and forth

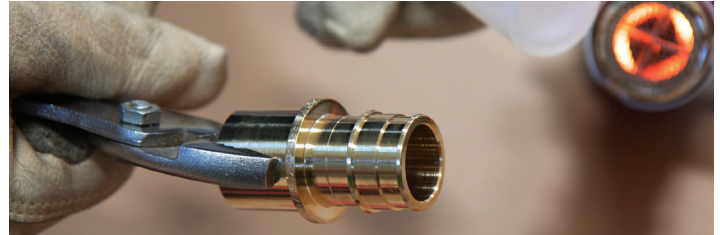


Figure 2-37: Remove fitting

5. After removing the fitting, measure:
 - 2" (50.8 mm) minimum for 3/8" to 1" pipe
 - 3" (76.2 mm) minimum for 1 1/4" to 2" pipe
 - 5" (127 mm) minimum for 2 1/2" and 3" pipe



Figure 2-38: Measure from end of pipe

6. Square cut the piping at the proper marking.



Figure 2-39: Cut pipe at marking

7. Allow the fitting to cool before making the new connection.
8. Use a new ProPEX ring and follow the steps to make a new connection.

Troubleshooting ProPEX connections

Trouble-free ProPEX installations begin with a tool that is maintained in proper working condition. If the tool or segment fingers are damaged, it is very difficult to make a proper connection. Refer to the following guidelines to assist with challenges in the field.

Fittings won't seal

- Make sure the expander head is securely tightened onto the tool.
- Ensure the segment fingers are not bent. If the head does not completely close when the drive unit is fully retracted or the handles of the manual tool are open, replace the head.
- Examine the tool for excess grease on the segment fingers. Remove excess grease prior to making connections.
- Check the fitting for damage. Nicks and gouges will cause the fitting to leak.
- Make sure the internal driver cone is not damaged or bent.
- Make sure the last expansion is not held in the expanded position before the fitting is inserted. You should feel some resistance as the fitting goes into the piping. If you do not feel any resistance, the piping may be over expanded and will require additional time to shrink over the fitting.
- Be sure to rotate the tool $\frac{1}{8}$ turn after each expansion to avoid deep grooves in the piping which can result in potential leak paths.

Expansion is difficult

- Make sure the internal cone is properly greased.

Expansion head slips out of piping when making expansions

- Ensure the piping and ProPEX ring are dry.
- Make sure that grease is not getting into the piping.
- Examine the segment fingers to ensure they are not damaged or bent.

ProPEX ring slides down piping during expansion

- Ensure your hands are clean while handling the piping. Any sweat or oils on your hands can act as a lubricant. Due to the smoothness of PEX, any form of lubricant can cause the ProPEX ring to slide down the piping during expansion.
- If you anticipate the ProPEX ring may possibly slide down, position the ring slightly farther over the end of the piping and make the first couple of expansions slowly. Once the ring and the piping begin to expand together, continue with the normal number and type of expansions.
- Place your thumb against the ProPEX ring to help support it and feel for any movement. If caught early, you can slide the ring up the piping and expand as described in the previous bullet point.

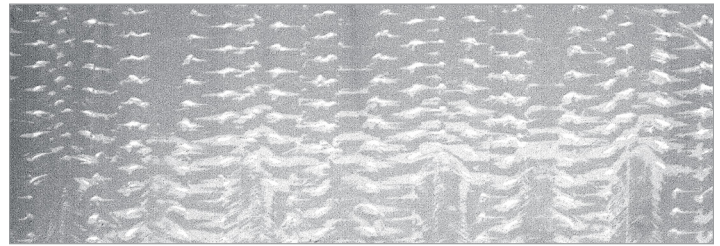


Figure 2-40: Expansion with proper rotation

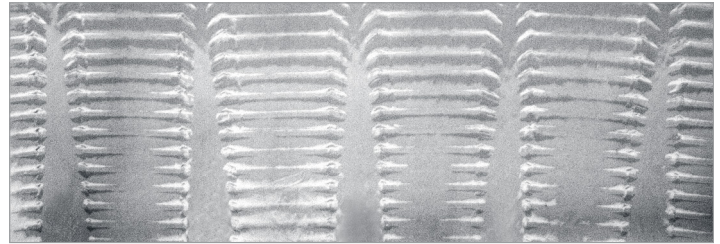


Figure 2-41: Expansion without proper rotation

More than the recommended number of expansions are needed to make a connection

- Ensure the head is hand-tightened to the expander tool.
- Examine the segment fingers for damage.
- Be sure to completely cycle the tool on each expansion (i.e., close the manual tool handle or release the trigger).

- Warming ProPEX fittings and ProPEX rings reduces contraction time. Put fittings and rings in your pockets prior to installation to keep them warm.
- Fewer expansions are necessary in temperatures below 40°F (4.4°C).

Note: Do not use a heat gun on EP fittings to speed up the contraction time as this could result in damage to the fitting.

Cold-weather expansions

- Uponor recommends the use of the Milwaukee M12 FUEL ProPEX expansion tool with RAPID SEAL™ heads for cold-weather installation of $\frac{3}{8}$ " to 1" Uponor piping systems.
- Temperatures affect the time required for the piping and ring to shrink onto the fitting. The colder the temperature, the slower the contraction time.



Figure 2-42: Milwaukee RAPID SEAL 1" head

Chapter 3

Fire-resistant Construction

Wood-frame wall assemblies

Wood-frame wall assemblies complying with ASTM E119 and CAN/ULC-S101 have the following requirements.

Building elements

- Studs: Nominal wood 2x4 spaced 16" on center (o.c.)
- Gypsum wallboard: Minimum one layer of 5/8" Type X gypsum wallboard

Pipe and fittings

- Pipe: Maximum density of Uponor PEX pipe is 4.85 lbs. per linear feet (7.23 kg/m) of cavity. Approved Uponor PEX pipes include:
 - Uponor AquaPEX White (up to 3")
 - Uponor AquaPEX Red (up to 1")
 - Uponor AquaPEX Blue (up to 1")
 - Uponor AquaPEX Reclaimed Water (up to 2")
 - Pre-insulated Uponor AquaPEX (up to 2" pipe with 1½" thick insulation)
 - Wirsbo hePEX (up to 4")

- Fittings: Maximum density of Uponor ProPEX brass or EP fittings is 3.33 lbs. (1.51 kg) per stud cavity.

Note: See assembly details for more information.

Assembly numbers

QAI Design No. P321-1B

- 1-hour
- Up to 4" PEX

QAI Design No. P321-1H

- 2-hour
- Up to 4" PEX

UL Design No. U372

- 1-hour
- Up to 2" PEX

Note: Maximum size is available through QAI.

Wood-frame floor/ceiling assemblies

Wood-frame floor/ceiling assemblies complying with ASTM E119 and CAN/ULC-S101 have the following requirements.

Building elements

- Joists: Nominal 2x10 solid sawn wood, open-web wood or wood I-joist (10" to 24" depth) installed at 24" o.c. maximum
- Subfloor: Minimum 5/8" plywood; if using optional topping, subfloor may be 5/8" oriented strand board (OSB)
- Gypsum wallboard:
 - Minimum one layer of 5/8" Type X gypsum wallboard when using solid sawn wood joists
 - Minimum two layers of 1/2" Type X gypsum wallboard when using wood I-joists (10" to 24" depth)

Pipe and fittings

- Pipe: One or more Uponor PEX piping runs ½" to 2"; weight of PEX piping not to exceed 0.63 lbs./ft. (0.94 kg/m) of joist cavity. Support pipe with metal clips 16" o.c. for piping up to 1" diameter or metal clips 24" o.c. for piping larger than 1" diameter.

- Fittings: Brass or EP fittings with a weight not exceeding 0.1 lbs./ft. (0.15 kg/m) per joist cavity

Note: See assembly details for more information.

Assembly numbers

QAI Design No. P321-1F

- 1-hour
- Up to 2" PEX

UL Design No. L557

- 1-hour
- Up to 2" PEX

Fire-resistive assembly ratings (ASTM E119/ANSI/UL 263 and CAN/ULC-S101)			
Construction type	Assembly type	UL design no.	QAI
Non-combustible concrete/steel	Floor/ceiling	K913	P321-1D (2-hr)
		G524	P321-1E (2-hr)
		G573	P321-1C (2-hr)
	Walls	V444	P321-1A (1-hr)
		—	P321-1G (2-hr)
Wood frame construction	Floor/ceiling	L557	P321-1F (1-hr)
	Walls	U372	P321-1B (1-hr)
		—	P321-1H (2-hr)

Table 3-1: ASTM E119 (ANSI/UL 263) and CAN/ULC-S101 listings

Steel/concrete wall assemblies

Steel/concrete wall assemblies complying with ASTM E119 and CAN/ULC-S101 have the following requirements.

Building elements

Studs: 3 $\frac{5}{8}$ " steel studs spaced maximum 24" o.c.

- Gypsum wallboard: Minimum one layer of $\frac{5}{8}$ " thick Type X gypsum wallboard

Pipe and fittings

- Pipe: Maximum density of Uponor PEX pipe is 4.85 lbs. per linear foot (7.23 kg/m) of cavity. Approved Uponor PEX pipes include:

- Uponor AquaPEX White (up to 3")
- Uponor AquaPEX Red (up to 1")
- Uponor AquaPEX Blue (up to 1")
- Uponor AquaPEX Reclaimed Water (up to 2")
- Pre-insulated Uponor AquaPEX (up to 2" pipe with 2" thick insulation)
- Pre-insulated Wirsbo hePEX (up to 2" pipe with 2" thick insulation)
- Wirsbo hePEX (up to 4")

- Fittings: Maximum density of Uponor ProPEX brass or EP fittings is 3.33 lbs. (1.51 kg) per stud cavity.

Note: See assembly details for more information.

Assembly numbers

QAI Design No. P321-1A

- 1-hour
- Up to 4" PEX

QAI Design No. P321-1G

- 2-hour
- Up to 4" PEX

UL Design No. V444

- 1-hour
- Up to 4" PEX

Note: Maximum size is available through QAI.

Steel/concrete floor/ceiling assemblies

Steel/concrete floor/ceiling assemblies complying with ASTM E119 or CAN/ULC-S101 have the following requirements.

Building elements

- Concrete floor: Minimum slab thickness of 6 $\frac{1}{2}$ "
- Steel reinforcement: Various sized Grade 40 or 60 steel bars located as required by ACI-318
- Steel joists: Minimum nominal depth of 10" spaced maximum of 6'-0" o.c.
- Steel floor: Minimum 1 $\frac{1}{2}$ " depth, 22 gauge uncoated or galvanized fluted

Pipe and fittings

- Pipe: Maximum volume of Uponor PEX pipe is 14 cubic inches per 1 cubic foot (8101 cubic centimeters per 1 cubic meter). Approved Uponor PEX pipes include:
 - Uponor AquaPEX White (up to 2")
 - Uponor AquaPEX Red (up to 1")
 - Uponor AquaPEX Blue (up to 1")
 - Uponor AquaPEX Reclaimed Water (up to 2")
 - Pre-insulated Uponor AquaPEX (up to 2" pipe with 2" thick insulation)
 - Pre-insulated Wirsbo hePEX (up to 2" pipe with 2" thick insulation)
 - Wirsbo hePEX (up to 2")

Note: See assembly details for more information.

Assembly numbers

ITS Design No. UW/FCA 120-01

- 1-hour
- Up to 2" PEX

ITS Design No. UW/FCA 120-02

- 2-hour
- Up to 2" PEX

QAI Design No. P321-1C

- 2-hour
- Up to 2" PEX

QAI Design No. P321-1D

- 2-hour
- Up to 2" PEX

QAI Design No. P321-1E

- 2-hour
- Up to 2" PEX

UL Design No. K913

- 2-hour
- Up to 2" PEX

UL Design No. G524

- 2-hour
- Up to 2" PEX

UL Design No. G573

- 2-hour
- Up to 2" PEX



Wood-frame assemblies (U.S.)

Multiport tee detail

Wood-frame floor/ceiling assembly (UL Design No. L557/QAI Design No. P321-1F)
Wood-stud wall assembly (UL Design No. U372/QAI Design No. P321-1B)

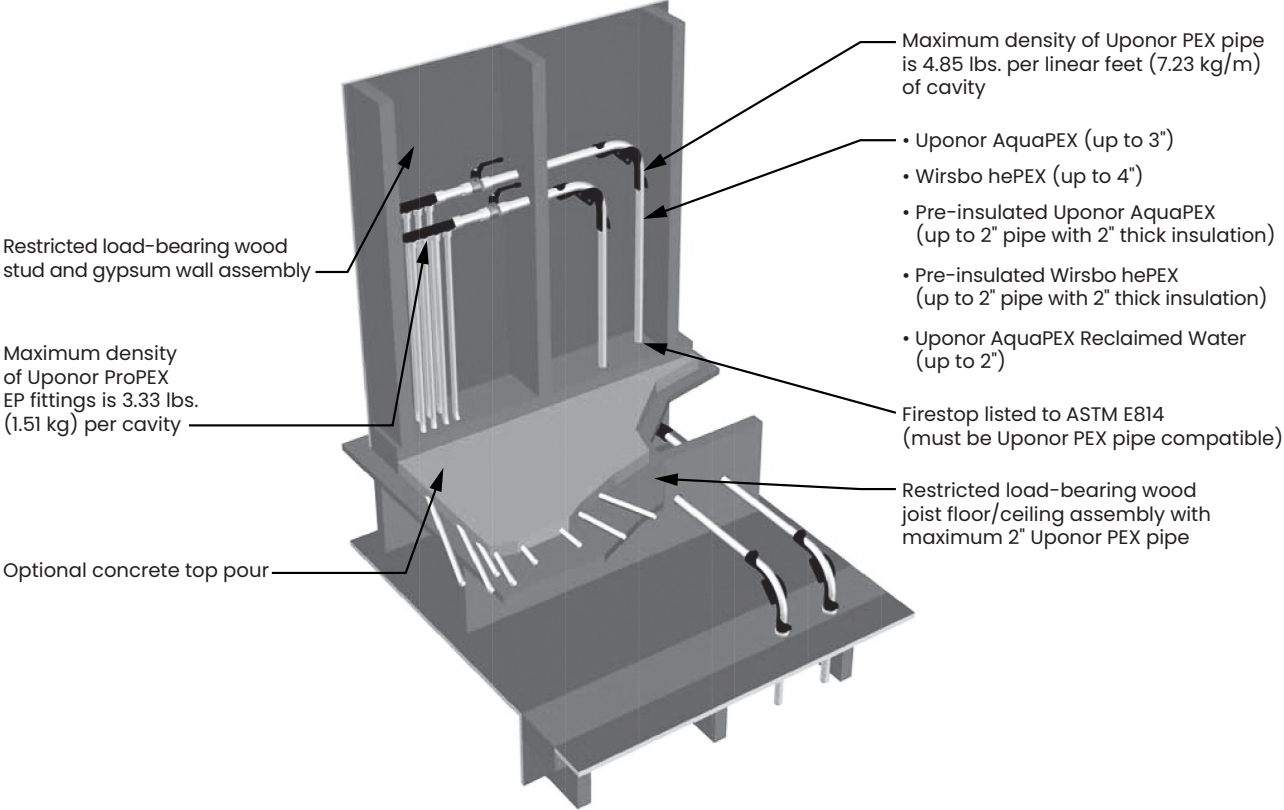


Figure 3-1: Multiport tee detail (U.S.)



Fixture detail 1

Wood-frame floor/ceiling assembly (UL Design No. L557/QAI Design No. P321-1F)
Wood-stud wall assembly (UL Design No. U372/QAI Design No. P321-1B)

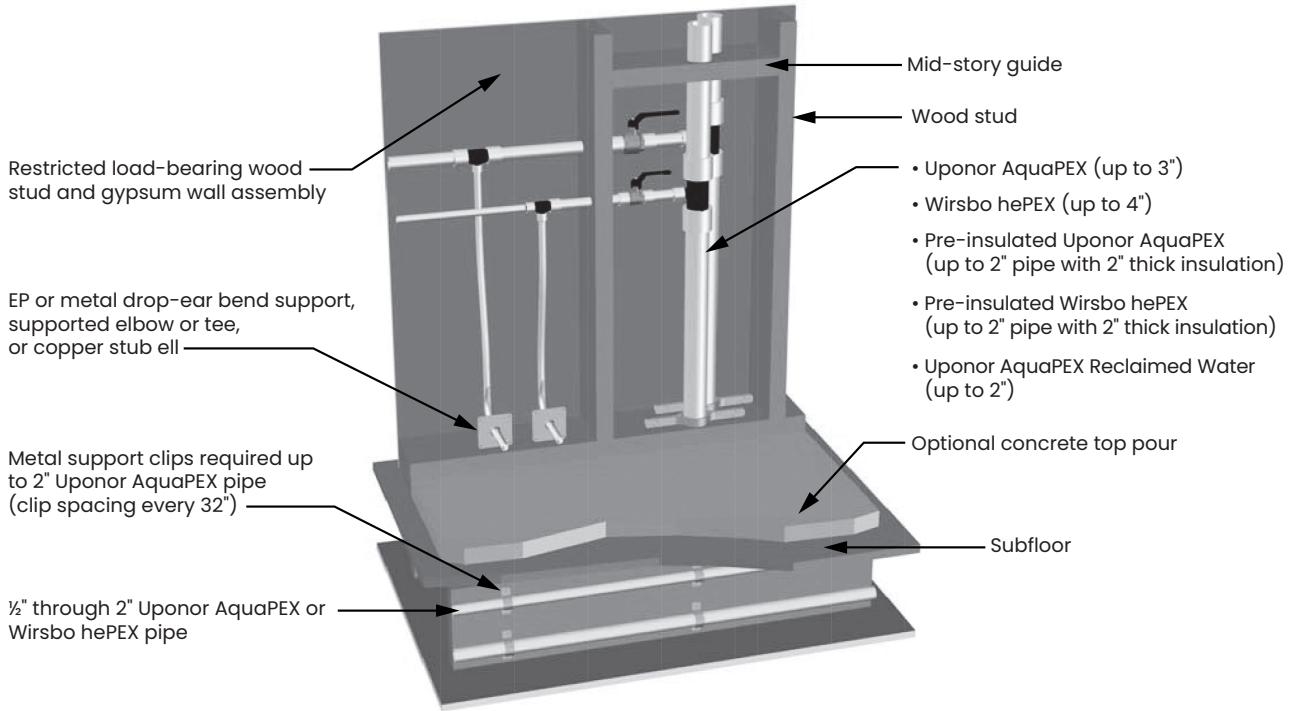


Figure 3-2: Fixture detail 1 (U.S.)



Fixture detail 2

Wood-frame floor/ceiling assembly (UL Design No. L557/QAI Design No. P321-1F)
Wood-stud wall assembly (UL Design No. U372/QAI Design No. P321-1B)

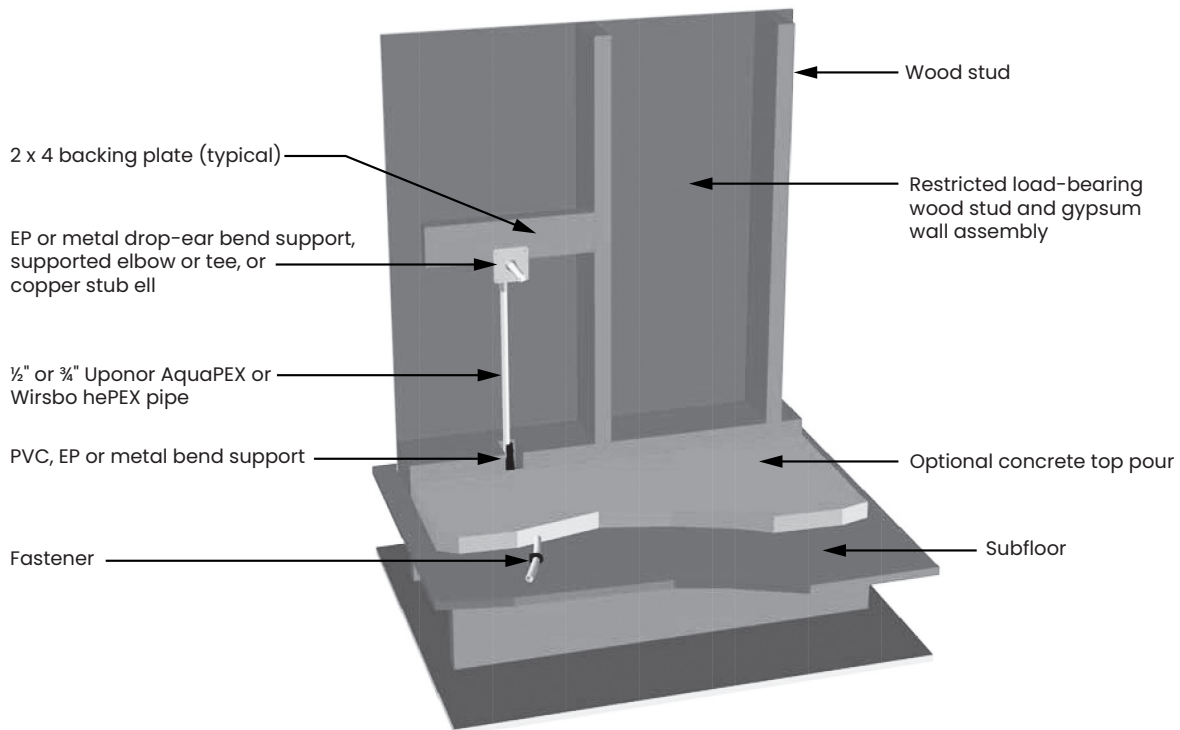


Figure 3-3: Fixture detail 2 (U.S.)



Wood-frame assemblies detail

Wood-frame floor/ceiling assembly (UL design no. L557/ITS design no. UW/FCA 60-01/QAI design no. P321-1F)

Wood-frame wall assembly (UL design no. U372/ITS design no. UW/WA 60-02/QAI design no. P321-1B/P321-1H)

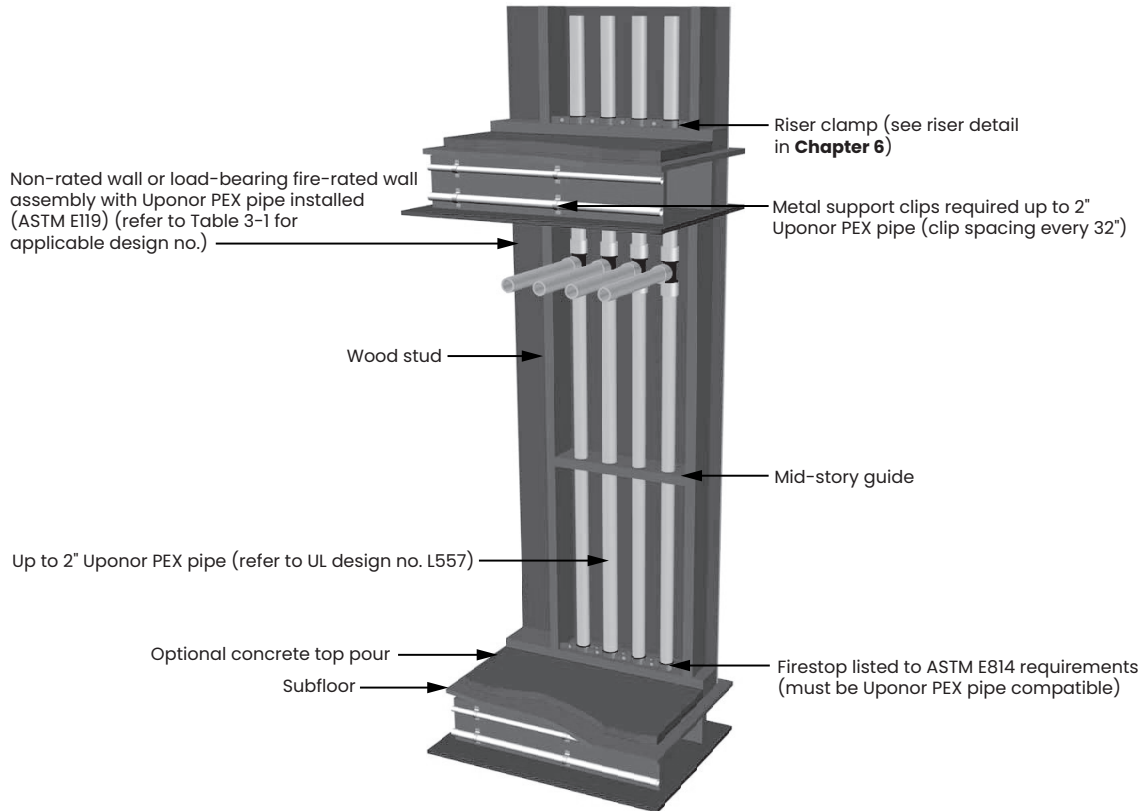


Figure 3-4: Wood-frame assemblies detail (U.S.)



Wood-frame assemblies (Canada)

Multiport tee detail

Wood-frame floor/ceiling assembly (ITS Design No. UW/FCA 60-01/QAI Design No. P321-1F)

Wood-stud wall assembly (ITS Design No. UW/WA 60-02/QAI Design No. P321-1B)

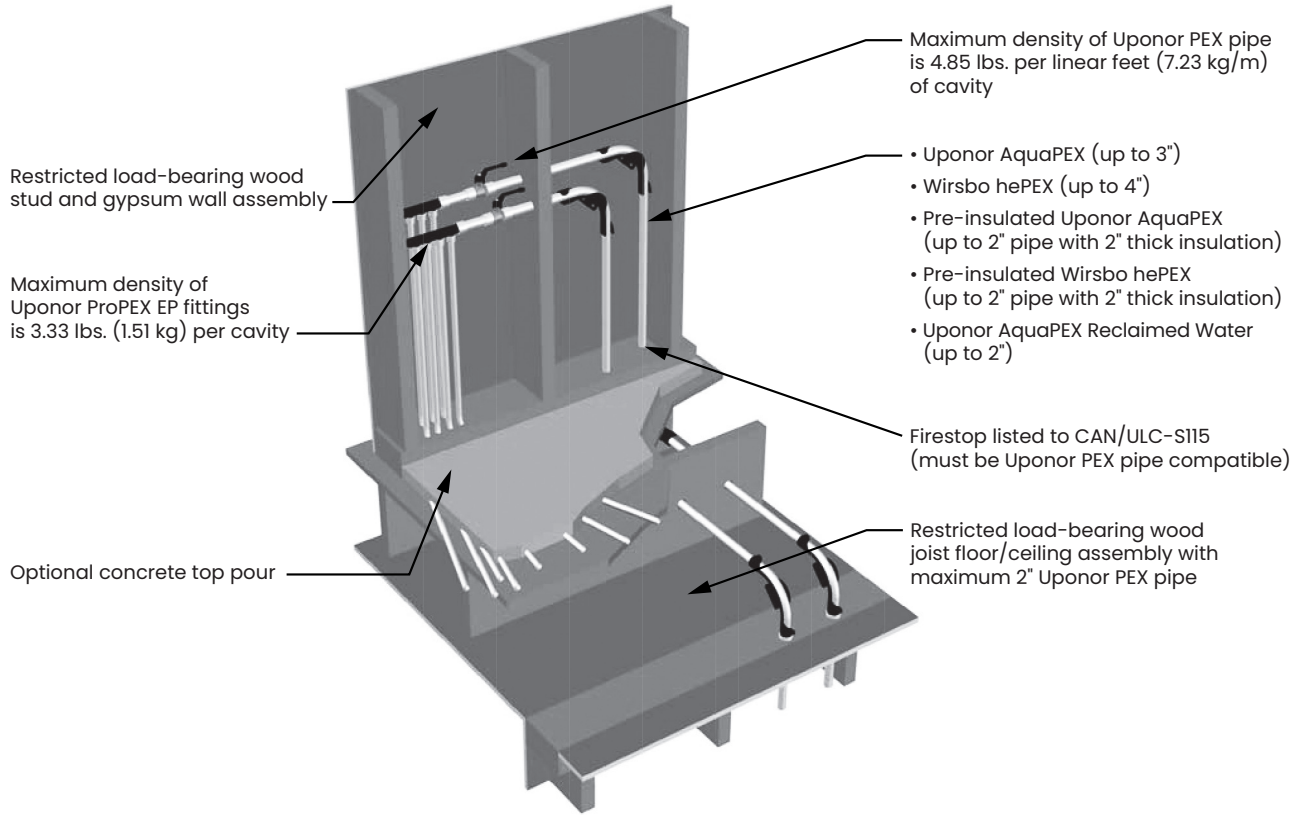


Figure 3-5: Multiport tee detail (Canada)



Fixture detail 1

Wood-frame floor/ceiling assembly (ITS Design No. UW/FCA 60-01/QAI Design No. P321-1F)
Wood-stud wall assembly (ITS Design No. UW/WA 60-02/QAI Design No. P321-1B)

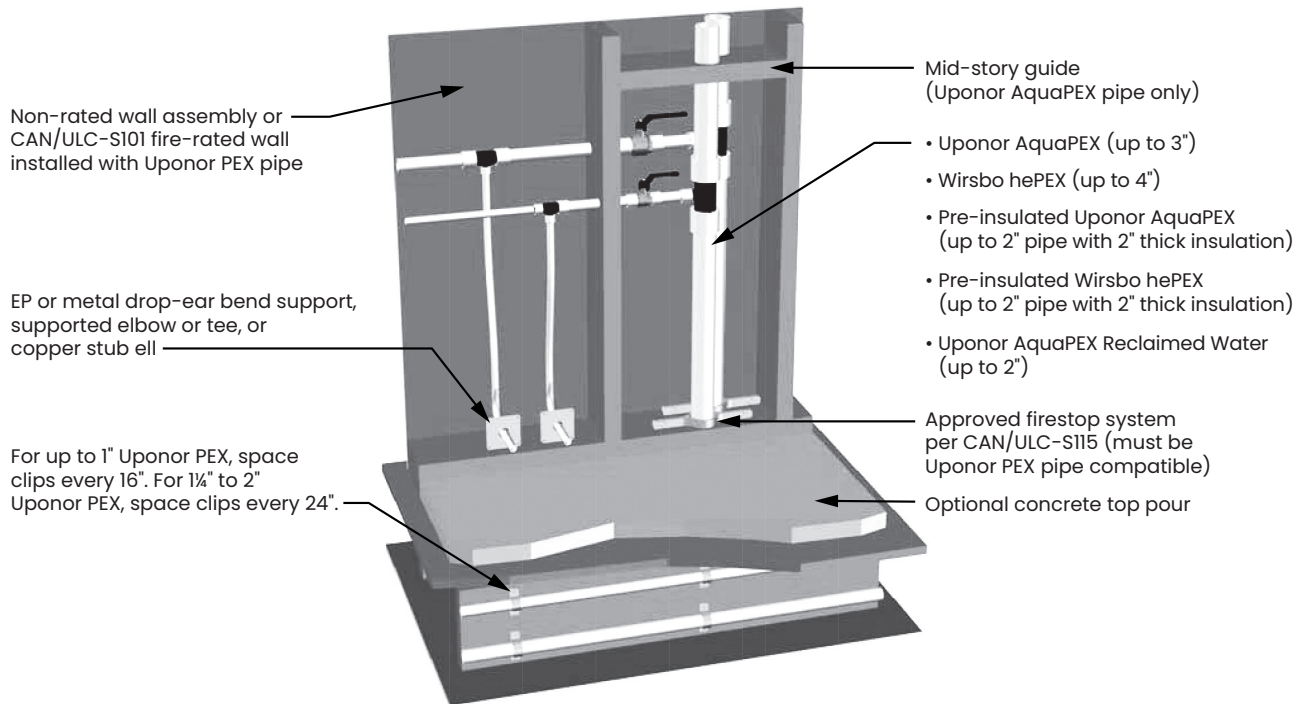


Figure 3-6: Fixture detail 1 (Canada)



Fixture detail 2

Wood-frame floor/ceiling assembly (ITS Design No. UW/FCA 60-01/QAI Design No. P321-1F)
Wood-stud wall assembly (ITS Design No. UW/WA 60-02/QAI Design No. P321-1B)

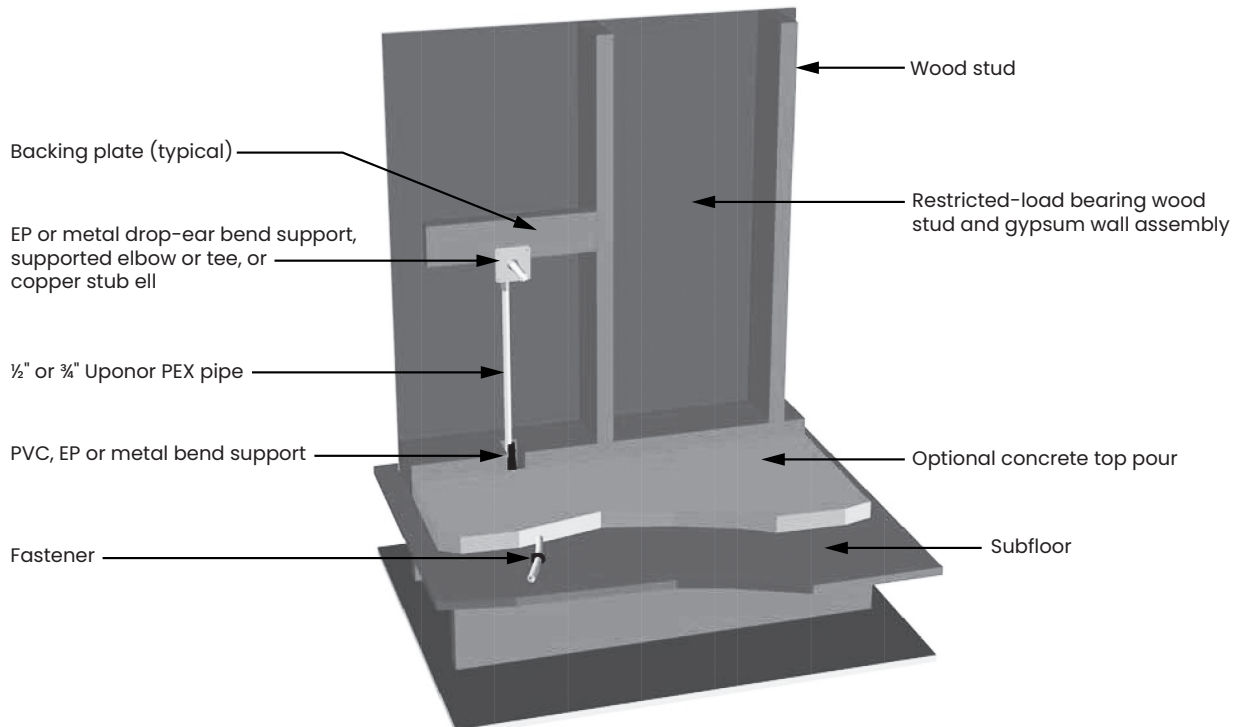


Figure 3-7: Fixture detail 2 (Canada)



Concrete assemblies (U.S.)

Multiport tee detail

Concrete floor/ceiling assembly (UL Design No. K913/QAI Design No. P321-1D)
Steel-stud wall assembly (UL Design No. V444/QAI Design No. P321-1A)

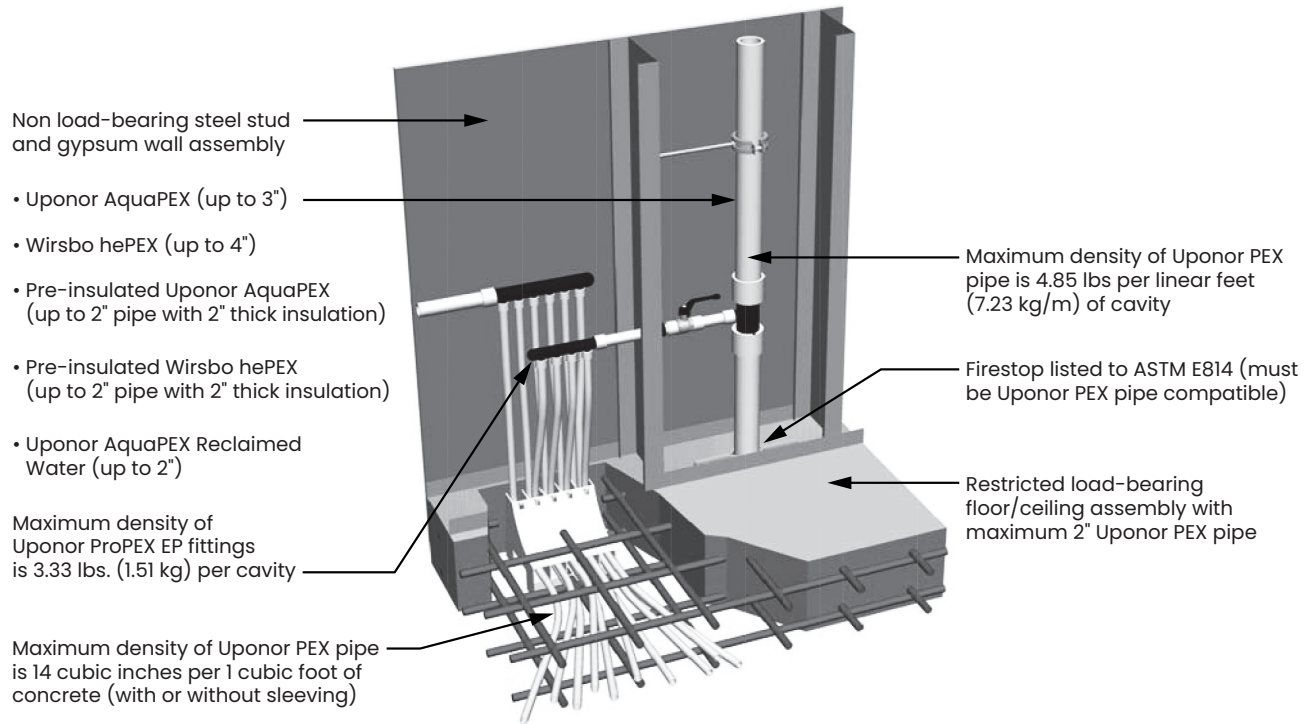


Figure 3-8: Multiport tee detail (U.S.)



Fixture detail

Concrete floor/ceiling assembly (UL Design No. K913/QAI Design No. P321-1D)
Steel-stud wall assembly (UL Design No. V444/QAI Design No. P321-1A)

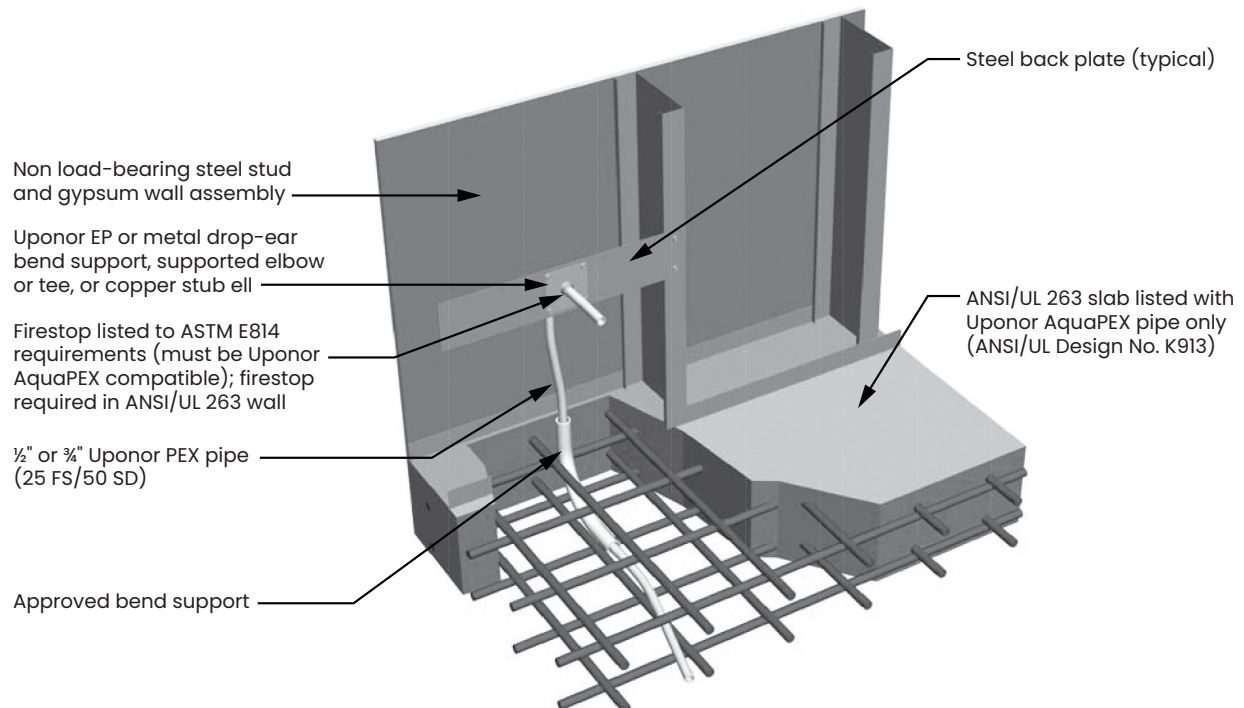


Figure 3-9: Fixture detail (U.S.)



Concrete assemblies detail

Concrete floor/ceiling assembly (UL design no. K913/ITS design no. UW/FCA 120-01/-02/QAI design no. P321-1D)
Steel-stud wall assembly (UL design no. V444/ITS design no. UW/WA 60-01/QAI design no. P321-1A/P321-1G)

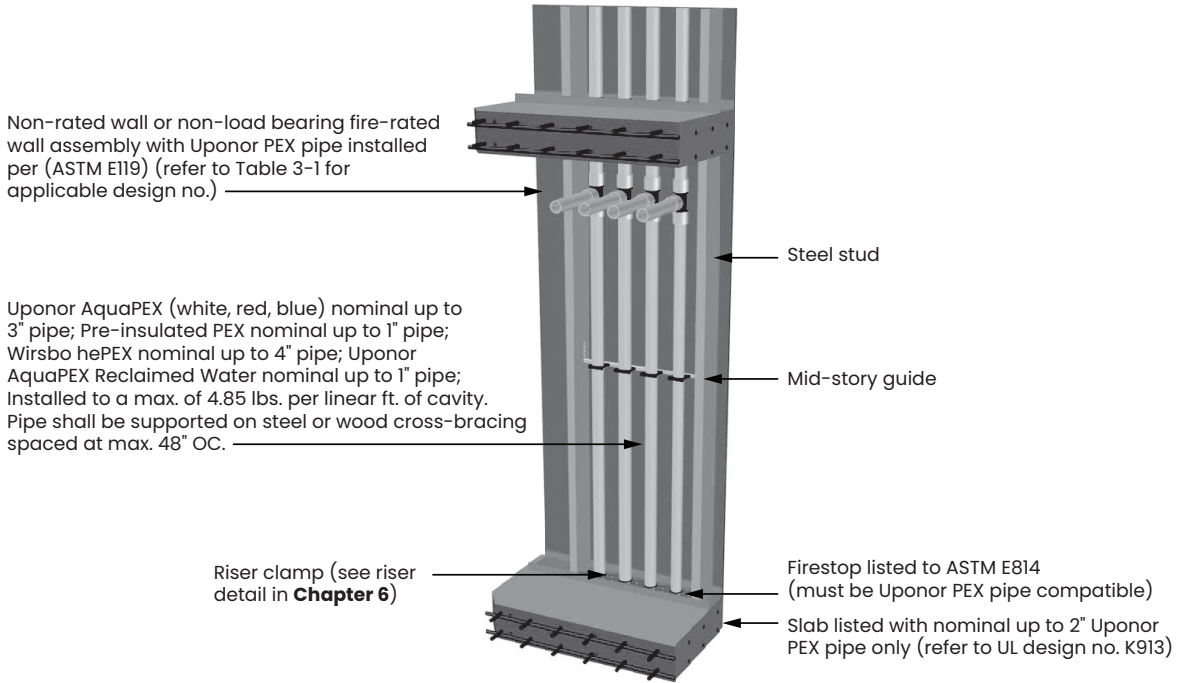


Figure 3-10: Concrete assemblies detail (U.S.)



Concrete assemblies (Canada)

Multiport tee detail

Concrete floor/ceiling assembly (ITS design no. UW/FCA 120-02/QAI design no. P321-1D)
Steel-stud wall assembly (ITS design no. UW/WA 60-01/QAI design no. P321-1A)

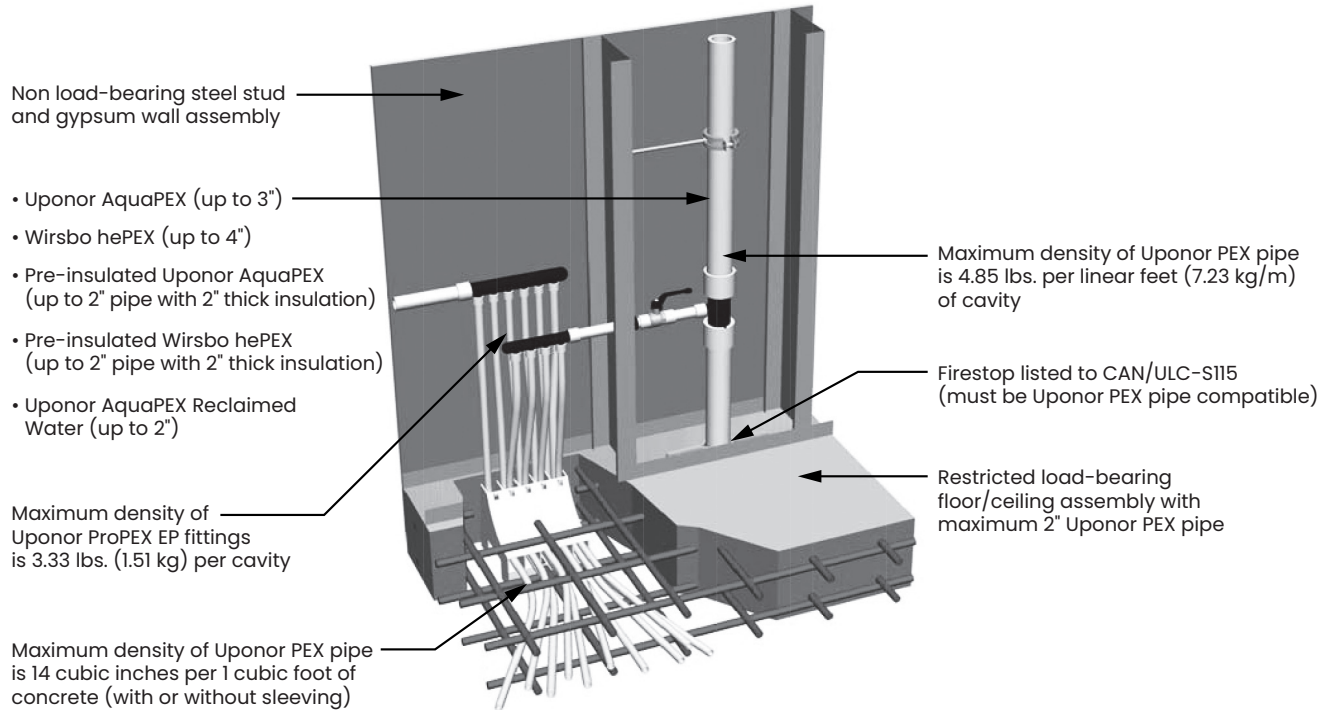


Figure 3-11: Multiport tee detail (Canada)



Fixture detail

Concrete floor/ceiling assembly (ITS design no. UW/FCA 120-02/QAI design no. P321-1D)
Steel-stud wall assembly (ITS design no. UW/WA 60-01/QAI design no. P321-1A)

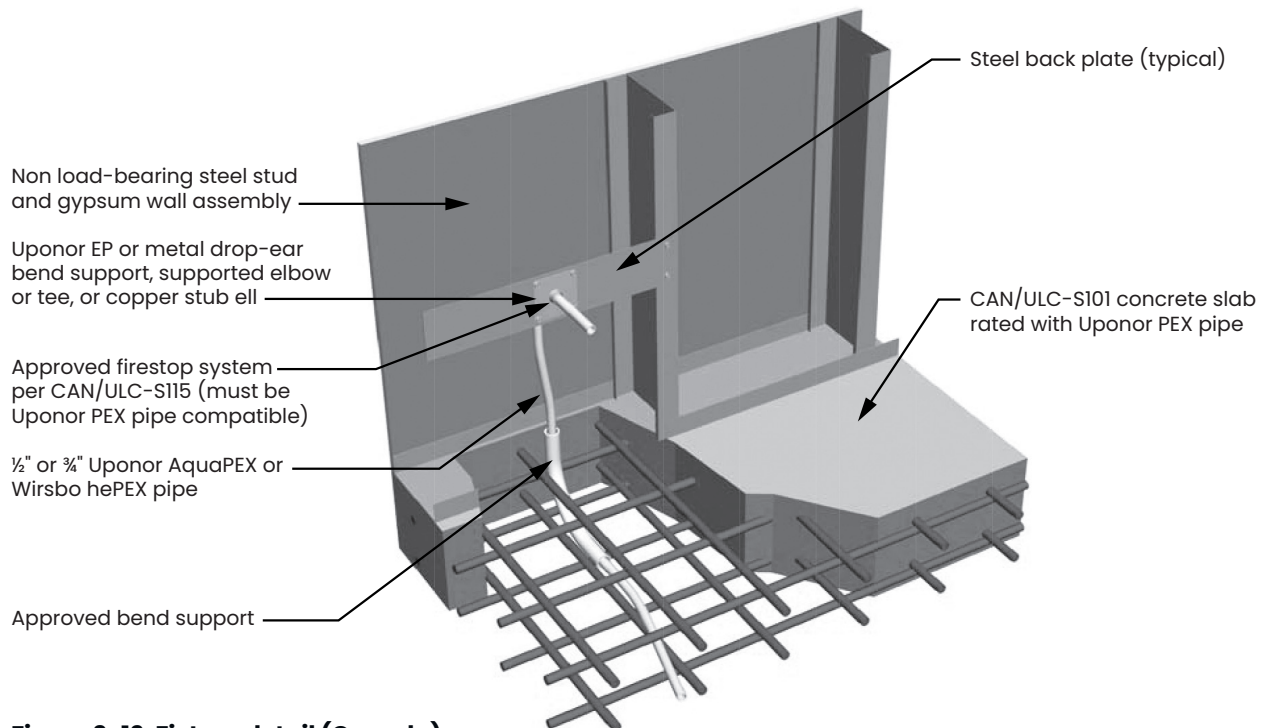


Figure 3-12: Fixture detail (Canada)

ASTM E814 or CAN/ULC-S115

Combustible and non-combustible pipes penetrating a wall or a floor/ceiling fire-rated assembly must include a code-compliant means of passive fire protection. The function of a passive fire protection system, such as firestopping, is to contain the fire within the area in which it started by preventing the products of combustion (smoke, hot gasses, and flames) from spreading throughout the structure.

Effective firestopping requires accurate adherence to a specific combination of conditions that have been tested and listed as a system per ASTM E814, CAN/ULC-S115, or ANSI/UL 1479. Listed firestop components include the penetrated substrates, penetrating item, penetration hole, insulating materials, sealants, and installation method. Deviation from the listed fire assembly documentation severely compromises the effectiveness of the firestop system.

Fire assembly documentation and listings shall be obtained from the selected firestop solution manufacturer. Most of the firestop manufacturers have system selector tools or navigators on their websites to easily research and find a listing that matches the specified type of construction.

Fire stopping solutions

There is a wide range of firestopping solutions that have been tested and listed with PEX pipe, including intumescent caulks, wrap strips, pass-through devices, collars and cast-in-place sleeves. Some firestop manufacturers include, but are not limited to, 3M™, Hilti®, RectorSeal®, Passive Fire Protection Partners, Specified Technologies Inc., Holdrite®, and ProSet Systems®.

The steps below show an example of how to research and find a listed firestop assembly for PEX pipe.

Step one

Choose a firestop solution manufacturer and consult their website or search the **UL Product iQ™ directory** for applicable listings. (See **Figure 3-13**.)

Step two

Select the desired and specified features of the through-penetration system. Defining the country of use, assembly type, penetrating item, firestopping product, and F rating of the system may help refine search results. (See **Figure 3-14**.)

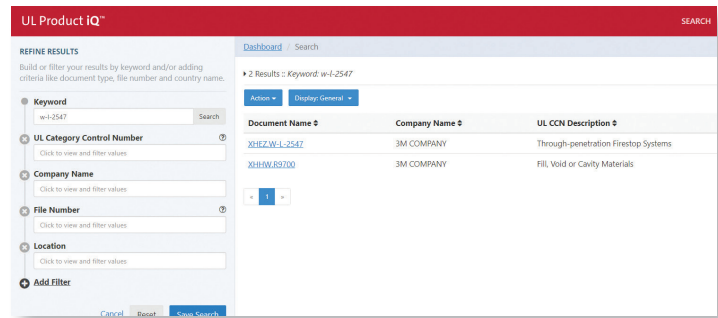


Figure 3-13: UL Product iQ™

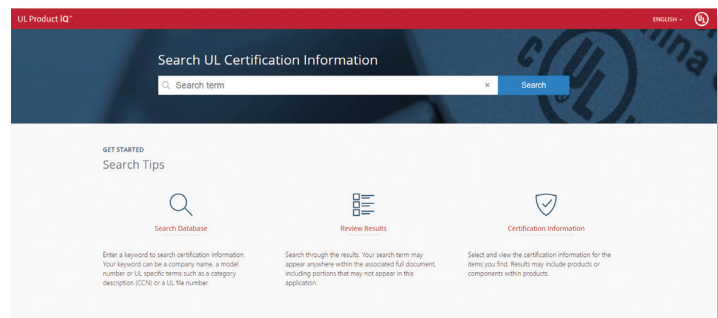


Figure 3-14: Select appropriate features

Step three

Review the system matches for accuracy and consider all available options. Regarding fire listings for pressure pipe applications, domestic water piping (Division 22, Section 22 11 16) and hydronic piping (Division 23, Section 23 21 13) may be defined as being “closed” or “pressure” type systems. (See **Figure 3-15** on the following page.)

- WL2547 3M™ Fire Barrier Sealant CP 25WB+ 1, 2
- 3M™ Fire Barrier Sealant IC 15WB+
- 3M™ Fire Barrier Water tight Sealant 3000 WT

UL Max 2" SDR 9 PEX (closed only). U300, U400, or V400 series gypsum wallboard assemblies. Max. diameter of opening 1½" larger than OD or penetrant. Point contact to max. 1½" annular space. Concentric or eccentric installations. 1 & 2 hour F rating. No mineral wool required.

Figure 3-15: Search results

Step four

Ensure the selected fire assembly document matches:

- Type of construction
- F rating of assembly
- Through penetrant defined as crosslinked polyethylene pipe or PEX pipe

- Range of pipe size being installed
- Penetration hole size and shape
- Firestop solution availability

(See **Figures 3-13, 3-14, and 3-15.**)

Note: It may be desirable to select a firestop product that can be used for other MEP system penetrations, such as drain, waste, and vent (DWV) and conduit applications. This can help ease coordination on the job site during the firestop installation.

Refer to the respective firestop manufacturer for more information pertaining to the appropriate application of their products. Be mindful of information stated in the published listings to ensure compliance during installation.

Note: Ensure the required firestop material defined in the assembly (i.e., sealant) does not come into contact with Uponor EP fittings. Assemblies define the penetrating item as "PEX pipe" and therefore only PEX pipe shall come into contact with the required firestopping material.

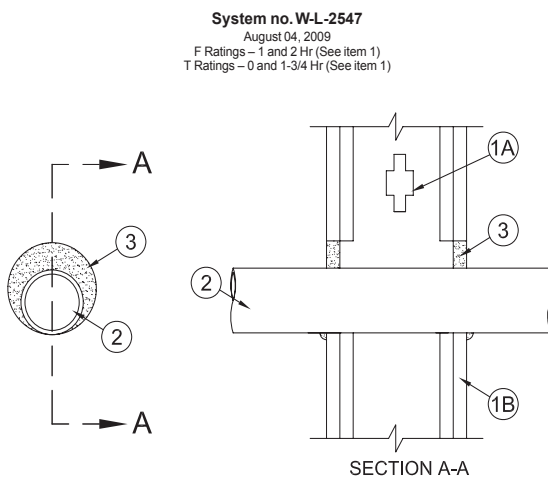
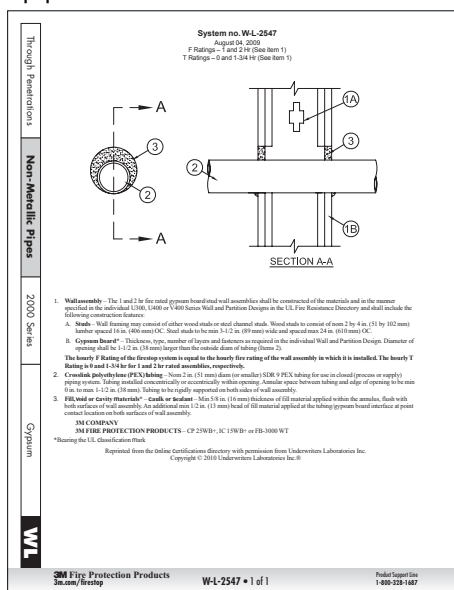


Figure 3-17: Assembly drawing

Figure 3-16: Fire assembly document

1. **Wall Assembly** – The 1 and 2 hr fire rated gypsum board/stud wall assemblies shall be constructed of the materials and in the manner specified in the individuals U300, U400 or V400 Series Wall and Partition Designs in the UL Fire Resistance Directory and shall include the following construction features:

- A. **Studs** – Wall framing may consist of either wood studs or steel channel studs. Wood studs to consist of nom 2 by 4 in. (51mm by 102mm) lumber spaced 16 in. (406mm) o.c. Steel studs to be min 3½ in. (89mm) wide and spaced max 24 in. (610mm) o.c.
- B. **Gypsum Board*** – Thickness, type, number of layers and fasteners as required in the individuals Wall and Partition Design. Diameter of opening shall be 1½ in. (38mm) larger than the outside diameter of tubing (items 2).

The hourly F Rating of the firestop system is equal to the hourly fire rating of the wall assembly in which it is installed. The hourly T Rating is 0 and 1½ hr for 1 and 2 hr rated assemblies, respectively.

2. **Crosslink Polyethylene (PEX) Tubing** – Nom 2 in. (51 mm) diameter (or smaller) SDR9 PEX tubing for use in closed (process or supply) piping system. Tubing installed concentrically or eccentrically within opening. Annular space between tubing and edge of opening to be min 0 in. to max 1½ in. (38mm). Tubing to be rigidly supported on both sides of wall assembly.

3. **Fill, Void or Cavity Materials* – Caulk or Sealant** – Min 5/8 in. (16mm) thickness of fill materials applied within the annulus, flush with both surfaces of wall assembly. An additional min ½ in. (13 mm) bead of fill material applied at the tubing/gypsum board interface at the tubing/gypsum board interface at point contact location on both surfaces of wall assembly.

3M Company
3M FIRE PROTECTION PRODUCTS – CP25WB+, IC15WB+ OR FB-3000WT

*Bearing the UL Classification Mark

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Figure 3-18: Assembly criteria

ASTM E814 and CAN/ULC-S115 listings

■ = ASTM E814 and CAN/ULC-S115 ■ = CAN/ULC-S115 only

Assembly types		Manufacturer							
		3M™		Hilti®		RectorSeal®		STI	
		Wall	Floor/clg	Wall	Floor/clg	Wall	Floor/clg	Wall	Floor/clg
Wood-stud/steel-stud assemblies	1-hour	PHV-120-04	F-C-2039	W-L-2186	F-C-2081	W-L-2342	F-C-2298	F-C-2319	F-C-2032
		PHV-120-11	F-C-2240	W-L-2235	F-C-2230	W-L-2262	F-C-8015	W-L-2100	F-C-2252
		W-L-2091	F-C-2343	W-L-2466	F-C-2310	W-L-2373	F-C-2329	W-L-2144	F-C-2319
		W-L-2146	F-C-2344	W-L-2474	F-C-2334	W-L-2430	F-C-2212	W-L-2241	F-E-2003
		W-L-2173	F-C-2391	W-L-2480	F-C-8038	W-L-2526	F-E-2007	W-L-2242	F-C-8021
		W-L-2448	F-E-2002	W-L-2537	F-C-8044	W-L-2121	F-C-2221	W-L-2423	F-C-8029
		W-L-2483	F-E-2012	W-L-2467	F-C-2416	W-L-2209	F-C-2385	W-L-2508	F-E-8003
		W-L-2543	F-E-2040	W-L-5224		W-L-2528		W-L-2548	F-C-8045
		W-L-2547	PHV-120-04	W-L-2671		W-L-2402		W-L-2549	F-E-8010
		W-L-2299	PHV-120-11	W-L-2057		W-L-2638		W-L-7193	
	PV-60-02				W-L-2639		F-C-8021		
					W-L-2007		F-C-8029		
					W-L-2170		W-L-5290		
					W-L-2287		W-L-2631		
					W-L-2457				
					W-L-2524				
					W-L-2594				
					W-L-2595				
	2-hour	PHV-120-04	PHV-120-04	W-L-2186	F-C-2081	W-L-2342	F-C-2221	W-L-2100	
		PHV-120-11	PHV-120-11	W-L-2235	F-C-2310	W-L-2262	F-C-2385	W-L-2144	
W-L-2090			W-L-2466		W-L-2373		W-L-2241		
W-L-2091			W-L-2474		W-L-2430		W-L-2242		
W-L-2146			W-L-2480		W-L-2526		W-L-2423		
W-L-2448			W-L-2537		W-L-2121		W-L-2508		
W-L-2483			W-L-2467		W-L-2209		W-L-2548		
W-L-2543			W-L-5224		W-L-2528		W-L-2549		
W-L-2547			W-L-2671		W-L-2402		W-L-7193		
W-L-2299					W-L-2638		W-L-5290		
					W-L-2639		W-L-2631		
					W-L-2170				
					W-L-2287				
					W-L-2457				
					W-L-2524				
				W-L-2594					
				W-L-2595					

Table 3-2a: Fire assemblies per manufacturer

Note: This table is not meant to address every compatible fire assembly or firestop manufacturer. It is the end user's responsibility to ensure that the fire assembly documentation being used is approved and current for the specific application. Please refer to the respective manufacturer's website for detailed listing information.

ASTM E814 and CAN/ULC-S115 listings

■ = ASTM E814 and CAN/ULC-S115 ■ = CAN/ULC-S115 only

Assembly types	Manufacturer									
	3M™		Hilti®		RectorSeal®		STI		HOLDRITE	
	Wall	Floor/clg	Wall	Floor/clg	Wall	Floor/clg	Wall	Floor/clg	Floor/clg	
Concrete assemblies	1-hour						C-AJ-2605	C-AJ-2605		
	C-AJ-2510	C-AJ-2510	C-AJ-2170	C-AJ-2170	W-J-2162	C-AJ-2628	W-J-2021	C-AJ-2031	F-A-2188	
	C-AJ-2536	C-AJ-2536	C-AJ-2407	C-AJ-2407	W-J-2122	F-A-2171	W-J-2043	C-AJ-2140	F-A-2221	
	PHV-120-04	F-A-2115	C-AJ-2647	C-AJ-2647	W-J-2180	C-AJ-2701	W-J-2076	C-AJ-2291	F-B-2042	
	PHV-120-11	PH-120-10	W-J-2207	C-AJ-2674	W-J-2025	C-AJ-2176	W-J-2077	F-A-2186	F-A-2269	
	C-AJ-2213	PHV-120-04	W-J-2229	F-B-2040	C-AJ-2628	F-A-2235	W-J-2232	F-A-2224	F-A-2222	
	C-AJ-2378	PHV-120-11	W-J-2206	F-B-2041	C-AJ-2679	F-A-2237	W-J-2233	F-A-2225	F-A-2037	
	W-J-2231	C-AJ-2076	W-J-5122	F-A-2142	C-AJ-2701	C-AJ-2494	W-J-5148	C-AJ-2586		
	W-J-2110	C-AJ-2213	W-J-2321	W-J-2071	W-J-2295	C-AJ-2679	C-AJ-2586	C-AJ-5345		
	C-AJ-2213	C-AJ-2378			W-J-2296	C-AJ-2702	C-AJ-5345	C-BJ-2046		
	2-hour									
	C-AJ-2378	C-AJ-2213			C-AJ-2702		C-BJ-2046			
	C-AJ-2738	C-AJ-2378			C-AJ-2176		W-J-2291			
	PHV-120-12	C-AJ-2738			C-AJ-2494					
	C-AJ-2698	PHV-120-12			W-J-2035					
		C-AJ-2698			W-J-2051					
					W-J-2142					
					W-J-2197					
					W-J-2220					
					W-J-2222					
					W-J-2224					
					W-J-2266					
	3-hour									
			C-BJ-2028	C-BJ-2028	C-AJ-2119	C-AJ-2119	C-AJ-2671	C-AJ-2671	F-A-2176	
			C-BJ-2040	C-BJ-2040	C-AJ-2194	C-AJ-2194	C-AJ-5344	C-AJ-5344	F-A-2221	
			C-BJ-2041	C-BJ-2041	C-AJ-2622	C-AJ-2622	C-AJ-5346	C-AJ-5346	F-B-2042	
								C-AJ-2578	F-A-2269	
							F-A-2203	F-A-8034		
							F-A-2204	F-A-2222		

Table 3-2b: Fire assemblies per manufacturer

Note: This table is not meant to address every compatible fire assembly or firestop manufacturer. It is the end user's responsibility to ensure that the fire assembly documentation being used is approved and current for the specific application. Please refer to the respective manufacturer's website for detailed listing information.

Cast-in-place sleeves

Several manufacturers offer cast-in-place sleeves, which provide floor/ceiling penetrations in concrete slab applications. Some manufactures include:

- Holdrite
- ProSet Systems
- Hilti HydroFlame

Refer to the respective manufacturer's website for detailed product information.



Figure 3-19: HILTI CP 680-P cast-in-place devices



ASTM E84 — surface burning characteristics

As defined by the International Building Code (IBC), combustible piping may be installed in areas required to be of noncombustible construction, provided the piping is installed in a wall or concrete-floor slab or the pipe has a flame-spread (FS) index rating of not more than 25 and a smoke-developed (SD) index rating of not more than 50 when tested in accordance with ASTM E84.

Uponor PEX-a piping systems comprised of Uponor PEX-a piping, Uponor ProPEX rings, Uponor EP fittings, Uponor brass fittings and Uponor PEX-a Pipe Support products are listed for installation in return-air plenums as tested in accordance with ASTM E84.

The below listings apply to Uponor PEX-a piping systems installed in either horizontal or vertical orientations in the field. Refer to **Table 3-3** for installation requirements.

QAI P321-1 ½" to ¾" Uponor PEX-a (uninsulated)

Adjacent runs of uninsulated ½" to ¾" Uponor PEX-a piping in a return-air plenum must be separated by 18".

QAI P321-2 Up to and Including 3" Uponor PEX-a Supported with Uponor PEX-a Pipe Support

See **Chapter 6** for installation details. Uponor PEX-a piping manufactured with a maximum nominal outside diameter (OD) of 3" and supported with Uponor PEX-a Pipe Support. Pipe or fitting sections without

PEX-a Pipe Support must be covered with a rated insulation per **Table 3-5**. There is no minimum length of PEX-a Pipe Support segments. There are also no spacing limitations between adjacent runs of this pipe.

QAI P321-1 Up to and Including 3" Uponor PEX-a (insulated)

Uponor PEX-a piping manufactured with a maximum nominal OD of 3" and encased in a minimum ½" thick insulation in accordance with **Table 3-5** shall have no limitation on spacing.

Classified as to surface burning characteristics			
ASTM E84	Flame spread	Smoke developed	Limitations
Nominal ½" to ¾" size	25 or less	50 or less	Adjacent pipe runs shall be located at least 18" apart.
3" maximum nominal size Uponor PEX-a Supported with Uponor PEX-a Pipe Support	25 or less	50 or less	Pipe or fitting sections without PEX-a Pipe Support must be covered with a rated insulation per Table 3-5 . There is no minimum length of PEX-a Pipe Support segments.
3" maximum nominal size Uponor PEX-a with ½" insulation	25 or less	50 or less	½" minimum thickness insulation as specified in Table 3-5 .

Table 3-3: Uponor PEX ASTM E84 requirements

ASTM E84 requirements for PEX-a Pipe Support

Uponor PEX-a Pipe Support has been tested and approved for use in ASTM E84 applications. To meet the requirements, PEX-a Pipe Support must be installed per the following requirements:

- Pipe or fittings without PEX-a Pipe Support shall be covered with a minimum ½" thick insulation.
- There is no minimum segment length of PEX-a Pipe Support.

When installed per the above requirements, there are no spacing limitations between parallel piping runs.

Note: The above requirements also apply to PEX-a Pipe Support installed in a vertical position for ASTM E84 applications.

Note: Exposed sections of ½" and ¾" Uponor PEX pipe can be installed un-insulated if the pipe runs are separated by a minimum of 18".

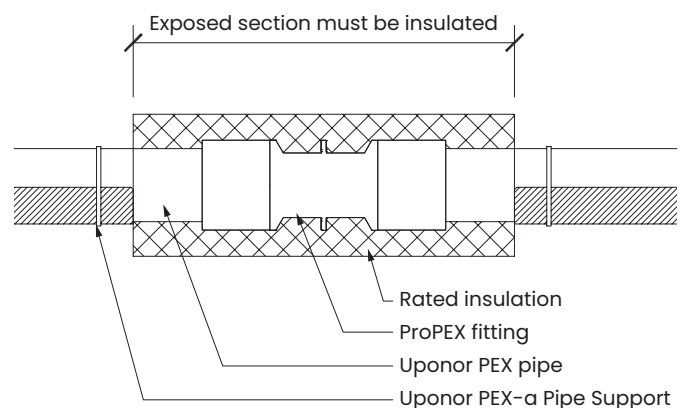


Figure 3-20: PEX-a Pipe Support installations in ASTM E84 applications

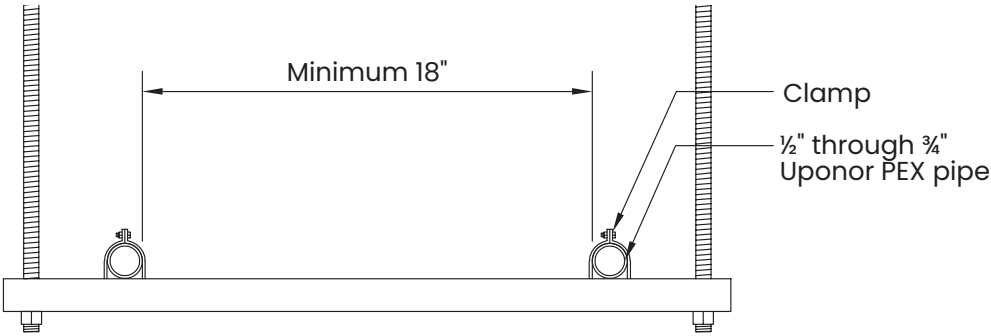


Figure 3-21: QAI P321-1

Guidelines: ½" through ¾" (uninsulated)

Limitations: Adjacent runs shall be located at least 18" apart.

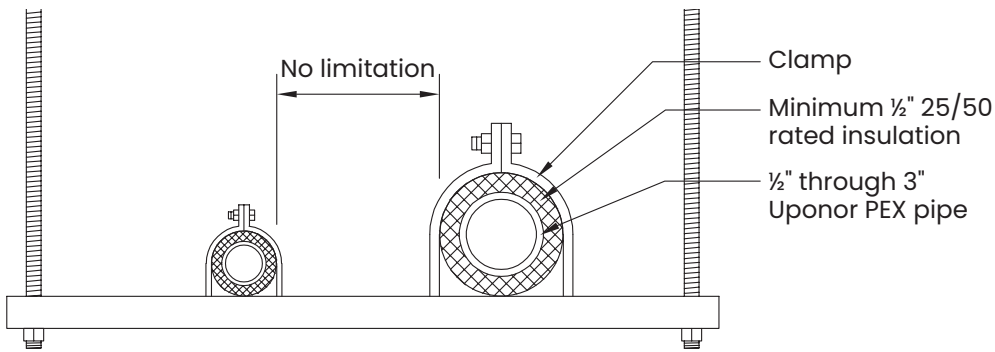


Figure 3-22: QAI P321-1

Guidelines: ½" through 3" (insulated)

Limitations: ½" minimum thickness insulation as specified in **Table 3-3**.

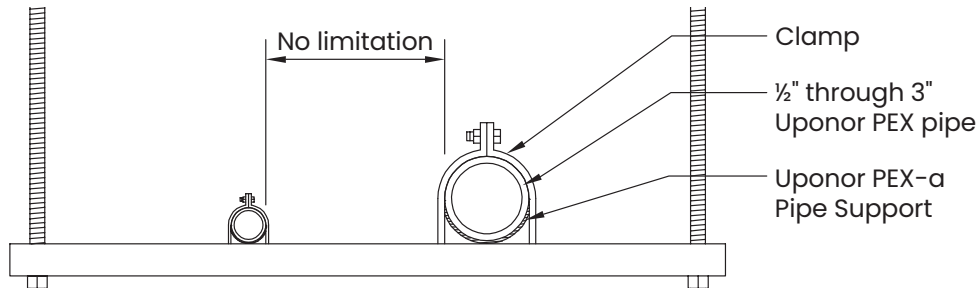


Figure 3-23: QAI P321-2

Guidelines: ½" through 3" (PEX-a pipe support)

Pipe or fitting sections without PEX-a pipe support must be covered with a rated insulation per **Table 3-5**.

There is no minimum length of PEX-a pipe support segments.



CAN/ULC-S102.2
– surface
burning
characteristics

As defined by the National Building Code of Canada (NBCC), combustible piping may be installed in areas required to be of noncombustible construction, provided the piping is installed in a wall or concrete-floor slab or the pipe has a flame-spread (FS) index rating of not more than 25 and a smoke-developed (SD) index rating of not more than 50 when tested in accordance with CAN/ULC-S102.2.

Uponor PEX-a piping systems comprised of Uponor PEX-a piping, Uponor ProPEX rings, Uponor EP fittings, Uponor brass fittings and Uponor PEX-a pipe support products are listed for installation in return-air plenums as tested in accordance with CAN/ULC-S102.2.

The below listings apply to Uponor PEX-a piping systems installed in either horizontal or vertical orientations in the field. Refer to **Table 3-4** for installation requirements.

QAI P321-1
½" Uponor PEX-a
(uninsulated)

Adjacent runs of un-insulated ½" Uponor PEX-a piping in a return-air plenum have no spacing limitations.

¾" and 1" Uponor PEX-a
(uninsulated)

Adjacent runs of un-insulated ¾" and 1" Uponor PEX-a piping must be separated by 18".

QAI P321-1
Up to and including 3"
Uponor PEX (insulated)

Uponor PEX piping manufactured with a maximum nominal OD of 3" and encased in ½" insulation in accordance with **Table 3-5** shall have no limitation on spacing.

QAI P321-3
Up to and including
2" Uponor PEX-a (water-
filled, uninsulated)

Adjacent runs of water-filled, uninsulated piping in a return-air plenum have a no spacing limitations.

Classified as to surface burning characteristics			
CAN/ULC S102.2	Flame spread	Smoke developed	Limitations
½" nominal size	25 or less	50 or less	No spacing limitations.
¾" and 1" nominal sizes	25 or less	50 or less	Adjacent pipe runs shall be located at least 18" apart.
2" maximum nominal size (water-filled)	25 or less	50 or less	No spacing limitations.
3" maximum nominal size Uponor PEX-a with ½" insulation	25 or less	50 or less	½" minimum thickness insulation as specified in Table 3-5 .

Table 3-4: Uponor PEX CAN/ULC-S102.2 requirements

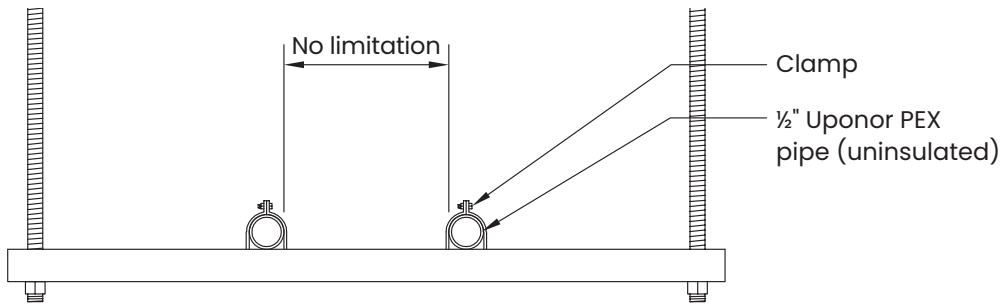


Figure 3-24: QAI P321-1

Guidelines: 1/2" (uninsulated)

Limitations: No spacing limitations.

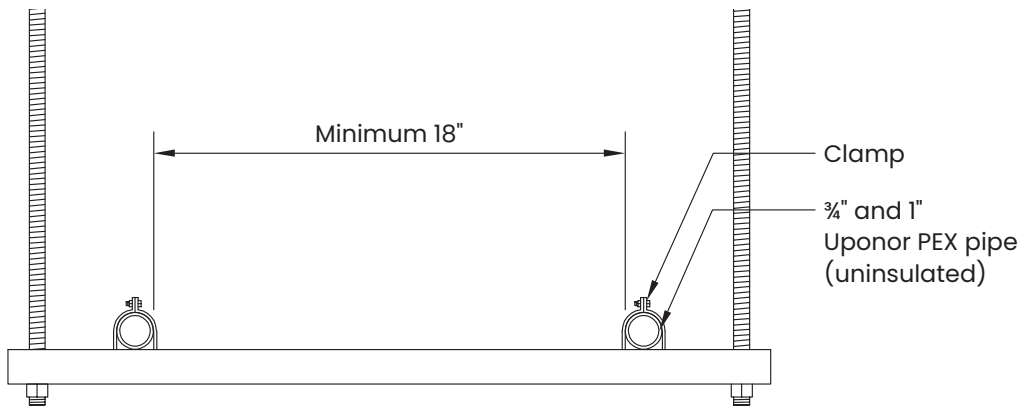


Figure 3-25: QAI P321-1

Guidelines: 3/4" and 1" (uninsulated)

Limitations: Adjacent pipe runs shall be located at least 18" apart.

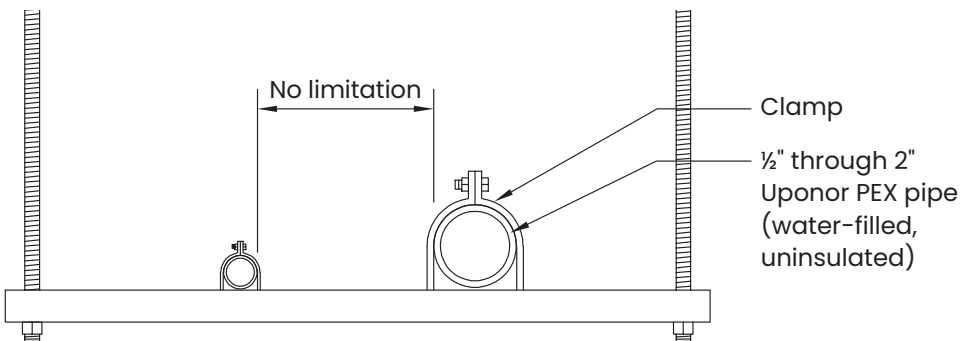


Figure 3-26: QAI P321-3

Guidelines: 1/2" through 2" (water-filled)

Limitations: No spacing limitations

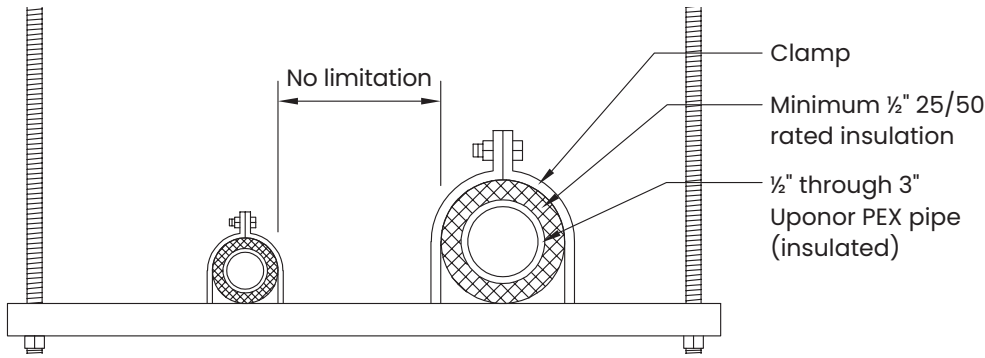


Figure 3-27: QAI P321-1

Guidelines: 1/2" through 3" (insulated)

Limitations: 1/2" minimum thickness insulation as specified in **Table 3-5**

Specifications for pipe insulations in ASTM E84 and CAN/ULC-S102.2 applications			
Products (minimum thickness)	ASTM E84 and CAN/ULC-S102.2		Density of insulation
	Flame spread	Smoke developed	
1/2" Manson Alley-K Fiberglass Pipe Insulation	25 or less	50 or less	4.0 pcf
1/2" Johns Manville Micro-Lok Fiberglass Pipe Insulation	25 or less	50 or less	3.3 pcf
1/2" Johns Manville Micro-Lok HP	25 or less	50 or less	3.5 pcf
1/2" Owens Corning VaporWick Pipe Insulation	25 or less	50 or less	4.0 pcf
1/2" Owens Corning Fiberglass Pipe Insulation	25 or less	50 or less	3.5 pcf
1/2" Knauf Earthwool Redi-Klad Pipe Insulation	25 or less	50 or less	3.8 pcf
1/2" GLT Pipe and Tank Insulation	25 or less	50 or less	4.5 pcf
1/2" Nomalock Pipe Insulation*	25 or less	50 or less	4.0 pcf

Table 3-5: Specifications for pipe insulations in ASTM E84 and CAN/ULC-S102.2 applications

*Check the rated grade of Nomalock insulations for plenum use.

Underwriters Laboratories (UL) 2846

Until recently, piping materials were to be tested under the ASTM E84 method, which was originally developed to test building construction components. The UL 2846 test method was developed specifically for plastic piping materials to test flame and smoke development.

Uponor PEX piping (up to 4") carries the UL 2846 *Standard for Fire Test of Plastic Water Distribution Plumbing Pipe for Visible Flame and Smoke Characteristics*.

Approved Uponor PEX pipes include:

- Uponor AquaPEX (up to 3")
- Wirsbo hePEX (up to 4")

Installation criteria

Piping must be covered with a minimum ½" thick, UL-classified pipe and equipment covering material as described on the marking.

Chapter 4

System Design Parameters

The Uponor advantage

Designing a domestic water or hydronic distribution system with Uponor PEX pipe and ProPEX fittings offers many advantages, including reliability, corrosion-resistance, cost-effectiveness, greater resiliency in freezing conditions, heat-kink reparability, code-compliance, and superior thermal and acoustical properties, all backed by a 25-year transferable limited warranty.

Domestic water systems

For domestic water systems, the smaller inside diameter of SDR9 Uponor AquaPEX piping allows decreased system volume to provide hot water to fixtures in a shorter amount of time while still meeting end-use fixture requirements. This provides an efficient system that can meet peak flow demands while conserving water and energy use.

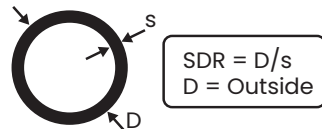
Additionally, designing with multiport tees and small-dimension (½" to 1") coiled piping reduces the number of behind-the-wall connections in a unit application by 70 percent for greater system performance.

Hydronic piping systems

For hydronic piping systems, Wirsbo hePEX is manufactured with an oxygen barrier to protect ferrous components in hydronic heating hot-water or chilled-water applications, providing a durable, reliable, corrosion-resistant solution that offers greater system longevity and performance.

Standard dimension ratio (SDR)

Standard dimension ratio (SDR) is a term used in describing the size of PEX piping — it is the conceptual equivalent of a pipe schedule. Dimension ratio (DR) is the average outside diameter (OD) of PEX piping divided by its minimum wall



thickness.

Figure 4-1: ISO Equation **ISO**

Equation $2S/P = R-1$
Where S = HDS, P = psi,
R = SDR

Temperature and pressure ratings

Temperature and pressure ratings for PEX piping are determined by the Plastics Pipe Institute

(PPI) as required by the ASTM F876 standard. It is important to understand the hydrostatic strength (ratings) on Uponor PEX piping does NOT take into account environmental or system factors which could affect system life. These factors could include, but are not limited to, water temperature and quality, use patterns, chlorine type and level, UV exposure, installation methods, etc. See **Table 4-1** for operating parameters. Additional system design recommendations can be found in PPI TR-4. The minimum burst pressure per ASTM F876 is 480 psi at 73°F (22.7°C) for ½" PEX and 475 psi at 73°F (22.7°C) for ¾" and larger PEX.

Additional supporting information can be found in PPI TN-53, *Guide to Chlorine Resistance Ratings of PEX Pipes and Tubing for Potable Water Applications*, regarding operating parameters.

Hydrostatic design basis (HDB)

Through scientific research and historical experience, hydrostatic design basis (HDB) ratings have been shown to be useful indicators of relative long-term strength of thermoplastic materials

when tested under the conditions specified in test method ASTM D2837. The HDB is used to determine the temperature and pressure ratings of a specific material. These temperature and pressure ratings are based on an extrapolated life of 50 years.

Standard PPI TR-3 defines the policies and procedures for developing HDB ratings for thermoplastic piping materials or pipe. Uponor maintains standard grade ratings for Uponor PEX piping as tested in accordance with TR-3. Uponor piping products carry the following temperature and pressure ratings shown in **Table 4-1**.

To start the evaluation, pipes of all sizes are empirically tested to ASTM D2837 to determine the hydrostatic design basis (HDB); this test method is used for all polyethylene-based piping. That data is then multiplied by 0.5 design factor to determine the hydrostatic design stress (HDS). The HDS is then run through an ISO equation (ISO R-161-1690) to determine the temperature and pressure limits of the pipe.

System type	Uponor PEX maximum operating parameters		
	Temperature	Pressure	Velocity
Water service piping	See Table 4-3		10 ft./sec.
Domestic cold-water piping	See Table 4-3		10 ft./sec.
Domestic hot-water piping	140°F (60°C)	80 psi (5.5 bar)	8 ft./sec.
Domestic hot-water recirculation piping (dedicated)*	140°F (60°C)	80 psi (5.5 bar)	2 ft./sec.
Heating hot-water piping	See Table 4-3		8 ft./sec.
Chilled-water piping	See Table 4-3		8 ft./sec.

Table 4-1: Uponor PEX maximum operating parameters

*Sized per the requirements stated in ASPE Plumbing Engineering Design Handbook (PEDH), Volume 2, Plumbing Systems

Note: For systems requiring pressures and/or temperatures beyond the recommended values, please contact Uponor Technical Services at 888.594.7726.

Excessive temperature and pressure capability

In the event of an equipment or system malfunction, Uponor PEX is capable of withstanding temperatures of up to 210°F at 150 psi (99°C at 10 bar) for a maximum of 48 hours until repairs can be made.

Note: Excessive temperature and pressure requirements are meant solely to demonstrate that PEX piping can temporarily withstand intermittent elevated values and shall not be used as system design parameters.

ASTM F876 temperature and pressure ratings for SDR9 PEX		
Rated temp. (°F)	Hydrostatic design stress (psi)	Pressure rating for water (psi)
73.4	630	160
180	400	100
200	315	80

Table 4-2: ASTM F876 temperature and pressure ratings for SDR9 PEX

Hydrostatic temperature and pressure ratings**	
°F/°C	psi/bar
200.0/93.3	80/5.5
190.0/87.8	90/6.2
180.0/82.2	100/6.9
170.0/76.7	106/7.3
160.0/71.1	111/7.7
150.0/65.6	117/8.0
140.0/60.0	123/8.5
130.0/54.4	128/8.8
120.0/48.9	134/9.2
110.0/43.3	139/9.6
100.0/37.8	145/10.0
90.0/32.2	151/10.4
80.0/26.7	156/10.8
73.4/23.0	160/11.0
60.0/15.6	168/11.6
50.0/10.0	173/11.9
40.0/4.4	179/12.3

Table 4-3: Interpolated hydrostatic temperature and pressure ratings of Uponor PEX for water service, domestic cold water, and hydronic systems.

** ServicePEX can satisfy the performance requirements of section F.7 of **PPI TR-3** for polyethylene (PE) materials to qualify for a **higher 0.63 design factor** resulting in a temperature/pressure rating of **200 psi at 73.4°F (13.8 bar at 23°C)**.

Uponor PEX Design Requirements for Domestic Hot-Water Systems

To provide clarity around domestic hot-water (DHW) and DHW recirculation (DHW-R) systems, refer to the following definitions along with the information in **Table 4-1**.

Important: Damage caused by improper operating conditions in DHW-R systems will **void** the Uponor **warranty**.

If there are differences between Uponor recommendations and local code, always follow the more-restrictive criteria. For example, where Uponor's recommendations are more restrictive than the local code, follow the Uponor recommendations to ensure the product performs as expected and remains covered under warranty.

Definitions

- **Domestic hot-water (DHW) supply** – This is the portion of the domestic water system that supplies hot potable water from the heat source to the various fixtures throughout the building. The piping is sized using applicable codes' water supply fixture units (WSFUs) and/or uniform friction loss for the specific building.
- **Domestic hot-water recirculation (DHW-R) system** – Per the ASSE International Plumbing Dictionary, the DHW-R system is defined as a portion of the water distribution system that allows for continual or intermittent circulation and movement of the hot-water supply within the piping between end-use fixture outlets and the hot-water heating source, usually by means of a pump or gravity loop. The DHW-R system includes all portions of the DHW system where the water is being circulated, including supply and dedicated return piping and any components other than end-of-line fixtures.

- **Dedicated DHW-R piping** – This is the specific part of the DHW-R system that returns (or recirculates) hot potable water to the heat source to be reheated and recirculated. The water in this piping does not supply any fixtures. DHW-R piping is most often sized based on the heat loss of the supply piping and uniform friction loss but may also be sized based on the minimum flow rate of the balancing valves.

DHW design

Chlorine resistance

Uponor AquaPEX piping is tested and listed to PEX 5106 NSF-pw (CL5). Per ASTM F876, the CL5 chlorine resistance rating is intended for an end-use condition of 100-percent operation at 140°F (60°C) at 80 psi (5.5 bar) for maximum operating conditions per the standard, which is the highest chlorine-resistance rating available through ASTM. Products marked with a '5' in the first digit of the four-digit code and also bearing the CL5 designation [e.g., PEX 5106 NSF-pw (CL5)] indicate the product is approved for use in continuous operation of DHW and DHW-R systems with up to a maximum temperature of 140°F (60°C) and maximum system pressure of 80 psi (5.5 bar).

Controlling system parameters: Pressure, temperature, and flow rate

Temperature and pressure fluctuations naturally occur within plumbing systems as water molecules heat and cool. It is important to control the temperature

and pressure in Uponor AquaPEX plumbing systems with proper design, installation, and equipment to ensure temperature and pressure fluctuations stay within the limitations of each system component for the long-term performance of the plumbing system.

DHW and DHW-R temperature

Controlling the delivered water temperature in all plumbing systems is critical to ensure system longevity, occupant health, energy efficiency, and sustainability. The following are examples for properly controlling the DHW temperature to ensure it does not exceed the maximum recommended temperature of 140°F (60°C) for Uponor AquaPEX pipe.

Temperature dial

Tank-style water heaters come standard with a dial to set the temperature of the water in the tank. Many or most of these dials come with arbitrary markings (e.g., A, B, C, or Warm, Hot, etc.). Confirm the dial setting through a temperature gauge installed on the outlet of the heater (hot side). Use a thermometer to measure the temperature of the water flow at the closest fixture. Allow the water to run to ensure the water sample is an accurate reflection of the tank temperature.

Digital control

Devices, such as indirect water tanks or tankless water heaters, use onboard controls to manage the water temperature being supplied to the DHW system. Become familiar with these

controls to properly set a reasonable, effective, and efficient temperature, which is typically 115°F (46°C) to 122°F (50°C). Confirm through the temperature display that the set temperature is not exceeded during a heat-up cycle.

Aquastat

Set the aquastat dial to the desired setting based on a typical delivery temperature or design requirement. Confirm the aquastat (or tank) setting by sampling the DHW and the nearest fixture.

Tempering valve

In cases where local or onboard controls cannot consistently control the desired water temperature delivery, consider installing a tempering valve to ensure operating condition limits are not exceeded.

Modulating valve

Due to the size and volume needed to provide DHW to occupants in commercial structures, it may be necessary to install a modulating valve (or valves) to control the fluctuations and swings in demand for the supply water temperature.

System pressure

If system pressure is not properly controlled and maintained, excessive static or fluctuating pressures can cause premature performance issues with the plumbing system, including water heaters, washing machines, dishwashers, and toilet flush valves, to name a few. The following bullets provide information regarding the origination of

increased system pressures along with means to prevent or control pressure fluctuations

- **Backflow preventors/ check valves** – When water is heated, it expands. This may increase the system water pressure above the recommended code limit of 80 psi. In systems with no backflow preventers, volume expansion can be absorbed back into the water mains. However, a system with backflow preventers experiences the volume expansion within the plumbing system, which may increase pressures beyond the limits of the plumbing system components. Because backflow preventers are often installed in water meters and are difficult to identify, it is important to install an expansion tank in these circumstances.

- **Expansion tanks** – In accordance with most major plumbing codes in North America, systems with backflow preventers or check valves on the main water service line will require an expansion tank or other approved device to control thermal expansion. Systems using these devices are more likely to experience elevated pressures that may be above the maximum recommended limit of 80 psi due to thermal expansion of the heated water. Install expansion tanks on the cold-water supply line to the heater and size accordingly based on the water

heater tank capacity. Also, refer to the water heater manufacturer's installation guidelines for expansion tanks and other similar devices.

- **Pressure-reducing valves (PRVs)** – Recent trends have seen many utilities increase the supply water pressure above 80 psi to provide service to more homes. In this case, Uponor recommends installing a pressure-reducing valve (PRV) to limit the pressure entering the plumbing system. Typical system pressurization should be between 50 and 60 psi.
- **Secondary pressure-relief valves** – In situations where other methods of controlling over pressurization are not working or are not an option, install a secondary pressure-relief valve. Typical relief valves that come with water heaters are set to relieve pressure at 125 or 150 psi. A secondary relief valve set to 80 psi will ensure the system is properly protected from pressure spikes.
- **Pressure zones** – For commercial installations that require pressures above 80 psi to deliver the minimum pressure to fixtures in multistory buildings or high rises, pressure zones are typically used where floors (typically 5-9 levels) or sections of the building are broken into zones and use a PRV to control the pressure. In these applications, ensure risers are within the operating

parameters as noted in **Table 4-1**. Ensure the piping materials in these applications meet the temperature and pressure ratings.

- **Water hammer** – Water hammer is a high-pressure shockwave that spreads through a piping system when moving water is forced to stop or change direction quickly. This phenomenon happens when the domestic water system includes swing-check and fast-closing solenoid valves. Water hammer is present when there is a knocking or banging sound in the system but may not always be noticeable, depending on the piping materials installed. These spikes can damage system equipment, including pumps, appliances, gauges, etc., along with create excessive stress in the pipes, causing reduced service life. Consider installing silent or spring-assisted check valves along with water hammer arrestors. Other options for addressing water hammer include reducing the operating pressure and/or flow rate velocity or installing PRVs in the supply line.
 - **Booster pumps** – Booster pumps that increase low water pressure and flow can sometimes exceed the limitations for the domestic water piping. Ensure booster pump sizing does not allow the system to exceed pipe limitations.
- **Balancing valves** – Balancing valves maintain flow conditions to ensure control valves function properly. These are important to include because unbalanced systems can produce wide temperature, pressures, and velocity swings.

Sizing and maximum velocity

Uponor requires DHW-R flow rate velocity at a maximum of 2 feet per second (fps) and that the hot-water piping system (which includes the recirculation lines) meets the following requirements stated in the *ASPE Plumbing Engineering Design Handbook, Volume 2, Plumbing Systems*:

1. Calculate the heat loss rates of the hot-water supply piping.
2. Calculate the circulation rates for all parts of the circulating piping and the total circulation rate required.
3. Determine the allowable uniform friction head loss and the total head required to overcome friction losses in the piping when the water is flowing at the required circulation rate.
4. Calculate the rates of flow for various piping sizes that will give the uniform pressure drop established in **Step 3**, and tabulate the results.
5. Size the system based upon the tabulation set up in **Step 4**.
6. With the sizes established in **Step 5**, repeat **Steps 1 through 5** as a check on the assumptions made.

Recirculated Hot-Water Systems

Hot-water systems are often recirculated to maintain satisfactory temperatures. There are several recirculating methods available, including:

- **Continuous** – Circulates water 24 hours a day. This method is not considered cost or energy effective when the building's use patterns are not aligned with continuous flow.
- **Thermostatic (aquastat)** – This method measures the water temperature and turns the circulator on or off, based on system needs.
- **Timed** – This method uses a timer to turn the circulator on or off. The time range for circulator operation should be based on the building's usage patterns.
- **Demand** – This method utilizes buttons and motion sensors to turn the circulator on or off only when an occupant needs hot water.

Per **Table 4-1**, regardless of the recirculation method used, Uponor PEX pipe is rated for use in DHW-R systems with a maximum temperature of 140°F (60°C) and a maximum pressure of 80 psi (5.5 bar).

Balancing DHW-R systems

DHW-R systems require flow balancing to maintain satisfactory system temperatures and flows. If systems are not properly balanced, circulated water has the tendency to short

circuit through the shortest loop in the system, thus creating high velocities in that loop and resulting in hot water delays to remote loops. It is important to insulate DHW-R lines, and they typically require little flow to maintain satisfactory system temperatures. Uponor limits maximum velocity for DHW-R systems to 2 fps in dedicated hot-water return piping using Uponor PEX (see **Table 5-9**).

For system balancing, use calibrated devices such as balancing valves or flow limiters. Consider thermostatic balancing valves with an electronically commutated motor (ECM)/variable-speed DHW return pumps. Each balancing valve requires a check valve, either inline or incorporated into the balancing valve assembly, to prevent reverse flow from fixture discharge.

Pump selection and sizing

Carefully consider pump selection and sizing in DHW-R systems. Be sure pump-flow capacity does not exceed the recommended flow velocity for the dedicated recirculation line of 2 fps.

• **Residential** – For residential installations, select pumps that are specifically designed and marketed for DHW-R systems (e.g., Grundfos UP16-10 or Taco 0018e, which have the capability of setting the flow with an app) versus a higher-flow-capacity circulator.

Smaller pumps such as these do not have the capacity to recirculate DHW above 2 fps, where larger pumps will have to be properly balanced. Always review the plumbing design, including pipe size, flow, etc., in comparison with the DHW-R pump sizing.

• **Commercial** – For commercial recirculation installations, install balancing valves (circuit setters) or flow-limiting devices integral with the DHW-R pump and dedicated piping. Uponor recommends installing devices where an accurate flow or pressure differential is provided. Installing pressure gauges on the suction and discharge sides of the pump will also provide helpful information as to the pump's operation status. Additionally, refer to the pump manufacturer's operation and maintenance guidelines for additional information to verify pump operating conditions.

Sizing an Uponor PEX piping system

Uponor PEX pipe is manufactured to have an outside diameter (OD) equal to copper tube size (CTS) dimensions and a wall thickness with a standard dimension ratio (SDR) of 9 (i.e., wall thickness is one-ninth the pipe OD).

Due to the thickness of PEX, which provides superior insulation and durability characteristics, the inside diameter (ID) of Uponor PEX pipe is slightly smaller than that of copper pipe. However, Uponor PEX is three times smoother than new copper pipe. This smoothness means it can be designed at higher velocities, thus reducing the difference in flow characteristics between PEX-a and copper (resulting from PEX-a's smaller ID).

Interpolation method

Pressure ratings at different temperatures are determined by using a linear relationship between the standard-grade ratings. See **Table 4-3** for interpolated temperature and pressure ratings.



Important: The temperature and pressure ratings shown in **Table 4-3** apply specifically to closed-loop hydronic systems and domestic cold-water (potable) systems. Consistent with the International Plumbing Code (IPC) 604.8 regarding system water pressures, the use of PEX in domestic hot-water systems (including domestic hot-water recirculation) should not exceed 80 psi system pressure. Exceeding this pressure, along with water quality and other environmental conditions, may affect the service life of the piping.

Calculating friction loss

There are two commonly accepted methods to calculate head loss or friction loss in piping systems. The first method, which is preferred and will be discussed in this manual, is the Darcy-Weisbach methodology. The second method is the Hazen-Williams methodology.

Darcy-Weisbach method

The Darcy-Weisbach equation is a phenomenological equation, which is directly related to empirical test data. This method relates

friction in piping to the roughness of the pipe, fluid velocity, fluid density (water temperature), and fluid viscosity without leveraging correction factors. This is the same for systems using different concentrations of fluids (e.g., propylene glycol).

The following shows a Darcy-Weisbach equation:

$$h_f = f \cdot \frac{l}{D} \cdot \frac{V^2}{2g}$$

Where,

h_f = head loss due to friction (ft)

f = dimensionless friction factor

l = length of pipe (ft)

D = internal pipe diameter (ft)

V = average velocity (ft/sec)

g = acceleration due to gravity ($\frac{ft}{sec^2}$)

All the parameters in the equation are functions of system design and layout except for the dimensionless friction factor, f . The friction factor f is derived using the Colebrook formula which represents f implicitly.

$$\frac{1}{\sqrt{f}} = -2 \cdot \log \left[\frac{\epsilon/D}{3.7} + \frac{2.51}{Re \sqrt{f}} \right] \left(\frac{lb \cdot sec}{ft^2} \right)$$

Where,

f = dimensionless friction factor

D = internal pipe diameter (ft)

ϵ = internal roughness (ft)

The roughness of Uponor PEX-a pipe is 1.58×10^{-6} ft.

Re = Reynolds number = $\frac{\rho V D}{\mu}$

Where,

D = internal pipe diameter (ft)

ρ = fluid density ($\frac{lb}{ft^3}$)

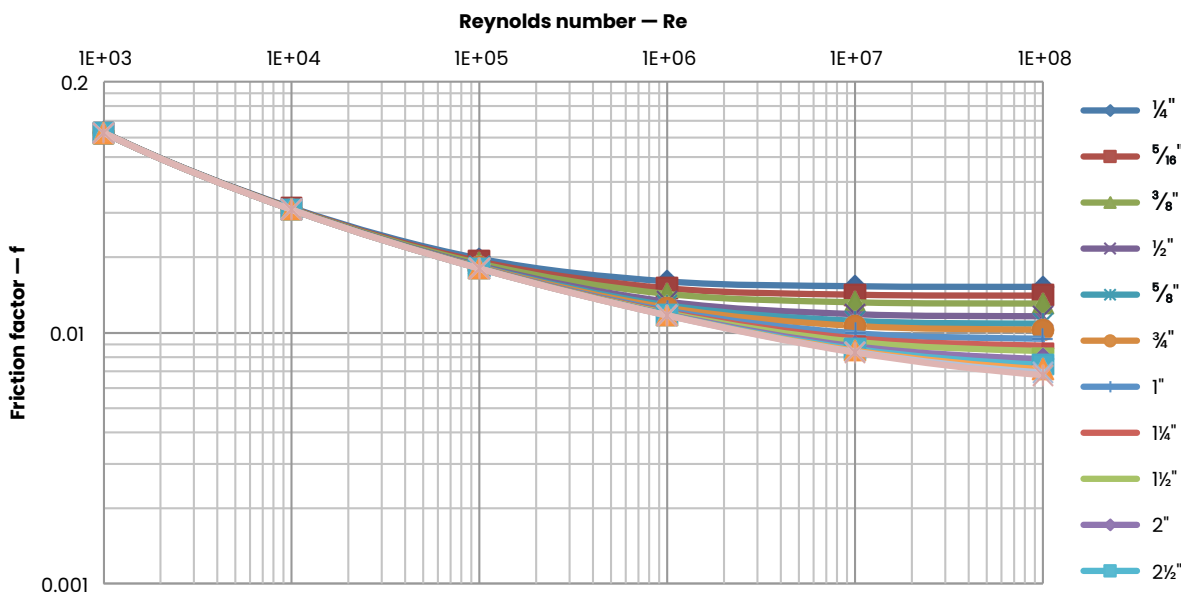
V = average velocity (ft/sec)

μ = dynamic viscosity

Note: Since the Colebrook formula is an implicit formula, many approximations have been derived to explicitly represent the friction factor. Using the Manadilli approximation yields a very small error with respect to the Colebrook equation. In fact, the maximum error is up to 2.06 percent. The Manadilli approximation shown below is used for all Uponor pipe head-loss calculations.

$$f = \left[\frac{1}{-2 \cdot \log \left(\frac{\epsilon}{3.7 \cdot D} + \frac{95}{Re^{0.983}} - \frac{96.82}{Re} \right)} \right]^2$$

Moody Diagram for ASTM PEX by pipe size – Manadilli Approximation



The friction factor can also be found by using a standard Moody Diagram. The Moody Diagram is a function of the Reynolds number and the ratio between pipe roughness and internal diameter. Refer to **Figure 4-2** for the Moody Diagram created for PEX pipe.

Figure 4-2: Moody diagram for ASTM PEX by pipe size

Pressure differential

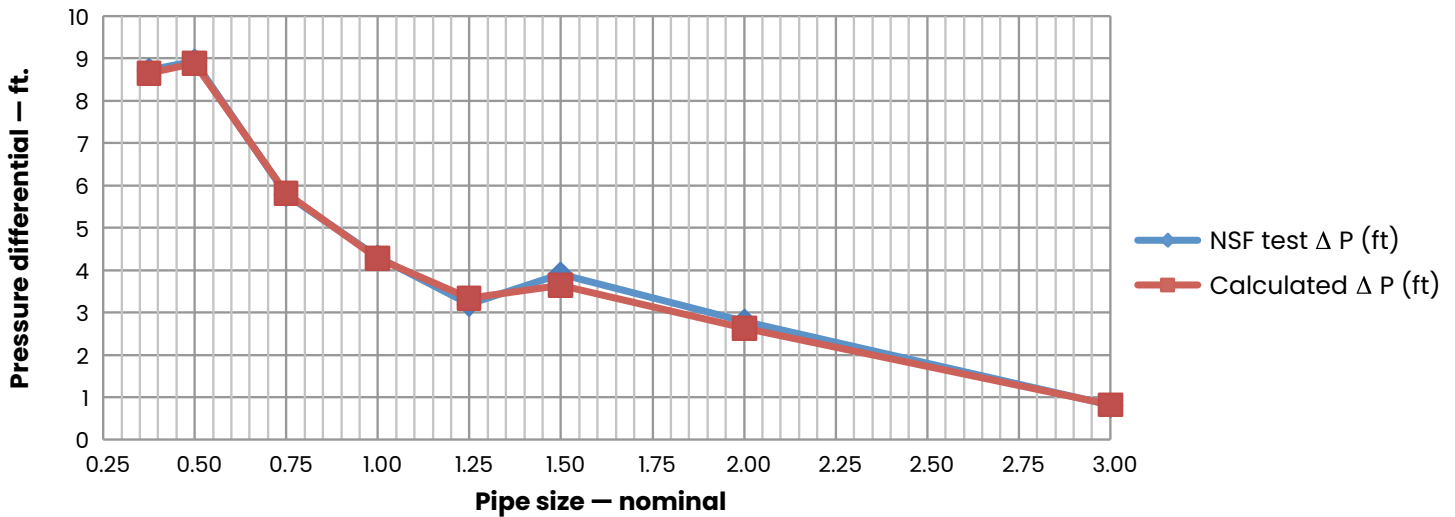


Figure 4-3: Friction loss comparing Darcy-Weisbach vs. NSF test data

Hazen-Williams method

The Hazen-Williams method is another method for sizing PEX. However, it is not preferred by Uponor (especially for heating and cooling system sizing). Like the Darcy-Weisbach formula, this formulation is also based on empirical relationships with water flowing through pipes.

However, correlation with test data is much more limited. This formulation set was derived for fire sprinkler design and large water supply networks with 3" and larger piping. It is also strictly for 100 percent water and does not account for temperature and fluid viscosity.

Since its development, additional temperature correction and fluid correction factors have been established. However, results can show significant error when compared to test data.

The following equation shows the Hazen-Williams method.

$$h_f = 0.2083 \cdot \left(\frac{100}{C} \right)^{1.852} \cdot \frac{q^{1.852}}{D^{4.8655}}$$

Where,

$$h_f = \text{head loss due to friction per 100 ft.} \left(\frac{ft_{water}}{100 ft_{pipe}} \right)$$

C = Hazen-Williams roughness constant

The Hazen-Williams roughness constant for Uponor PEX-a is 163.

q = volumetric flow rate (gpm)

D = internal pipe diameter (in)

Comparing Darcy-Weisbach and Hazen-Williams

NSF performed testing to calculate the friction loss of Uponor PEX pipe and Uponor ProPEX fittings. The testing allowed Uponor to analyze empirical test data and compare it with the Darcy-Weisbach and Hazen-Williams methods. The following graph illustrates the comparison.

Percent error from test data

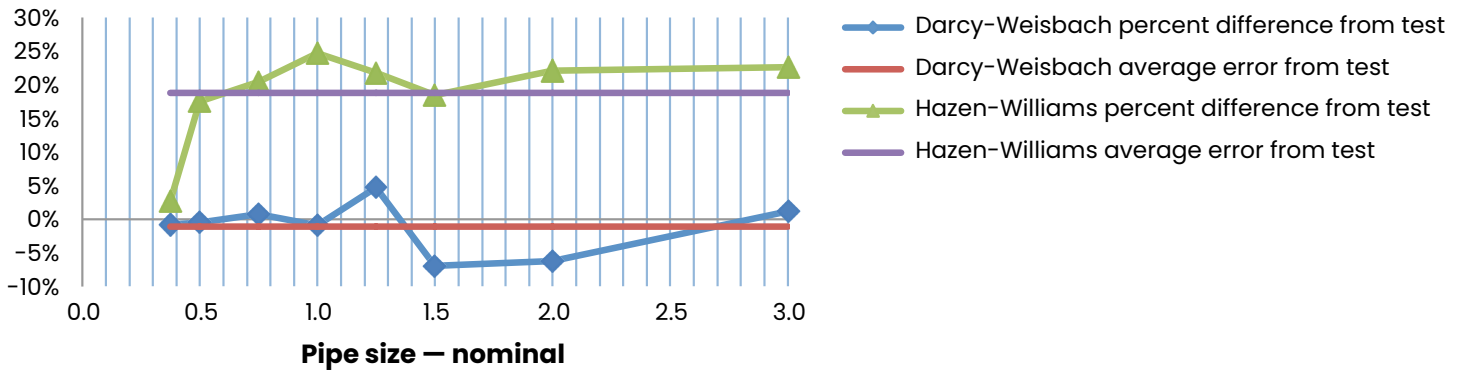
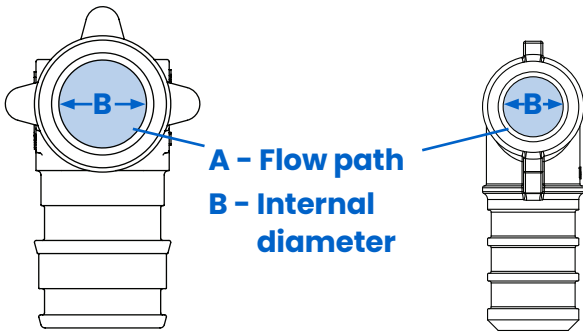


Figure 4-4: Darcy-Weisbach and Hazen-Williams comparison

The Y axis represents the percent error from the test data; the X axis represents nominal pipe size. The graph shows the average error when using the Darcy-Weisbach method is less than 1 percent when compared to the test data. The Hazen-Williams method, however, yields an 18 percent average error compared to the test data.

Note: The test was performed with 70°F (21.1°C), 100 percent water.



**Figure 4-5: ProPEX
ASTM F1960 and
CAN/CSA B137.5
expansion fitting**

**29% LARGER I.D.
70% GREATER FLOW¹**

¹When comparing 1" F1960 EP with F2159 plastic fittings.

**Figure 4-6: ASTM
F1807/F2159
insert fitting**

		Uponor ProPEX cold-expansion fitting		Standard insert (crimp) fitting	
		ASTM F1960 brass	ASTM F1960 EP	ASTM F1807 brass	ASTM F2159 plastic
A Flow path	½"	0.112 sq. inches 2.8 gpm @ 8 ft./sec. 3.5 gpm @ 10 ft./sec.	0.116 sq. inches 2.9 gpm @ 8 ft./sec. 3.6 gpm @ 10 ft./sec.	0.096 sq. inches 2.4 gpm @ 8 ft./sec. 3.0 gpm @ 10 ft./sec.	0.078 sq. inches 1.9 gpm @ 8 ft./sec. 2.4 gpm @ 10 ft./sec.
	¾"	0.278 sq. inches 6.9 gpm @ 8 ft./sec. 8.7 gpm @ 10 ft./sec.	0.273 sq. inches 6.8 gpm @ 8 ft./sec. 8.5 gpm @ 10 ft./sec.	0.221 sq. inches 5.5 gpm @ 8 ft./sec. 6.9 gpm @ 10 ft./sec.	0.166 sq. inches 4.1 gpm @ 8 ft./sec. 5.2 gpm @ 10 ft./sec.
	1"	0.496 sq. inches 12.4 gpm @ 8 ft./sec. 15.5 gpm @ 10 ft./sec.	0.488 sq. inches 12.2 gpm @ 8 ft./sec. 15.2 gpm @ 10 ft./sec.	0.396 sq. inches 9.9 gpm @ 8 ft./sec. 12.4 gpm @ 10 ft./sec.	0.292 sq. inches 7.3 gpm @ 8 ft./sec. 9.1 gpm @ 10 ft./sec.
	1¼"	0.724 sq. inches 21.8 gpm @ 8 ft./sec. 22.6 gpm @ 10 ft./sec.	0.739 sq. inches 18.4 gpm @ 8 ft./sec. 23.0 gpm @ 10 ft./sec.	0.595 sq. inches 14.8 gpm @ 8 ft./sec. 18.6 gpm @ 10 ft./sec.	Not available
	1½"	0.923 sq. inches 23.0 gpm @ 8 ft./sec. 28.9 gpm @ 10 ft./sec.	0.923 sq. inches 23.0 gpm @ 8 ft./sec. 28.9 gpm @ 10 ft./sec.	0.817 sq. inches 20.4 gpm @ 8 ft./sec. 25.5 gpm @ 10 ft./sec.	Not available
	2"	1.877 sq. inches 47.1 gpm @ 8 ft./sec. 58.6 gpm @ 10 ft./sec.	1.730 sq. inches 43.1 gpm @ 8 ft./sec. 54.0 gpm @ 10 ft./sec.	1.463 sq. inches 36.5 gpm @ 8 ft./sec. 54.7 gpm @ 10 ft./sec.	Not available
	2½"	3.110 sq. inches 77.6 gpm @ 8 ft./sec. 97.1 gpm @ 10 ft./sec.	2.688 sq. inches 67.0 gpm @ 8 ft./sec. 83.8 gpm @ 10 ft./sec.	Not available	Not available
	3"	4.562 sq. inches 113.8 gpm @ 8 ft./sec. 142.3 gpm @ 10 ft./sec.	3.871 sq. inches 96.5 gpm @ 8 ft./sec. 120.7 gpm @ 10 ft./sec.	Not available	Not available
B Minimum internal diameter	½"	0.378"	0.385"	0.350"	0.315"
	¾"	0.595"	0.590"	0.530"	0.460"
	1"	0.795"	0.788"	0.710"	0.610"
	1¼"	0.960"	0.970"	0.870"	Not available
	1½"	1.084"	1.084"	1.020"	Not available
	2"	1.550"	1.484"	1.365"	Not available
	2½"	1.990"	1.850"	Not available	Not available
	3"	2.410"	2.220"	Not available	Not available

Table 4-4: Uponor ProPEX fittings vs. standard insert (crimp) fittings

Note: Refer to **Table C-1** in **Appendix C** for an equivalent length comparison.

Calculating friction loss through fittings

There are two commonly accepted methods when analyzing pressure loss or head loss of fittings. The first and preferred method uses C_v values to precisely calculate fitting losses. The C_v value represents how many gpm can flow through a fitting at 1 psi pressure drop.

The C_v method for calculating friction loss

C_v is a function of flow rate versus pressure drop across the fitting. It also accounts for the density of the fluid. Refer to the following friction loss calculation using the C_v method.

$$\Delta P = \left(\frac{P_f}{P_w} \right) \left(\frac{F}{C_v} \right)^2$$

Where,

ΔP = pressure drop across the fitting (psi)

$$P_f = \text{fluid density} \left(\frac{\text{lb}}{\text{ft}^3} \right)$$

$$P_w = \text{density of water at } 60^\circ\text{F} \left(\frac{\text{lb}}{\text{ft}^3} \right)$$

The density of water at 60°F (15.6°C) is 62.38 pounds per cubic foot.

F = volumetric flow rate through the fitting (gpm)

C_v = known C_v rating of the fitting

This calculation yields a value in pounds per square inch which, for hydronic sizing, needs to be converted to feet of head as 100 percent water. The conversion to feet of water is shown below.

$$h_f = \frac{144\text{in}^2 \cdot \Delta P}{1\text{ft}^3 \cdot P_f}$$

Where,

h_f = head loss due to friction across the fitting (ft.)

$$P_f = \text{fluid density} \left(\frac{\text{lb}}{\text{ft}^3} \right)$$

ΔP = pressure drop across the fitting (psi)

This value can be cumulatively added to the values from the other fittings in the distribution line to calculate the total loss for the fittings in the system.

For example, a fitting with a C_v of 5.0 would flow 5.0 gpm at a 1 psi pressure drop across the fitting. Since C_v is a function of flow rate versus pressure drop, it yields an accurate representation of fitting friction loss. The second method uses equivalent lengths. Uponor has created charts for both equivalent length and C_v . The equivalent lengths were developed using a flow velocity of 8 fps.

Example 2

For a given elbow with a C_v of 6.7 and a flow rate of 3.5 gpm at a water temperature of 160°F (71.1°C), what is the friction loss of the fitting (in feet)? Assuming the fluid is 100 percent water, here is the calculation.

$$P_f = 60.99 \frac{\text{lb}}{\text{ft}^3}$$

$F = 3.5 \text{ gpm}$

$C_v = 6.7$

$$\Delta P = \left(\frac{P_f}{P_w} \right) \left(\frac{F}{C_v} \right)^2 = \left(\frac{60.99 \frac{\text{lb}}{\text{ft}^3}}{62.38 \frac{\text{lb}}{\text{ft}^3}} \right) \left(\frac{3.5 \text{ gpm}}{6.7} \right)^2 = 0.267 \text{ psi}$$

Note: To make the units work in the C_v formula, it must be assumed the C_v has the units of gpm and the result multiplied by 1 psi.

With the pressure differential known, the value found can be converted to head loss in feet as seen below.

$$h_f = \frac{144\text{in}^2 \cdot \Delta P}{1\text{ft}^3 \cdot P_f} = \frac{144\text{in}^2 \cdot 0.267 \text{ psi}}{1\text{ft}^3 \cdot 60.99 \frac{\text{lb}}{\text{ft}^3}} = 0.63 \text{ ft.}$$

Reverse osmosis and de-ionized water systems

Reverse-osmosis systems and systems using de-ionized water for drinking water applications are approved for use with Uponor PEX piping, granted the pH is between 5 and 8 and the maximum temperature does not exceed 140°F (60°C). Uponor requires the use of EP or stainless-steel fittings with de-ionized and reverse-osmosis water. For process-water applications, such as clean labs and other industrial-type pure water applications, please contact Uponor Technical Services for more information.

Surge pressure and sound intensity

The main sources of sound in a water piping system are cavitation, surface roughness and water hammer caused by surge pressure. Typical polymers will absorb sound in the range of 10 dB/cm, whereas metals are on the order of 0.1 to 1.0 dB/cm. For a given change in velocity, the intensity of sound from

copper pipe will be higher than that of PEX—a piping. Peak pressures caused by a quick-acting valve could be reduced by 18 percent to 40 percent by utilizing Uponor PEX instead of copper pipe.

When comparing the change in sound intensity when switching from copper to PEX piping, with all else remaining the same, the sound intensity in the radial outward direction is the primary area to evaluate.

Beginning with the general wave equation:

$$I^2 p = (1/c^2)(M^2 p / M t^2)$$

and some simplifying assumptions (e.g., point source of sound), the relationship for intensity can be derived with the following formula:

$$I = pv$$

Where:

I = sound intensity
p = sound pressure
v = particle velocity

Water hammer

In addition to sizing the piping and pumps to the correct flow velocity, **take care to avoid water hammer and excessive**

surge pressures. Pump systems operating with on/off cycling or pumps oversized for the piping can create high pressure and fatigue the piping material. Properly sized variable-speed drive (VFD) constant-pressure pumping systems and pressure-reducing valves (PRVs) can alleviate these issues. Pumps should be sized to operate at maximum efficiency with the lowest energy usage for the required flow rate. Water hammer is probably the most significant concern and can be evaluated using the following:

$$A = 4660 / [1 + kD/(Et)]^{1/2}$$

Where:

A = Wave velocity
k = Bulk modulus of water (300,000 psi)
D = Inside diameter of pipe
E = Tensile modulus of pipe material
t = Wall thickness

For ½" nominal size piping, the dimension ratio (D/t) of PEX piping is approximately 7; it is approximately 11 for copper (Type K).

Assuming a PEX piping modulus of 250,000 psi and copper modulus of 16,000,000 psi, the wave velocity is:

PEX piping – 1,520 ft./sec.

Copper piping – 4,240 ft./sec.

The surge pressure is calculated as $P = Av / (2.31 g)$, where v is the water velocity prior to the valve closing and $g = 32.2$. Assuming this is also the sound pressure (i.e., no losses), the sound intensity can be calculated as:
 $I = (A^2)(v) / 74.4$

For PEX piping,
 $I = 31,000 (v)$

For copper piping,
 $I = 242,000 (v)$

This demonstrates that for a given change in water velocity, the intensity of the sound from copper piping will be approximately eight times that of the PEX piping. While some assumptions are made in reaching this conclusion, even a conservative estimate would give copper piping a sound intensity two to four times that of PEX piping.

Thermal conductivity and insulation considerations

Dew point and condensation

Uponor recommends insulating all mechanical piping (heating hot water/chilled water) and domestic hot-water piping (including domestic hot-water recirculation) to meet code requirements, conserve energy, and maintain desired fluid temperatures. Uponor also

recommends insulating any piping installed in an unconditioned space or poorly ventilated areas with excessive moisture content.

Insulation also provides protection from condensation on pipes and fittings. Condensation is the conversion of a vapor (or gas) to a liquid.

Dew point is the point at which water vapor changes to liquid (which is what causes condensation on surfaces). There are multiple factors that can influence condensation on surfaces.

The key environment conditions that can help determine potential condensation include the following factors.

- Ambient air temperature
- Relative humidity (rh)
- Water vapor pressure
- Surface temperature of object(s) within a space

When the ambient air temperature or objects are at or below dew point, the water vapor condenses on the surfaces because the air near the surface cannot hold any more water.

Insulating piping

Some local codes require insulation of chilled-water piping due to condensation that can occur on the outside of the piping. This is a requirement for any piping material, including copper, CPVC, PEX, steel and polypropylene.

PEX piping has a very low coefficient of thermal conductivity of 2.628 Btu-in/(hr-ft²·°F), whereas copper has a coefficient of thermal conductivity between 2,080 and 2,773 Btu-in/(hr-ft²·°F).

It is important to note that if the surface temperature of the pipe or insulation is less than the design dew point temperature in the cavity, the pipe or insulation surface will condense.

Table 4-5 yields surface temperature of the outermost layer with respect to water temperature, insulation thickness, and ambient air temperature. Use this data to ensure condensation will not occur. See **Appendix D**.

Example

A nominal 1" (25 mm) PEX pipe with ½" insulation carrying 40°F (4.4°C) water would have a 69.5°F (20.83°C) insulation surface temperature given an 80°F (26.6°C) ambient temperature. Assuming a relative humidity of 60 percent at an 80°F (26.6°C) ambient temperature, the dew-point temperature would be 65°F (18.3°C). Since the dew-point temperature is 4.5°F (2.5°C) lower than the surface

temperature, there is no concern for condensation on the piping system.

If the surface temperature is lower than or equal to the dew-point temperature, a higher level of insulation is necessary. If the surface temperature is 1 to 2 degrees higher than the dew-point temperature of the piping system, a higher level of insulation is recommended.

Water temp. (°F)	Copper no insulation	PEX no insulation	PEX ½" insulation	PEX 1" insulation	PEX 1½" insulation	PEX 2" insulation
	Surface temperature (°F)					
30	30.0	32.9	66.9	73.4	75.8	77.0
40	40.0	42.3	69.5	74.7	76.7	77.6
50	50.0	51.8	72.1	76.0	77.5	78.2
60	60.0	61.2	74.8	77.4	78.3	78.8
70	70.0	70.6	77.4	78.7	79.2	79.4
80	80.0	80.0	80.0	80.0	80.0	80.0

Table 4-5: PEX-a vs. copper surface temperature comparison at 80°F (26.6°C) ambient temperature

Notes:

1. Assumes SDR9 PEX and Type L copper pipe.
2. Insulation conductivity of 0.25 (BTU · in.)/(hr · ft.² · °F).
3. Assumes natural convection at a rate of 1 Btu/(hr · ft.² · °F); 0.88–3.53 are standard values for natural convection.
4. Calculations based on standard cylindrical thermal resistance calculations.

Fluid operating temperature range (°F)	Insulation conductivity		Nominal pipe or tube size (inches)		
	Conductivity Btu · in. / (hr · ft. ² · °F)	Mean rating temperatures, °F	<1	1 to <1½	1½ to < 4
141–200	0.25 – 0.29	125	1.5	1.5	2.0
105–140	0.21 – 0.28	100	1.0	1.0	1.5
40–60	0.21 – 0.27	75	0.5	0.5	1.0
<40	0.20 – 0.26	75	0.5	1.0	1.0

Table 4-6: Minimum pipe insulation thickness per the International Energy Conservation Code (IECC) and ASHRAE 90.1 for piping serving as part of a heating or cooling system or service water heating system

Types of insulation

Uponor PEX pipe conforms to ASTM F876, and has a standard dimension ratio (SDR) of 9 and a copper tube size (CTS) controlled outside diameter. This allows the use of most CTS insulation products. For fitting insulation kits, standard CTS fiberglass tee and elbow kits will work with Uponor ProPEX fittings.

Pre-insulated Uponor PEX pipe

Wirsbo hePEX and Uponor AquaPEX are available pre-insulated with insulation thicknesses of ½", 1", 1½" and 2". The pre-insulated pipes are approved for direct-burial, however Uponor recommends the use of a minimum of 1" insulation for direct-burial applications due to soil compression forces. Visit uponor.com for more information about these pre-insulated piping products.

Insulating requirements for ASTM E84 and CAN/ULC S102.2

Wirsbo hePEX and Uponor AquaPEX are approved for use in applications requiring ASTM E84 and/or CAN/ULC S102.2 certification. For full installation requirements, refer to **Chapter 3: Fire-resistant Construction**.

Table 3-5 shows different types of insulation that meet ASTM E84 and CAN/ULC S102.2.

Uponor Ecoflex products

Ecoflex potable PEX pipes

Ecoflex potable PEX pipes feature a single Uponor

AquaPEX service pipe for potable-water distribution applications. The piping is surrounded by multi-layer, closed-cell, PEX-foam insulation and a water-resistant, corrugated, HDPE jacket, making it ideal for water service and other direct-burial applications. Ecoflex potable PEX pipes use ProPEX fittings up to 3".

Ecoflex potable PEX pipes are available in the following sizes:

- 1" in coils up to 600 ft.
- 1¼" in coils up to 500 ft.
- 1½" to 3" in coils up to 300 ft.
- Longer and custom lengths are also available

Ecoflex potable PEX plus pipes

Ecoflex potable plus pipes feature Uponor AquaPEX service pipe with a self-regulating heating cable. The pipe and cable are surrounded by multi-layer, closed-cell, PEX-foam insulation and a water-resistant, corrugated, HDPE jacket, making it ideal for direct-burial applications.

Ecoflex potable plus pipes are available in 1¼" pipe sizes with a 5.5" jacket or on a made-to-order basis.

Ecoflex thermal single and thermal twin pipes

Ecoflex thermal pipes are designed for fluid transfer in heating and cooling applications. The Wirsbo hePEX service pipes in Ecoflex thermal piping feature an oxygen-diffusion barrier extruded onto the service pipe to help reduce the amount of oxygen molecules that can migrate through the pipe wall. This oxygen barrier protects ferrous

components within the fluid pathway from corrosion. The pipe is surrounded by multi-layer, closed-cell, PEX foam insulation and water-resistant, corrugated HDPE jacket, making it ideal for direct-burial applications. For connections, utilize ProPEX fittings up to 3".

Ecoflex thermal pipes are available in the following sizes and coil lengths:

- ¾" Thermal Single with 2.7" Jacket, 1,000-ft. coil
- 1" Thermal Single with 2.7" Jacket, 1,000-ft. coil
- 1" Thermal Single with 5.5" Jacket, 600-ft. coil
- 1¼" Thermal Single with 6.9" Jacket, 300-ft. coil
- 1½" Thermal Single with 6.9" Jacket, 300-ft. coil
- 2" Thermal Single with 6.9" Jacket, 300-ft. coil
- 2½" Thermal Single with 6.9" Jacket, 300-ft. coil
- 3" Thermal Single with 7.9" Jacket, 300-ft. coil
- 4" Thermal Single with 7.9" Jacket, 300-ft. coil
- 1" Thermal Twin with 6.9" Jacket, 600-ft. coil
- 1¼" Thermal Twin Jr. with 5.5" Jacket, 600-ft. coil
- 1¼" Thermal Twin with 6.9" Jacket, 500-ft. coil
- 1½" Thermal Twin with 6.9" Jacket, 300-ft. coil
- 2" Thermal Twin with 7.9" Jacket, 300-ft. coil
- 2½" Thermal Twin with 7.9" Jacket, 300-ft. coil

For additional information, refer to the Ecoflex Pre-insulated Pipe Systems Design and Installation Manual on uponor.com.



Figure 4-7: Pre-insulated Uponor PEX pipe



Figure 4-8: Uponor Ecoflex potable PEX pipe



Figure 4-9: Uponor Ecoflex potable PEX plus pipe

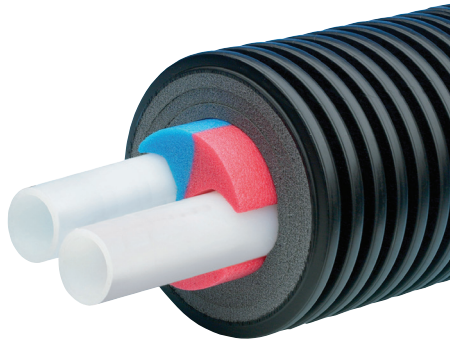


Figure 4-10: Uponor Ecoflex thermal twin pipe

Pre-insulated Uponor PEX with ½" insulation			
Tubing size	Insulation thickness	R-value	Heat loss at 70°F Δ T
½"	0.6" (15mm)	3.9	7.4 Btu/(hr • ft)
¾"	0.6" (15mm)	3.6	9.0 Btu/(hr • ft)
1"	0.6" (15mm)	3.4	10.6 Btu/(hr • ft)
1¼"	0.6" (15mm)	3.3	12.1 Btu/(hr • ft)
1½"	0.6" (15mm)	3.2	13.6 Btu/(hr • ft)
2"	0.6" (15mm)	3.1	16.5 Btu/(hr • ft)

Table 4-7: Pre-insulated Uponor PEX with ½" polyethylene insulation R-value/heat loss

Note: Pre-insulated Uponor AquaPEX consists of PEX-a pipe and closed cell, crosslinked polyethylene insulation with a thermal conductivity of 0.25 Btu•in/(hr•ft²•°F).

Pre-insulated Uponor PEX with 1" insulation			
Tubing size	Insulation thickness	R-value	Heat loss at 70°F Δ T
½"	1.0" (25mm)	7.5	6.3 Btu/(hr • ft)
¾"	1.1" (28mm)	7.9	7.1 Btu/(hr • ft)
1"	1.0" (25mm)	6.4	8.8 Btu/(hr • ft)
1¼"	1.0" (25mm)	6.1	10.0 Btu/(hr • ft)

Table 4-8: Pre-insulated Uponor PEX with 1" polyethylene insulation R-value/heat loss

Pre-insulated Uponor PEX with 1½" insulation			
Tubing size	Insulation thickness	R-value	Heat loss at 70°F Δ T
1½"	1.7" (42mm)	11.2	7.0 Btu/(hr • ft)
2"	1.6" (40mm)	9.9	8.6 Btu/(hr • ft)

Table 4-9: Pre-insulated Uponor PEX with 1½" polyethylene insulation R-value/heat loss

Uponor PEX vs. copper heat loss comparison – Btu/(hr•ft)

Nominal pipe sizes	Delta T (°F)	Insulation thickness (K=0.24)	20				40				60				80				100			
			0"	½"	1"	1½"	0"	½"	1"	1½"	0"	½"	1"	1½"	0"	½"	1"	1½"	0"	½"	1"	1½"
			½"	Uponor PEX	5.44	2.22	1.63	1.37	10.89	4.44	3.25	2.74	16.33	6.65	4.88	4.10	21.78	8.87	6.51	5.47	27.22	11.09
½"	Type L copper	5.76	2.24	1.63	1.37	11.52	4.47	3.27	2.74	17.27	6.71	4.90	4.11	23.03	8.95	6.53	5.48	28.79	11.18	8.16	6.85	
	¾"	Uponor PEX	7.48	2.73	1.95	1.61	14.96	5.47	3.89	3.21	22.44	8.20	5.84	4.82	29.92	10.94	7.78	6.43	37.40	13.67	9.73	8.03
¾"	Type L copper	8.06	2.77	1.96	1.61	16.12	5.54	3.91	3.22	24.18	8.31	5.87	4.84	32.25	11.07	7.83	6.45	40.31	13.84	9.78	8.06	
	1"	Uponor PEX	9.42	3.23	2.25	1.83	18.85	6.47	4.50	3.66	28.27	9.70	6.75	5.49	37.69	12.93	8.99	7.33	47.11	16.17	11.24	9.16
1"	Type L copper	10.36	3.29	2.27	1.84	20.73	6.58	4.53	3.68	31.09	9.86	6.80	5.52	41.46	13.15	9.06	7.36	51.82	16.44	11.33	9.20	
	1¼"	Uponor PEX	11.29	3.72	2.54	2.05	22.58	7.44	5.08	4.09	33.87	11.16	7.63	6.14	45.16	14.88	10.17	8.19	56.45	18.60	12.71	10.24
1¼"	Type L copper	12.67	3.80	2.57	2.06	25.34	7.60	5.14	4.12	38.00	11.40	7.70	6.18	50.67	15.20	10.27	8.24	63.34	19.00	12.84	10.30	
	1½"	Uponor PEX	13.08	4.20	2.83	2.26	26.15	8.40	5.66	4.51	39.23	12.60	8.49	6.77	52.30	16.79	11.31	9.03	65.38	20.99	14.14	11.28
1½"	Type L copper	14.97	4.31	2.86	2.27	29.94	8.61	5.73	4.55	44.91	12.92	8.59	6.82	59.89	17.23	11.45	9.10	74.86	21.53	14.32	11.37	
	2"	Uponor PEX	16.46	5.13	3.39	2.66	32.93	10.27	6.77	5.33	49.39	15.40	10.16	7.99	65.85	20.54	13.55	10.65	82.31	25.67	16.94	13.32
2"	Type L copper	19.58	5.31	3.45	2.69	39.16	10.63	6.89	5.38	58.73	15.94	10.34	8.08	78.31	21.25	13.78	10.77	97.89	26.57	17.23	13.46	
	2½"	Uponor PEX	19.30	5.92	3.92	3.00	38.60	11.85	7.84	6.01	57.90	17.77	11.76	9.01	77.20	23.69	15.68	12.01	96.50	29.61	19.60	15.01
2½"	Type L copper	24.20	6.32	4.09	3.10	48.41	12.63	8.18	6.20	72.61	18.95	12.26	9.30	96.82	25.26	16.35	12.40	121.02	31.58	20.44	15.50	
	3"	Uponor PEX	22.54	6.94	4.47	3.44	45.07	13.88	8.93	6.89	67.61	20.82	13.40	10.33	90.14	27.76	17.86	13.77	112.68	34.70	22.33	17.22
3"	Type L copper	28.79	7.31	4.59	3.50	57.58	14.62	9.17	7.01	86.37	21.93	13.76	10.51	115.16	29.24	18.35	14.01	143.95	36.55	22.93	17.51	

Table 4-10: Uponor PEX vs. copper heat loss comparison – Btu/(hr•ft)

- All calculations based on cylindrical thermal resistance methodology (ASPE/ASHRAE).
- Based on fluid velocity of 8 ft./sec. at 160°F/71.1°C (maximizing heat transfer from 100% water).
- Pipe convection set to be 1.761 Btu/hr•ft²•°F (based on standard value for free convection of air).
- This heat loss comparison uses 0.24 Btu•in/(hr•ft²•°F) as the insulation thermal conductivity. This is a standard value for fiberglass pipe insulation at a 100°F/37.8°C mean temperature.

Heat trace

Uponor approves the use of heat-trace cables with Uponor PEX products, provided the product has automatic thermostatic control capability and the temperature does not exceed the maximum rating listed on the piping (200°F/93.3°C). Wrap heat tape around the piping and secure the cable with plastic cable ties, not tape; then insulate with either closed-cell or fiberglass pipe insulation.

Nominal pipe size	R-value
½"	0.03
¾"	0.04
1"	0.052
1¼"	0.063
1½"	0.075
2"	0.098
2½"	0.122
3"	0.144

Table 4-11: SDR9 PEX R-value

Uponor PEX has superior insulating qualities when compared to copper in the same application. Even though the difference in R-value is relatively small, the higher R-value of Uponor PEX piping will always result in less heat loss than with the same nominal-size copper pipe.

Pipe	Btu/(h·ft·°F)
Copper	173-231
PEX-a	0.219
CPVC	0.079

Table 4-12: Thermal conductivity of piping materials

When comparing samples of the same thickness, CPVC has a lower thermal conductivity than Uponor PEX. To represent these values in the form of a pipe wall, we must compare the conductivity through a CTS SDR9 Uponor PEX pipe wall to that of a CTS SDR11 CPVC wall; SDR9 is 22 percent thicker than SDR11.

When conductivity is applied to the pipe wall thickness, Uponor PEX is within two percent of the thermal resistance of CPVC.

Chapter 5

Designing and Sizing Uponor PEX Systems

This chapter details how to design and size an Uponor PEX piping system. Note that Uponor Construction Services is available for estimation and design support for domestic

water and hydronic piping systems as well. To learn more about Uponor Construction Services, visit uponor.com/construction-services.

Uponor PEX domestic water systems

This section profiles potable-water design and layout techniques that are primarily found in multifamily and commercial buildings, generally referred to as fire-resistant construction buildings, where both plumbing and building codes apply.

Unit/In-suite piping

Uponor AquaPEX pipe for distributing water to fixtures may be installed overhead, through framing, in slab, or below grade. Common design methods for unit piping in multifamily commercial buildings include:

- Trunk and branch
- Home run
- Uponor Logic

Uponor Logic	
Number of fittings	9
Number of connections	33
Nominal pipe size	Length (ft.)
1/2"	261
3/4"	38
1"	5
Total	304

Table 5-1: Uponor Logic pipe and fittings usage

Home run	
Number of fittings	7
Number of connections	27
Nominal pipe size	Length (ft.)
1/2"	475
3/4"	30
1"	5
Total	510

Table 5-2: Home run pipe and fittings usage

Uponor Logic plumbing

Uponor Logic is the smart way to plumb, using flexible Uponor PEX pipe and multiport tees to minimize connections and maximize system performance. With an Uponor Logic layout, plumbing systems typically require fewer fittings than a trunk and branch design and less pipe than a home run layout.

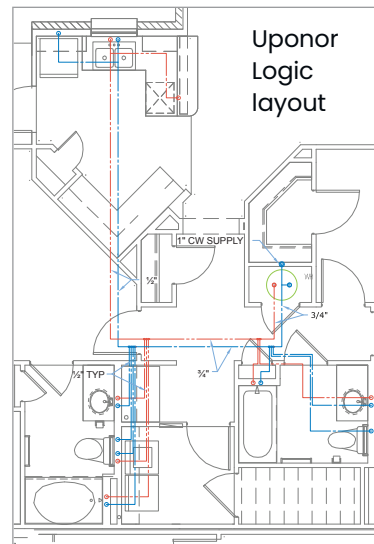


Figure 5-1: Uponor Logic layout

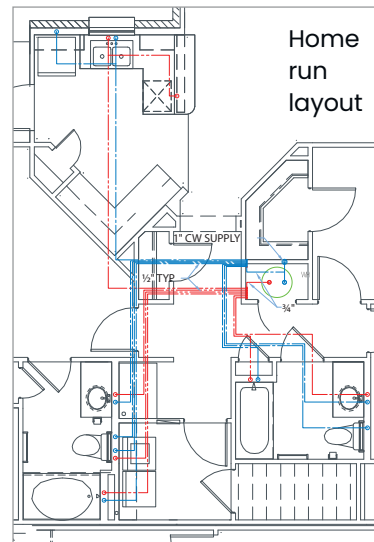


Figure 5-2: Home run layout

Critical path = HWS – W.H. to tub **UPC tub** = 4 wsfu = 4 gpm
CWS = 60°F **HWS** = 120°F **Mixed** = 110°F **Hot-water multiplier** = 0.83 = 3.32 gpm

System type	I.D. (in.)		Distance (ft.)		Volume (gal.)			Velocity (ft./sec.)		Pressure loss (psi)			First-use HW time to fixture
	½"	¾"	½"	¾"	½"	¾"	Total	½"	¾"	½"	¾"	Total	Critical path (tub only)
Copper T&B	0.527	0.745	13	33	0.147	0.746	0.893	4.8	2.43	1.22	0.561	1.781	16.1 sec.
Home run	0.475	0.671	32	9	0.294	0.165	0.459	5.8	3	4.16	0.252	4.412	8.3 sec.
Uponor Logic	0.475	0.671	19	17	0.174	0.312	0.486	5.8	3	2.47	0.476	2.946	8.7 sec.

Table 5-3: Performance comparisons

Copper trunk and branch	
Number of fittings	39
Number of connections	93
Nominal pipe size	Length (ft.)
½"	234
¾"	73
1"	5
Total	312

Table 5-4: Copper trunk and branch pipe and fittings usage

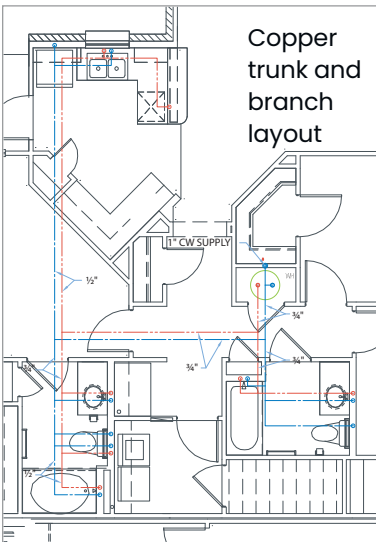


Figure 5-3: Copper trunk and branch layout

Efficiencies of Uponor Logic

For unit and in-suite applications, Uponor Logic reduces the number of fittings by up to 70 percent when compared to copper trunk and branch and requires 40 percent less tubing than a home run system. Uponor offers a full line of EP multiport tees for ultimate design flexibility.

Hot-water performance

Uponor Logic delivers hot water nearly 46 percent faster than a copper trunk and branch system for the first-use fixture and nearly 43 percent faster than a home run system for the second-use fixture.

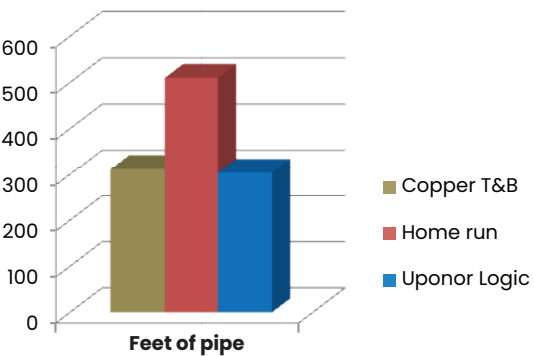
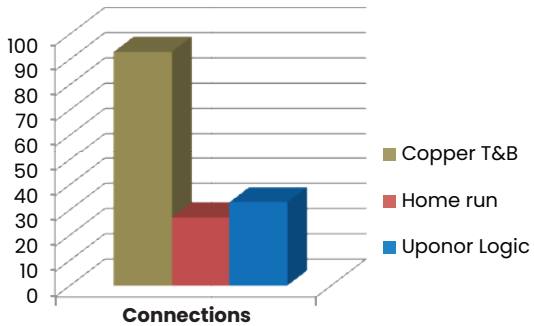
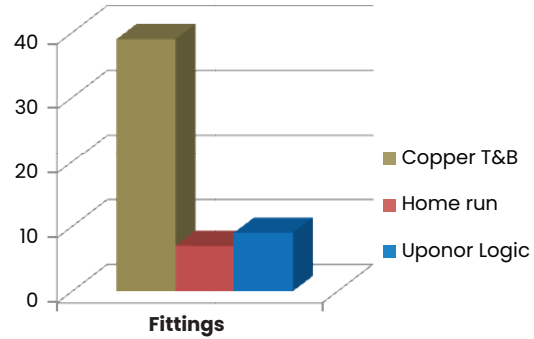


Figure 5-4: Fittings, connections, and feet of pipe

System type	First-use HW time to fixture	Second-use HW time to fixture
	Critical path (tub only)	Critical path (lav only)
Copper T&B	16.1 sec.	4.2 sec.
Home run	8.3 sec.	7.5 sec.
Uponor Logic	8.7 sec.	4.3 sec.

Table 5-5: Hot water time-to-fixture comparisons

Public-use fixtures

Water hammer is probably the most significant concern when piping for public-use fixtures.

In typical installations with metallic piping where back-to-back restrooms are separated by a mechanical chase, the supply header is usually kept at roughly the same height as the fixture supply. This creates sharp, abrupt paths for the water, resulting in pressure surges (water hammer) when a fast-actuating valve closes. To compensate, most local codes require water hammer arrestors.

The flexibility of Uponor PEX piping combined with its ability to withstand

high surge pressures makes it the perfect product for supplying public-use fixtures. PEX has an approximate modulus of elasticity of 91,350 psi, compared to copper's 16,000,000 psi. Refer to **Chapter 6** for more information about expansion and contraction.

Because Uponor requires a minimum distance between ProPEX fittings (see **Table 2-1**), take care when creating a fixture header. In typical installations using Uponor PEX, the PEX header is elevated to allow for adequate spacing between ProPEX tees and to also offer ample room for PEX pipe drops to the fixture (see **Figure 5-5**).

Water hammer arrestors

When considering the need to install water hammer arrestors, there are two components of water hammer that are of significance: surge pressure and noise transmission. The intent of water hammer arrestors is to reduce the surge pressure to 150 psi and to minimize the amount of noise transmission.

The International Plumbing Code (IPC) and the Uniform Plumbing Code (UPC) both require water hammer arrestors at quick-closing valve locations. **Tables 5-6** and **5-7** show surge pressure for copper, CPVC, and PEX.

Pipe material	Maximum measured pressure (psi)				
Flow rate, gpm	2	2.5	3	4	6
½" Uponor PEX	136	150	169	193	244
½" PEX-b	143	168	177	212	274
½" CPVC	155	173	201	222	296
½" Type L Copper	194	239	266	318	422

Table 5-6: First peak pressure for each piping material and flow rate (cold water)

1. Pressure response measurements include 60 psi static pressure.
 2. Closing speed of quick-acting valve estimated at 25 milliseconds.
 3. Test performed at 54°F/12.2°C (cold water temperature).
- Surge Pressure in Plumbing Pipe Materials, PPI Report # 3285*

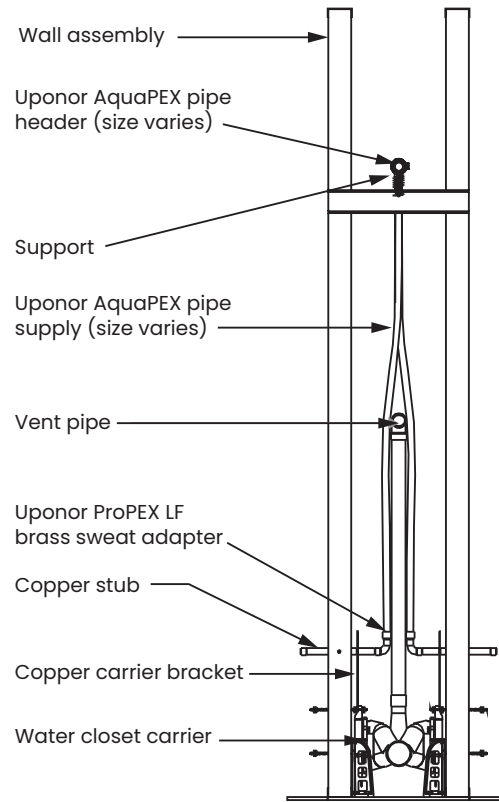


Figure 5-5: Fixture bank section view

Pipe material	Maximum measured pressure (psi)				
Flow rate, gpm	2	2.5	3	4	6
½" Uponor PEX	113	122	123	141	174
½" PEX-b	108	113	124	141	175
½" CPVC	142	157	174	203	252
½" Type L Copper	149	181	204	250	306

Table 5-7: First peak pressure for each piping material and flow rate (hot water)

1. Pressure response measurements include 60 psi static pressure.
2. Closing speed of quick-acting valve estimated at 25 milliseconds.
3. Test performed at 130°F/54.4°C (hot water temperature).

Surge Pressure in Plumbing Pipe Materials, PPI Report # 3285

These tables show the surge pressure in Uponor PEX is about 38 percent less than the surge pressure in copper. The main reason for the dramatic difference in these results is the flexibility of Uponor PEX piping. Because of its flexibility, Uponor PEX piping significantly dampens surge pressure.

Commercial flush bank detail

Water hammer arrestor where required by code
(exact locations vary by manufacturer)

Bend support
($\frac{1}{2}$ " to $\frac{3}{4}$ " typical)

Uponor AquaPEX pipe
supply (size varies)
Isolation ball valve (typical)

Stud wall assembly

Uponor AquaPEX pipe
header (size varies)

Uponor ProPEX EP tee
Support

Vent
pipe

Waste
pipe

Copper stub

Urinal carrier behind

Copper carrier bracket

Water closet carrier

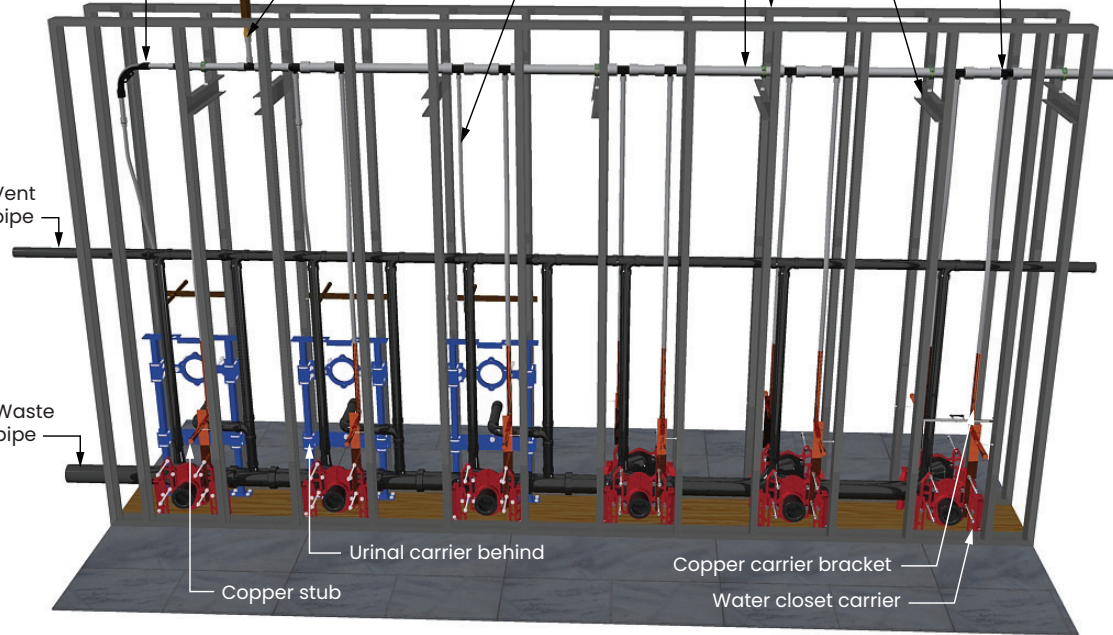


Figure 5-6: Fixture bank elevation view

Sizing an Uponor PEX domestic water system

Uniform friction loss method

For larger systems, the most common method of pipe sizing is the uniform friction loss method. This method utilizes the pipe material's specific flow characteristics in conjunction with velocity sizing criteria (see **Appendix B** for Uponor PEX friction loss tables).

The following examples illustrate how to employ the uniform friction loss method.

To simplify the uniform friction loss method when sizing an Uponor AquaPEX plumbing system, use Uponor's pipe sizing calculator at uponor.com/calculator.

Step one

Perform a building water supply calculation to determine how much pressure is available for friction loss through the pipe and fittings. (See **Figure 5-7**.)

Designer must know the following:

- Pressure available at building (minimum static pressure available before water meter or after hydro-pneumatic tank/booster-pump system)
- Minimum fixture working pressure (minimum pressure required at farthest fixture outlet)

Note: Be sure to select the most demanding fixture in the farthest fixture group (i.e., bathtub). Refer to local code for minimum fixture working pressure.

- Static loss (height in feet of the highest fixture outlet above the supply source)
- Additional component loss (total pressure loss in psi of the following system components – water meter, filters, softeners, backflow prevention devices and pressure regulators)

Step two

Calculate the total developed length (TDL) of the system and divide the available pressure for friction loss (calculated in **Figure 5-7**) by the TDL to determine the friction loss per foot or per 100 feet of pipe. (See **Figure 5-8**.)

Designer must know the following:

- Longest run to fixture (total linear feet of piping from water meter or supply source to the most hydraulically demanding fixture)
- Fitting allowance (percentage of longest run piping that represents friction loss through fittings and valves along the critical path, typically between 20 and 50 percent for an Uponor AquaPEX system)

Note: Alternatively, the designer can add up equivalent-length losses of fittings and valves along the critical path and add to the longest run footage.

Enter your domestic water supply parameters:		Calculation:
<input type="text" value="60"/>	Pressure available at building	+ 60.00 PSI
<input type="text" value="15"/>	Minimum fixture working pressure	- 15.00 PSI
<input type="text" value="20"/>	Static loss – system height (ft.)	20.00 x 0.433 - 8.66 PSI
<input type="text" value="5"/>	Additional component loss	- 5.00 PSI
		Available pressure for friction loss = 31.34 PSI

Figure 5-7: Building water supply calculation

Step three

Develop water size charts for each pipe material and water temperature. (See **Table 5-8**.)

Designer must know the following:

- Pipe materials being designed and range of sizes for each system
- Supply and return design water temperatures

Note: For commercial systems, size domestic hot-water return piping per the requirements stated in ASPE Plumbing Engineering Design Handbook, Volume 2, *Plumbing Systems*

- Maximum velocity of each pipe material per water temperature

- Table approved by the local authority having jurisdiction (AHJ) or referenced plumbing code table for converting gallons per minute (gpm) to water supply fixture units (WSFU)

- If the domestic cold-water system demand is predominately flush valve or flush tank WSFU

Step four

Apply the appropriate water size chart to the plumbing design. Calculate WSFU demand per pipe segment by adding all the WSFUs of the fixtures being supplied by that pipe segment. (See **Figure 5-10**.)

Enter your piping supply information:		Calculation:
<input type="text" value="250"/>	Longest run to fixture (ft.)	+ 250.00 FT
<input type="text" value="25"/>	Fitting allowance (% of number above)	+ 62.50 FT
		Total developed length = 312.50 FT
		Friction loss rate per foot (Friction loss/TDL) = 0.100 PSI/FT
		Friction loss rate per 100 feet (Friction loss/TDL * 100) = 10.028 PSI/100 FT

Figure 5-8: Determine the friction loss per foot (or per 100 feet) of pipe

Enter your system parameters for each table:			
A	B	C	
<input type="text" value="60"/>	<input type="text" value="120"/>	<input type="text" value="110"/>	Water size table temperature (°F)
<input type="text" value="10"/>	<input type="text" value="8"/>	<input type="text" value="2"/>	Maximum velocity per water temperature (ft./sec.)
<input type="text" value="FT"/> ▼	<input type="text" value="FT"/> ▼	<input type="text" value="FT"/> ▼	WSFU predominant fixture curve
<input type="text" value="2012 UPC"/> ▼			Applicable plumbing code

Figure 5-9: System parameters

Note: For a dedicated fixture supply pipe, Uponor permits the pipe to be of the same nominal size as the fixture being supplied, regardless of what is shown in **Table 5-8**. When performing a uniform friction loss calculation, Uponor recommends keeping the dedicated fixture supply piping run 25 feet (7.6 m) or less to eliminate any additional calculations.

If you have additional questions on your specific region or intended operating conditions for your project, please contact Uponor Construction Services.

Uponor AquaPEX water size table 2012 UPC – flush tank 100% water at 60°F 10.028 PSI/100 ft. Maximum velocity = 10 ft./sec.				Uponor AquaPEX water size table 2012 UPC – flush tank 100% water at 120°F 10.028 PSI/100 ft. Maximum velocity = 8 ft./sec.				Uponor AquaPEX water size table 2012 UPC – flush tank 100% water at 110°F 10.028 PSI/100 ft. Maximum velocity = 2 ft./sec.			
Pipe size	WSFU range	Velocity (ft./sec.)	GPM	Pipe size	WSFU range	Velocity (ft./sec.)	GPM	Pipe size	WSFU range	Velocity (ft./sec.)	GPM
3/8"	0-0	3.60	1.08	3/8"	0-0	4.10	1.23	3/8"	0-0	2.0	0.60
1/2"	1-2	4.60	2.54	1/2"	1-2	5.00	2.76	1/2"	0-0	2.0	1.10
3/4"	3-7	5.80	6.39	3/4"	3-8	6.40	7.05	3/4"	1-1	2.0	2.20
1"	8-17	7.00	12.73	1"	9-19	7.60	13.83	1"	2-3	2.0	3.64
1 1/4"	18-33	8.00	21.76	1 1/4"	20-33	8.00	21.76	1 1/4"	4-6	2.0	5.44
1 1/2"	34-63	9.00	34.10	1 1/2"	34-54	8.00	30.31	1 1/2"	7-9	2.0	7.58
2"	64-199	10.00	64.97	2"	55-134	8.00	51.97	2"	10-17	2.0	12.99
2 1/2"	200-375	10.00	99.01	2 1/2"	135-270	8.00	79.21	2 1/2"	18-29	2.0	19.80
3"	376-589	10.00	140.79	3"	271-443	8.00	112.63	3"	30-49	2.0	28.16

Table 5-8: Water size chart

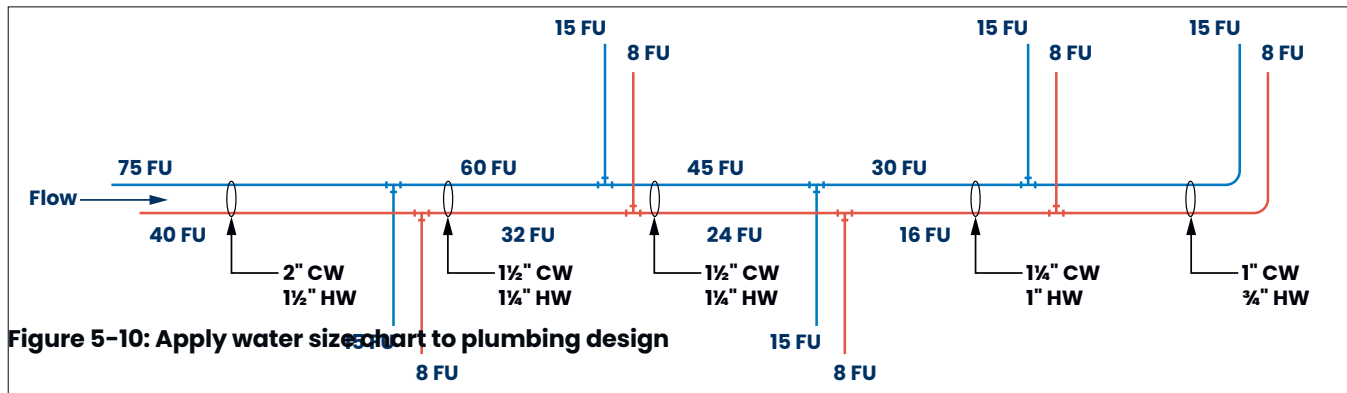


Figure 5-10: Apply water size chart to plumbing design

U.S. pipe sizing

For sizing an Uponor AquaPEX plumbing system in residential and light commercial buildings in the U.S., use the fixture unit tables for determining pipe size as published in the model plumbing codes.

To support this pipe sizing practice, Uponor consulted with the International Code Council (ICC) and the International Association of Plumbing and Mechanical Officials (IAPMO) by means of an evaluation report (ER) to substantiate their approvals.

The following ER numbers endorse the use of the current UPC Table 610.4 (see **page 62**) (or 2009–prior UPC Table) and 2018–prior IPC Table E201.1 (see **pages 63–64**) for pipe sizing an Uponor AquaPEX plumbing system.

- IAPMO ER-0253
- ICC ES PMG 1006

UPC table 610.4

Tables referenced from IAPMO ER 0253

**TABLE 610.4
FIXTURE UNIT TABLE FOR DETERMINING WATER PIPE AND METER SIZES**

METER AND STREET SERVICE (inches)	BUILDING SUPPLY AND BRANCHES (inches)	MAXIMUM ALLOWABLE LENGTH (feet)														
		40	60	80	100	150	200	250	300	400	500	600	700	800	900	1000
PRESSURE RANGE – 30 to 45 psi¹																
¾	½ ²	6	5	4	3	2	1	1	1	0	0	0	0	0	0	0
¾	¾	16	16	14	12	9	6	5	5	4	4	3	2	2	2	1
¾	1	29	25	23	21	17	15	13	12	10	8	6	6	6	6	6
1	1	36	31	27	25	20	17	15	13	12	10	8	6	6	6	6
¾	¼	36	33	31	28	24	23	21	19	17	16	13	12	12	11	11
1	¼	54	47	42	38	32	28	25	23	19	17	14	12	12	11	11
1½	¼	78	68	57	48	38	32	28	25	21	18	15	12	12	11	11
1	½	85	84	79	65	56	48	43	38	32	28	26	22	21	20	20
1½	½	150	124	105	91	70	57	49	45	36	31	26	23	21	20	20
2	½	151	129	129	110	80	64	53	46	38	32	27	23	21	20	20
1	2	85	85	85	85	85	85	82	80	66	61	57	52	49	46	43
1½	2	220	205	190	176	155	138	127	120	104	85	70	61	57	54	51
2	2	370	327	292	265	217	185	164	147	124	96	70	61	57	54	51
2	2½	445	418	390	370	330	300	280	265	240	220	198	175	158	143	133
PRESSURE RANGE – 46 to 60 psi¹																
¾	½ ²	7	7	6	5	4	3	2	2	1	1	1	0	0	0	0
¾	¾	20	20	19	17	14	11	9	8	6	5	4	4	3	3	3
¾	1	39	39	36	33	28	23	21	19	17	14	12	10	9	8	8
1	1	39	39	39	36	30	25	23	20	18	15	12	10	9	8	8
¾	¼	39	39	39	39	39	39	34	32	27	25	22	19	19	17	16
1	¼	78	78	76	67	52	44	39	36	30	27	24	20	19	17	16
1½	¼	78	78	78	78	66	52	44	39	33	29	24	20	19	17	16
1	½	85	85	85	85	85	85	80	67	55	49	41	37	34	32	30
1½	½	151	151	151	151	128	105	90	78	62	52	42	38	35	32	30
2	½	151	151	151	151	150	117	98	84	67	55	42	38	35	32	30
1	2	85	85	85	85	85	85	85	85	85	85	85	85	85	83	80
1½	2	370	370	340	318	272	240	220	198	170	150	135	123	110	102	94
2	2	370	370	370	370	368	318	280	250	205	165	142	123	110	102	94
2	2½	654	640	610	580	535	500	470	440	400	365	335	315	285	267	250
PRESSURE RANGE – Over 60 psi¹																
¾	½ ²	7	7	7	6	5	4	3	3	2	1	1	1	1	1	0
¾	¾	20	20	20	20	17	13	11	10	8	7	6	6	5	4	4
¾	1	39	39	39	39	35	30	27	24	21	17	14	13	12	12	11
1	1	39	39	39	39	38	32	29	26	22	18	14	13	12	12	11
¾	¼	39	39	39	39	39	39	39	39	34	28	26	25	23	22	21
1	¼	78	78	78	78	74	62	53	47	39	31	26	25	23	22	21
1½	¼	78	78	78	78	78	74	65	54	43	34	26	25	23	22	21
1	½	85	85	85	85	85	85	85	85	81	64	51	48	46	43	40
1½	½	151	151	151	151	151	151	130	113	88	73	51	51	46	43	40
2	½	151	151	151	151	151	151	142	122	98	82	64	51	46	43	40
1	2	85	85	85	85	85	85	85	85	85	85	85	85	85	85	85
1½	2	370	370	370	370	360	335	305	282	244	212	187	172	153	141	129
2	2	370	370	370	370	370	370	370	340	288	245	204	172	153	141	129
2	2½	654	654	654	654	654	650	610	570	510	460	430	404	380	356	329

For SI units: 1 inch = 25 mm, 1 foot = 304.8 mm, 1 pound-force per square inch = 6.8947 kPa

Notes:

¹ Available static pressure after head loss.

² Building supply, not less than ¾ of an inch (20 mm) nominal size.

IPC table E201.1

Tables referenced from ICC-ES-PMG 1006

Table E201.1
Minimum size of water meters, mains and distribution piping based on
water supply fixture unit values (w.s.f.u.)

Meter and service pipe (inches)	Distribution pipe (inches)	Maximum development length (feet)									
		40	60	80	100	150	200	250	300	400	500
Pressure range 30 to 39 psi		40	60	80	100	150	200	250	300	400	500
¾	½ ^a	2.5	2	1.5	1.5	1	1	0.5	0.5	0	0
¾	¾	9.5	7.5	6	5.5	4	3.5	3	2.5	2	1.5
¾	1	32	25	20	16.5	11	9	7.8	6.5	5.5	4.5
1	1	32	32	27	21	13.5	10	8	7	5.5	5
¾	1¼	32	32	32	32	30	24	20	17	13	10.5
1	1¼	80	80	70	61	45	34	27	22	16	12
1½	1¼	80	80	80	75	54	40	31	25	17.5	13
1	1½	87	87	87	87	84	73	64	56	45	36
1½	1½	151	151	151	151	117	92	79	69	54	43
2	1½	151	151	151	151	128	99	83	72	56	45
1	2	87	87	87	87	87	87	87	87	87	86
1½	2	275	275	275	275	258	223	196	174	144	122
2	2	365	365	365	365	318	266	229	201	160	134
2	2½	533	533	533	533	533	495	448	409	353	311

Meter and service pipe (inches)	Distribution pipe (inches)	Maximum development length (feet)									
		40	60	80	100	150	200	250	300	400	500
Pressure range 40 to 49 psi		40	60	80	100	150	200	250	300	400	500
¾	½ ^a	3	2.5	2	1.5	1.5	1	1	0.5	0.5	0.5
¾	¾	9.5	9.5	8.5	7	5.5	4.5	3.5	3	2.5	2
¾	1	32	32	32	26	18	13.5	10.5	9	7.5	6
1	1	32	32	32	32	21	15	11.5	9.5	7.5	6.5
¾	1¼	32	32	32	32	32	32	32	27	21	16.5
1	1¼	80	80	80	80	65	52	42	35	26	20
1½	1¼	80	80	80	80	75	59	48	39	28	21
1	1½	87	87	87	87	87	87	87	78	65	55
1½	1½	151	151	151	151	151	130	109	93	75	63
2	1½	151	151	151	151	151	139	115	98	77	64
1	2	87	87	87	87	87	87	87	87	87	87
1½	2	275	275	275	275	275	275	264	238	198	169
2	2	365	365	365	365	365	349	304	270	220	185
2	2½	533	533	533	533	533	533	533	528	456	403

For SI: 1 inch = 25.4mm, 1 foot = 304.8mm.

^aMinimum size for building supply is ¾-inch pipe.

(continued)

IPC table E201.1

Tables referenced from ICC-ES-PMG 1006

Table E201.1 (continued)
Minimum size of water meters, mains and distribution piping based on
water supply fixture unit values (w.s.f.u.)

Meter and service pipe (inches)	Distribution pipe (inches)	Maximum development length (feet)										
		40	60	80	100	150	200	250	300	400	500	
Pressure range 50 to 60 psi												
¾	½ ^a	3	3	2.5	2	1.5	1	1	1	0.5	0.5	
¾	¾	9.5	9.5	9.5	8.5	6.5	5	4.5	4	3	2.5	
¾	1	32	32	32	32	25	18.5	14.5	12	9.5	8	
1	1	32	32	32	32	30	22	16.5	13	10	8	
¾	1¼	32	32	32	32	32	32	32	32	29	24	
1	1¼	80	80	80	80	80	68	57	48	35	28	
1½	1¼	80	80	80	80	80	75	63	53	39	29	
1	1½	87	87	87	87	87	87	87	87	82	70	
1½	1½	151	151	151	151	151	151	139	120	94	79	
2	1½	151	151	151	151	151	151	146	126	97	81	
1	2	87	87	87	87	87	87	87	87	87	87	
1½	2	275	275	275	275	275	275	275	275	247	213	
2	2	365	365	365	365	365	365	365	329	272	232	
2	2½	533	533	533	533	533	533	533	533	533	486	

Meter and service pipe (inches)	Distribution pipe (inches)	Maximum development length (feet)										
		40	60	80	100	150	200	250	300	400	500	
Pressure range over 60 psi												
¾	½ ^a	3	3	3	2.5	2	1.5	1.5	1	1	0.5	
¾	¾	9.5	9.5	9.5	9.5	7.5	6	5	4.5	3.5	3	
¾	1	32	32	32	32	32	24	19.5	15.5	11.5	9.5	
1	1	32	32	32	32	32	28	28	17	12	9.5	
¾	1¼	32	32	32	32	32	32	32	32	32	30	
1	1¼	80	80	80	80	80	80	69	60	46	36	
1½	1¼	80	80	80	80	80	80	76	65	50	38	
1	1½	87	87	87	87	87	87	87	87	87	84	
1½	1½	151	151	151	151	151	151	151	144	114	94	
2	1½	151	151	151	151	151	151	151	151	118	97	
1	2	87	87	87	87	87	87	87	87	87	87	
1½	2	275	275	275	275	275	275	275	275	275	252	
2	2	365	368	368	368	368	368	368	368	318	273	
2	2½	533	533	533	533	533	533	533	533	533	533	

For SI: 1 inch = 25.4mm, 1 foot = 304.8mm.

^aMinimum size for building supply is ¾-inch pipe.

For sizing an Uponor AquaPEX plumbing system in residential high-rise and small commercial buildings in Canada, use **Table A-2.6.3.1.(2)A** and other applicable sections, or approved sizing methodology as accepted by the AHJ or within the National Plumbing Code of Canada (NPCC).

NPCC table A-2.6.3.1(2)A

Tables referenced from NPCC

		Current Table A-2.6.3.1.(2)A, Pressure Range 200-310 kPa															
Water Service Pipe Size in.	Water Distribution Pipe Size in.	Maximum Allowable Length, meters															
		12	18	24	30	46	61	76	91	122	152	183	213	244	274	305	
		Number of Fixture Units Served															
		Flow Velocity, m/s: 3.0 2.4 1.5															
Pressure Range		kPa															
		200	to	310													
3/4	1/2	6	5	4	3	2	1	0	0	0	0	0	0	0	0	0	
3/4	5/8	12	10	9	7	5	3	3	3	2	2	1	1	1	1	0	
3/4	3/4	18	16	14	12	9	6	5	5	4	4	3	2	2	2	1	
1	1	36	31	27	25	20	17	15	13	12	10	8	6	6	6	6	
1-1/2	1-1/4	83	68	57	48	38	32	28	25	21	18	15	12	12	11	11	
1-1/2	1-1/2	151	124	105	91	70	57	49	45	36	31	26	23	21	20	20	
2	1-1/2	151	151	132	110	80	64	53	46	38	32	27	23	21	20	20	
2	2	359	329	292	265	217	185	164	147	124	96	70	61	57	54	51	
2-1/2	2-1/2	445	418	390	370	330	300	280	265	240	220	198	175	158	143	133	

		Current Table A-2.6.3.1.(2)A, Pressure Range 311-413 kPa															
Water Service Pipe Size in.	Water Distribution Pipe Size in.	Maximum Allowable Length, meters															
		12	18	24	30	46	61	76	91	122	152	183	213	244	274	305	
		Number of Fixture Units Served															
		Flow Velocity, m/s: 3.0 2.4 1.5															
Pressure Range		kPa															
		311	to	413													
3/4	1/2	8	7	6	5	4	3	2	2	1	1	1	0	0	0	0	
3/4	5/8	13	13	12	11	9	7	5	5	3	3	2	2	1	1	1	
3/4	3/4	21	21	19	17	14	11	9	8	6	5	4	4	3	3	3	
1	1	42	42	41	36	30	25	23	20	18	15	12	10	9	8	8	
1-1/2	1-1/4	83	83	83	83	66	52	44	39	33	29	24	20	19	17	16	
1-1/2	1-1/2	151	151	151	151	128	105	90	78	62	52	42	38	35	32	30	
2	1-1/2	151	151	151	151	150	117	98	84	67	55	42	38	35	32	30	
2	2	359	359	359	359	359	318	280	250	205	165	142	123	110	102	94	
2-1/2	2-1/2	611	611	610	580	535	500	470	440	400	365	335	315	285	267	250	

		Current Table A-2.6.3.1.(2)A, Pressure Range Over 413 kPa															
Water Service Pipe Size in.	Water Distribution Pipe Size in.	Maximum Allowable Length, meters															
		12	18	24	30	46	61	76	91	122	152	183	213	244	274	305	
		Number of Fixture Units Served															
		Flow Velocity, m/s: 3.0 2.4 1.5															
Pressure Over		kPa															
		413															
3/4	1/2	8	8	7	6	5	4	3	3	2	1	1	1	1	1	0	
3/4	5/8	13	13	13	13	11	8	7	6	5	4	3	3	3	2	2	
3/4	3/4	21	21	21	21	17	13	11	10	8	7	6	6	5	4	4	
1	1	42	42	42	42	38	32	29	26	22	18	14	13	12	12	11	
1-1/2	1-1/4	83	83	83	83	83	74	62	54	43	34	26	25	23	22	21	
1-1/2	1-1/2	151	151	151	151	151	151	130	113	88	73	51	51	46	43	40	
2	1-1/2	151	151	151	151	151	151	142	122	98	82	64	51	46	43	40	
2	2	359	359	359	359	359	359	359	340	288	245	204	172	153	141	129	
2-1/2	2-1/2	611	611	611	611	611	611	610	570	510	460	430	404	380	356	329	

NPCC table 2.6.3.2

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2.6.3.2. Hydraulic Load

- 1) Except as provided in Sentence (3), the hydraulic load of a fixture or device that is listed in Table 2.6.3.2.A. shall be the number of fixture units given in the Table.
- 2) Except as provided in Sentences (1) and (3), the hydraulic load of a fixture that is not listed in Table 2.6.3.2.A. is the number of fixture units listed in Table 2.6.3.2.D.
- 3) Where fixtures are supplied with both hot and cold water, the hydraulic loads for maximum separate demands shall be 75% of the hydraulic load of the fixture units given in Tables 2.6.3.2.A. and 2.6.3.2.D. when using a detailed engineering design method.
- 4) The hydraulic load of urinals and water closets with direct flush valves shall be the number of fixture units listed in Tables 2.6.3.2.B. and 2.6.3.2.C. (See Appendix A.)

Table 2.6.3.2.A.
Sizing of Water Distribution Systems^{(1) (2)}
 Forming Part of Sentences 2.6.3.2.(1), (2) and (3), and 2.6.3.4.(2), (3) and (5)

Fixture or Device	Minimum Size of Supply Pipe, inches	Private Use Hydraulic Load, fixture units			Public Use Hydraulic Load, fixture units		
		Cold	Hot	Total	Cold	Hot	Total
Bathroom group with 6 LPF flush tank ⁽³⁾	n/a	2.7	1.5	3.6	-	-	-
Bathroom group with greater than 6 LPF flush tank ⁽³⁾	n/a	4	3	6	-	-	-
Bathroom group with more than 3 fixtures	-	-	-	(4)	-	-	-
Bathtub with or without shower head	½	1	1	1.4	3	3	4
Bathtub with ¾ inch spout	¾	7.5	7.5	10	7.5	7.5	10
Bedpan washer	1	-	-	-	7.5	7.5	10
Bidet	¾	1.5	1.5	2	-	-	-
Cothese washer 3.5 kg	½	1	1	1.4	2.25	2.25	3
Clothes washer 6.8 kg	½	-	-	-	3	3	4
Cothes washer, commercial ⁽⁵⁾	-	-	-	-	-	-	-
Dental lavatory	¾	-	-	-	1.5	1.5	2
Dental unit, cuspidor	¾	-	-	-	1	-	1
Dishwasher, commercial ⁽⁵⁾	-	-	-	-	-	-	-
Dishwasher, domestic	¾	-	1.4	1.4	-	-	-
Drinking fountain or water cooler	¾	-	-	-	0.25	-	0.25
Hose bibb	½	2.5	-	2.5	2.5	-	2.5
Hose bibb	¾	3	-	3	6	-	6
Hose bibb, combination hot and cold	½	1.9	1.9	2.5	1.9	1.9	2.5
Lavatory, 8.3 LPM or less	¾	0.5	0.5	0.7	1.5	1.5	2
Lavatory, greater than 8.3 LPM	¾	0.75	0.75	1	1.5	1.5	2
Sink, bar	¾	0.75	0.75	1	1.5	1.5	2
Sink, clinic service faucet	½	-	-	-	2.25	2.25	3
Sink, clinic service with direct flush valve	1	-	-	-	6	-	6
Sink, kitchen commercial, per faucet	½	-	-	-	3	3	4
Sink, kitchen domestic, 8.3 LPM	¾	1	1	1.4	1	1	1.4

NPCC table 2.6.3.2

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Fixture or Device	Minimum Size of Supply Pipe, inches	Private Use Hydraulic Load, fixture units			Public Use Hydraulic Load, fixture units		
		Cold	Hot	Total	Cold	Hot	Total
Sink, kitchen domestic, greater than 8.3 LPM	$\frac{3}{8}$	1.5	1.5	2	1.5	1.5	2
Sink, laboratory	$\frac{3}{8}$	-	-	-	1.5	1.5	2
Sink, laundry (1 or 2 compartments)	$\frac{3}{8}$	1	1	1.4	1	1	1.4
Sink, service or mop basin	$\frac{1}{2}$	-	-	-	2.25	2.25	3
Sink, washup, per faucet	$\frac{1}{2}$	-	-	-	1.5	1.5	2
Shower head, 9.5 LPM or less per head	$\frac{1}{2}$	1	1	1.4	3	3	4
Shower head, greater than 9.5 LPM per head	$\frac{1}{2}$	1.5	1.5	2	3	3	4
Shower, spray, multi-head, fixture unit per head	(5)	1	1	1.4	3	3	4
Urinal, with direct flush valve	$\frac{3}{8}$	(6)	-	(6)	(6)	-	(6)
Urinal, with flush tank	$\frac{3}{8}$	3	-	3	3	-	3
Urinal, with self-closing metering valve	$\frac{1}{2}$	2	-	2	4	-	4
Water closet, 6 LPF or less with flush tank	$\frac{3}{8}$	2.2	-	2.2	2.2	-	2.2
Water closet, greater than 6 LPF with flush tank	$\frac{3}{8}$	3	-	3	5	-	5
Water closet, with direct flush valve	1	(6)	-	(6)	(6)	-	(6)

Notes to Table 2.6.3.2.A.:

- (1) The fixture unit values in this Table are not applicable in certain assembly occupancies because of surges in use by the occupants. For such occupancies, refer to specific design information.
- (2) For fixtures not indicated in this Table, refer to Table 2.6.3.2.D.
- (3) Bathroom group is based on a $\frac{1}{2}$ -inch size bathtub supply pipe.
- (4) Add additional fixture to the fixture load for bathroom group.
- (5) Refer to manufacturer's recommendations.
- (6) For fixture unit values for fixtures with direct flush valves, see Sentence 2.6.3.2.(4) and Tables 2.6.3.2.B. and 2.6.3.2.C.

Table 2.6.3.2.B.
Sizing of Water Distribution Systems for Urinals with Direct Flush Valves
 Forming Part of sentences 2.6.3.2.(4) and 2.6.3.4.(5)

Number of Valves	Individual Fixture Unit Assigned in Decreasing Value	Fixture Units in Accumulative Values ⁽¹⁾
1	20	20
2	15	35
3	10	45
4	8	53
5 or more	5 each	58, plus 5 for each additional fixture in excess of 5

Notes to Table 2.6.3.2.B.:

- (1) The accumulative fixture unit values are the total values to be used in conjunction with Table 2.6.3.2.A.

NPCC table 2.6.3.2

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Number of Valves	Individual Fixture Unit Assigned in Decreasing Values	Fixture Units in Accumulative Values ⁽¹⁾
1	40	40
2	30	70
3	20	90
4	15	105
5 or more	10 for each public use and 6 for each private use	115, plus 10 for each public use additional fixture excess of 5 and 111, plus 6 for each private use additional fixture in excess of 5

Notes to Table 2.6.3.2.C:

(1) The accumulative fixture unit values are the total values to be used in conjunction with Table 2.6.3.2.A.

Table 2.6.3.2.D.
Hydraulic Loads of Fixtures Not Listed in Table 2.6.3.2.A.
Forming Part of Sentences 2.6.3.2.(2) and 2.6.3.4.(5)

Size of Supply Pipe, Inches	Hydraulic Load, fixture units	
	Private use	Public use
$\frac{3}{8}$	1	2
$\frac{1}{2}$	2	4
$\frac{3}{4}$	3	6
1	6	10

2.6.3.3. Static Pressure

- 1) Where the static pressure at any fixture may exceed 550 kPa, a pressure-reducing valve shall be installed to limit the maximum static pressure at the fixture to 550 kPa.

2.6.3.4. Size

- 1) Every water service pipe shall be sized according to the peak demand flow but shall not be less than $\frac{1}{4}$ inch size.
- 2) Except as provided in Sentence (3), the size of a supply pipe that serves a fixture shall conform to Table 2.6.3.2.A.
- 3) For fixtures listed in Table 2.6.3.2.A. that have a permitted supply pipe size of $\frac{3}{8}$ inch, a connector not more than 750mm long and not less than 6.3mm inside diameter may be used to supply water to the fixture.
- 4) No water system between the point of connection with the water service pipe or the water meter and the first branch that supplies a water heater that serves more than one fixture shall be sized less than $\frac{1}{4}$ inch.
- 5) Where both hot and cold water is supplied to fixtures in residential buildings containing one or two dwelling units or row houses with separate water service pipes, the water system may be sized in accordance with Table 2.6.3.4., where
 - a) the hydraulic loads for maximum separate demands on water distribution system piping are not less than 100% of the total hydraulic load of the fixture units given in Tables 2.6.3.2.A., 2.6.3.2.B., 2.6.3.2.C. or 2.6.3.2.D. for private use,
 - b) the minimum water pressure at the entry to the building is 200 kPa, and
 - c) the total maximum length of water system is 90 m.

Uponor PEX design parameters for domestic hot-water systems

To provide clarity around domestic hot-water systems, we have provided the below definitions which can be used along with **Table 4-1**.

Domestic hot-water supply

– The part of the domestic water system that supplies hot potable water from the heat source to the various fixtures throughout the building. The piping is sized using the applicable codes water supply fixture units (WSFUs) and/or uniform friction loss for the specific building.

Dedicated domestic hot-water recirculation piping

– The part of the domestic hot water system that returns (or recirculates) hot potable water to the heat source to be reheated and recirculated. The water in this piping does not supply any fixtures. Domestic hot-water recirculation piping is most often sized based on the heat loss of the supply piping and uniform friction loss, but may also be sized based on the minimum flow rate of balancing valves.

Hot-water system design

Uponor AquaPEX piping is tested and listed to PEX 5106 NSF-pw (CL5). Per ASTM F876, the CL5 chlorine resistance rating is intended for an end-use condition of 100 percent at 140°F/60°C at 80 psi (5.5 bar), which is the highest chlorine-resistance rating available through ASTM. Products marked with a '5' in the first digit of the four-digit code and also bearing the CL5 designation

[e.g., PEX 5106 NSF-pw (CL5)] indicate the product is approved for use in continuous, domestic, hot-water circulation systems with up to 140°F/60°C water temperatures at 80 psi (5.5 bar).

Sizing and maximum velocity

Uponor requires that the velocity of the dedicated recirculation piping shall not exceed 2 ft./sec. and that the hot-water piping system (which includes the recirculation lines) meets the following requirements stated in the *ASPE Plumbing Engineering Design Handbook, Volume 2, Plumbing Systems*:

1. Calculate the heat loss rates of the hot-water supply piping.
2. Calculate the circulation rates for all parts of the circulating piping and the total circulation rate required.
3. Determine the allowable uniform friction head loss and the total head required to overcome friction losses in the piping when the water is flowing at the required circulation rate.
4. Calculate the rates of flow for various piping sizes that will give the uniform pressure drop established in **Step 3**, and tabulate the results.
5. Size the system based upon the tabulation set up in **Step 4**.
6. With the sizes established in **Step 5**, repeat **Steps 1 through 5** as a check on the assumptions made.

While Uponor recommends the more accurate process above, the following

streamlined method is also available using the *ASPE Plumbing Engineering Design Handbook*:

1. Allow ½ gpm for each small hot-water riser (¾" to 1"), 1 gpm for each medium-sized hot-water riser (1¼" to 1½"), and 2 gpm for each large-sized hot-water riser (2" and larger).
2. Add 1 gpm for each group of 20 hot-water supplied fixtures.
3. Total the gpm from all risers and group of fixtures.
4. Using **Table 5-9**, select the correct pipe size for the recirculation line.

Recirculated hot-water systems

To maintain satisfactory temperatures, hot-water systems are often recirculated. Several recirculating methods are available:

- **Continuous** – Circulates water 24 hours a day. This method is not considered cost or energy effective when the buildings use patterns are not aligned with continuous flow.
- **Thermostatic (aquastat)** – This method measures the water temperature and turns the circulator on or off, based on system needs.

- **Timed** – This method uses a timer to turn the circulator on or off. The time range for circulator operation should be based on the building's usage patterns.
- **Demand** – This method utilizes buttons and motion sensors to turn the circulator on or off only when the occupant needs hot water.

Uponor AquaPEX is rated for use in continuous-circulation domestic-water systems with temperatures up to 140°F/60°C at 80 psi (5.5 bar).

Balancing of recirculated hot-water systems

Circulated hot-water systems require flow balancing to maintain satisfactory system temperatures. If systems are not properly balanced, circulated water has the tendency to short circuit through the shortest loop in the system, thus creating high velocities in that loop and resulting in hot water delays to remote loops. Hot-water recirculated lines should be insulated, and they typically require little flow to maintain satisfactory system temperatures. Uponor limits maximum velocity to 2 ft./

Nominal pipe size	Velocity (ft./sec.)	Flow rate (gpm)	Friction loss per foot at 120°F/48.9°C
½"	2	1.1	0.0195
¾"	2	2.2	0.0126
1"	2	3.6	0.0092
1¼"	2	5.4	0.0072
1½"	2	7.5	0.0059
2"	2	12.9	0.0042
2½"	2	19.8	0.0033
3"	2	28.1	0.0026

Table 5-9: Uponor AquaPEX flow rates at 2 ft./sec.

sec. in dedicated hot-water return piping using Uponor AquaPEX (see **Table 5-9**).

For system balancing, use calibrated devices such as balancing valves or flow limiters. Consider thermostatic balancing valves with ECM/variable driven domestic hot water return pumps. Each balancing valve requires a check valve, either in-line or incorporated into the balancing valve assembly, to prevent reverse flow from fixture discharge.

Expansion tanks

In accordance with most major plumbing codes in North America, systems that include backflow preventers, pressure reducing valves (PRVs), or check valves on the main water service line will require an expansion tank or other approved device to control thermal expansion. Systems utilizing these devices are more likely to experience elevated pressures that may be above the maximum

recommended limit of 80 psi. Note that excessive dynamic (rather than static) fluctuations within the plumbing systems' temperature and/or pressure can impact the long-term performance of the plumbing system components, including Uponor products.

It is important to take extreme care to control these scenarios with proper design, installation, and equipment that can manage these effects. It is

imperative to maintain and control both consistent and/or excessive temperature and pressure fluctuations above recommended system limits and/or code for the long-term health of the plumbing system. Refer to local code as well as the water heater manufacturer's installation guidelines for expansion tanks and other similar devices.

Uponor PEX hydronic piping systems

This section profiles hydronic piping design for commercial buildings, generally referred to as fire-resistant construction buildings, where both building and mechanical codes apply.

Determining flow rate

When sizing any hydronic system, you must first calculate the flow rate needed to meet the heating or cooling demand. Flow rate is a function of the mechanical properties of a fluid, the heat loss of the space to be served and the fluid's temperature differential. Insufficient flow causes uneven heating or cooling throughout a

building, while too much flow causes equipment to short-cycle, work inefficiently and fail more quickly. A simple formula for calculating flow rate for 100-percent water systems is:

$$\text{GPM} = \text{BTU/h} \div (\Delta T \times 500)$$

Example: Consider a fan-coil unit requiring 20,000 BTU of energy per hour with a design temperature differential (ΔT) of 20°F. Inserting those values into the formula yields a required flow rate of 2 gpm being delivered to that fan-coil to produce 20,000 BTU's. To determine each pipe segment's total gpm, add the cumulative gpm

for all downstream fan-coils. The total flow rate for a system can be calculated by adding together all terminal-unit flow rates for the system

minimum design velocity, maximum design velocity and maximum allowable head pressure per 100 feet of pipe. The values shown in **Table 5-10** are typical for designs utilizing Uponor PEX.

Pipe sizing

To determine pipe sizing, the system flow rates must remain within certain boundaries — namely,

Area	Design velocity		Friction loss
	Minimum	Maximum	Typical
Main	1.5 ft./sec.	8 ft./sec.	4 ft./100 ft.
Riser	1.5 ft./sec.	8 ft./sec.	
Long branch	1.5 ft./sec.	8 ft./sec.	
Short branch (<50 ft.)	1.0 ft./sec.	8 ft./sec.	

Table 5-10: Minimum and maximum design velocity

Once the various flow rates are calculated for the system, the pipe size can be determined by referencing the head loss tables in **Appendix B**. Using the example on the previous page with a flow rate of 2 gpm, and assuming a water temperature of 160°F (71°C), the Uponor PEX pipe size would be 3/4".

3/4" Uponor PEX (100% water)

Feet of head per 100 ft. of PEX																					
Velocity (ft/s)	GPM	40°F 4°C	45°F 7°C	50°F 10°C	55°F 13°C	60°F 16°C	65°F 18°C	70°F 21°C	80°F 27°C	90°F 32°C	100°F 38°C	110°F 43°C	120°F 49°C	130°F 54°C	140°F 60°C	150°F 66°C	160°F 71°C	170°F 77°C	180°F 82°C	190°F 88°C	200°F 93°C
1.0	1.10	1.25	1.19	1.11	1.09	1.06	1.04	1.02	0.99	0.95	0.93	0.90	0.88	0.86	0.84	0.82	0.81	0.79	0.78	0.77	0.76
1.2	1.32	1.71	1.62	1.52	1.49	1.45	1.43	1.40	1.35	1.31	1.27	1.24	1.20	1.18	1.15	1.13	1.11	1.09	1.07	1.06	1.04
1.4	1.54	2.22	2.10	1.98	1.94	1.89	1.86	1.82	1.76	1.71	1.66	1.61	1.58	1.54	1.51	1.48	1.45	1.43	1.40	1.38	1.36
1.6	1.76	2.79	2.64	2.49	2.44	2.38	2.34	2.30	2.22	2.15	2.09	2.04	1.99	1.95	1.91	1.87	1.84	1.80	1.78	1.75	1.73
1.8	1.98	3.41	3.24	3.05	2.99	2.92	2.87	2.82	2.72	2.64	2.57	2.50	2.44	2.39	2.34	2.30	2.26	2.22	2.19	2.15	2.13
2.0	2.20	4.06	3.86	3.65	3.58	3.51	3.45	3.38	3.27	3.17	3.09	3.01	2.94	2.88	2.82	2.77	2.72	2.67	2.63	2.60	2.56
2.2	2.43	4.81	4.57	4.31	4.23	4.14	4.07	3.99	3.86	3.75	3.65	3.56	3.48	3.40	3.34	3.27	3.22	3.16	3.12	3.07	3.03
2.4	2.65	5.58	5.31	5.01	4.91	4.81	4.73	4.64	4.50	4.37	4.25	4.15	4.05	3.97	3.89	3.82	3.75	3.69	3.64	3.59	3.54
2.6	2.87	6.41	6.10	5.76	5.65	5.53	5.44	5.34	5.17	5.02	4.89	4.77	4.66	4.57	4.48	4.40	4.32	4.25	4.19	4.13	4.08
2.8	3.09	7.28	6.94	6.55	6.43	6.30	6.19	6.08	5.89	5.72	5.57	5.44	5.32	5.21	5.11	5.01	4.93	4.85	4.78	4.71	4.65
3.0	3.31	8.20	7.82	7.38	7.25	7.10	6.98	6.86	6.65	6.46	6.29	6.14	6.00	5.88	5.77	5.67	5.57	5.48	5.40	5.33	5.26

Table 5-11: Determine the pipe size

System balancing

Balancing valves typically are used to regulate flow throughout a piping system. Much like one putting his or her thumb over a hole in a garden hose, balancing valves ensure proper flow to each unit in a system. It is important to remember that in the conversion of a design from metallic piping to PEX, the hydraulic characteristics must remain constant for proper operation to be ensured.

Understanding the hydraulics in a system is critical when sizing. Consider a garden hose with evenly spaced holes in it. Because water takes the path of least resistance, flow will be greatest in the hole nearest the water source and least in the hole farthest from the water source. The same principle holds true for any piping system, which is why it is important to identify the most demanding unit. The path from the heat or

cooling source to the most demanding unit is called the critical path or path of most resistance (most head loss) and will determine the pump’s requirements for differential pressure.

Optimization

An additional step that can be taken in the sizing of a PEX hydronic system involves optimization of the pipe design. Converting from copper to PEX will uphold the hydraulics in a system, but likely not maximize operational efficiency. For that, some fine-tuning is required. Some designers and engineers design their PEX pipe system layout so it performs much of the hydraulic balancing in a system naturally through reduction of pipe sizing on the non-critical paths, a job traditionally of balancing valves. In general, the lesser the demand placed on balancing valves, the greater the ability of a

control valve to have authority over the coil to each unit. This ensures high modularity of flow with respect to valve position and coil output while raising a building’s operational efficiency. This is because the control valve undergoes less short-cycling, which allows flow to be modulated according to load.

Uponor pipe sizing calculator

Uponor offers an online hydronic pipe sizing calculator that is

capable of generating flow tables for hydronic piping systems based on user-specific inputs. This calculator allows the user to quickly create tables that accurately assist in hydronic system design. The calculator also contains sections for sizing radiant heating and cooling systems and plumbing systems. This feature allows the user to enter basic fluid information to generate flow tables using common design methodology. The calculator will create flow

Figure 5-11: Uponor pipe sizing calculator example

tables with maximum and minimum flow rates based on friction loss per 100 ft. of pipe as well as the specified velocity inputs for various piping materials. Access the calculator at uponor.com/calculator. Enter the information into the calculator and it will output a table for each water temperature with a gallons-per-minute (gpm) range for each pipe size. **Table 5-12** shows the water size table created for water temp. 1.

Water temp 1			
PEX-ASTM F876 sizing table 100% water at 160°F 4 ft. of head loss/100 ft. Min. velocity = 1.5 ft./sec. Max. velocity = 8 ft./sec.			
Pipe size	GPM range	Velocity (ft./sec.)	Feet of head per 100 ft. of pipe
5/16"	Out of range	Out of range	Out of range
3/8"	0.45 – 0.48	1.50 – 1.60	3.71 – 4.00
1/2"	0.83 – 1.10	1.50 – 2.00	2.53 – 4.00
5/8"	1.21 – 1.86	1.50 – 2.30	1.99 – 4.00
3/4"	1.65 – 2.76	1.50 – 2.50	1.64 – 4.00
1"	2.73 – 5.46	1.50 – 3.00	1.20 – 4.00
1 1/4"	4.08 – 9.25	1.50 – 3.40	0.94 – 4.00
1 1/2"	5.68 – 14.78	1.50 – 3.90	0.76 – 4.00
2"	9.75 – 29.89	1.50 – 4.60	0.55 – 4.00
2 1/2"	14.85 – 52.48	1.50 – 5.30	0.42 – 4.00
3"	21.12 – 83.06	1.50 – 5.90	0.34 – 4.00
3 1/2"	28.46 – 123.34	1.50 – 6.50	0.29 – 4.00
4"	36.88 – 174.57	1.50 – 7.10	0.24 – 4.00

Table 5-12: Pipe size table for water temp. 1

The calculator also determines the head loss created in a distribution line, including pipe and fittings. Piping is calculated using the Darcy-Weisbach equation and fittings are calculated using their respective C_v values.

International Energy Conservation Code (IECC)

All piping serving as part of a heating or chilled-water system shall be thermally insulated in accordance with **Table C403.2.8** of the IECC or local/state codes where applicable. See **Table 4-6**.

Insulating piping

Some local codes require insulation of chilled-water piping due to condensation that can occur on the outside of the piping. This is a requirement for any piping material, including copper, CPVC, PEX, steel and polypropylene. PEX piping has a very low coefficient of thermal conductivity of 2.628 Btu • in./ (hr-ft.² • °F), whereas copper has a coefficient of thermal conductivity between 2,080 and 2,773 Btu • in./ (hr-ft.² • °F). It is important to note that if the surface temperature of the pipe or insulation is less than the design

Enter Your PEX Pipe Parameters:

1" Nominal Pipe Size

32 Length of Pipe in Feet

4 Elbows

0 Flow-through Tees

1 Branch Tees

2 Adapters

Enter Your Water Properties:

0% Glycol Mixture (%)

160 Water Temperature in °F

3.7 Flow in GPM

Results:

Velocity Output = 2.03 ft./sec.

Fitting Head Loss = 1.299 ft.

Pipe Head Loss = 0.658 ft.

Total Friction Head Loss = 1.957 ft.

Total Friction Pressure Loss = 0.83 PSI

[Calculate](#)

Figure 5-12: Head loss calculations

dew point temperature in the cavity, the pipe or insulation surface will condense. **Table 4-5** yields surface temperature of the outermost layer with respect to water temperature, insulation thickness, and ambient air temperature. Use this data to ensure condensation will not occur. See **Appendix D**.

Example: A nominal 1" (25 mm) PEX pipe with 1/2" insulation carrying 40°F (4.4°C) water would have a 69.5°F (20.83°C) insulation surface temperature given an 80°F (26.6°C) ambient temperature. Assuming a relative humidity of 60

percent at an 80°F (26.6°C) ambient temperature, the dew point temperature would be 65°F (18.3°C). Since the dew point temperature is 4.5°F (2.5°C) lower than the surface temperature, there is no concern for condensation on the piping system. If the surface temperature is lower than or equal to the dew point temperature, a higher level of insulation is necessary. If the surface temperature is one to two degrees higher than the dew point temperature of the piping system, a higher level of insulation is recommended.

Chapter 6

Installation Methods

This section profiles installation methods that are typical for commercial buildings to which both fire and building codes apply (generally referred to as fire-resistant construction buildings). Each method includes a detailed illustration with notes for installing piping in fire-resistant construction buildings.

For specific fire-assembly details, refer to **Chapter 3**.

Local code approvals

Before installing any piping, discuss the installation with local building officials. While the Uponor systems described in this section meet the requirements of most building and codes found in the United States and Canada, some inspectors are not aware of these types of installations. **Chapters 1 and 3** in this manual provide supporting information and listings for United States and Canadian code compliance.

Storing and handling PEX

Although not comprehensive, the following highlights the most common guidelines when storing and handling Uponor PEX.

- Uponor PEX is approved for direct connection to electric water heaters as well as power-vented gas water heaters where allowed by local code.
- Do not store Uponor PEX piping outdoors.
- Keep Uponor PEX piping in the original packaging until the time of installation.
- Do not use Uponor PEX piping where temperatures and pressures exceed ratings.
- Do not use or store Uponor AquaPEX White or Wirsbo hePEX piping where it will be exposed to direct sunlight for more than one month.
- Do not use or store Uponor AquaPEX Red or Uponor AquaPEX Blue piping where it will be exposed to direct sunlight for more than six months.
- Do not weld or glue to join Uponor PEX piping.
- Do not apply open flame to Uponor PEX piping.
- Minimum clearance from Insulation Contact (I.C.)-rated fixtures is 2". Minimum clearance from non-I.C. rated fixtures is 12". For distances closer than the above minimums, protect the pipe with an approved insulation.
- Do not install Uponor PEX within 5 ft. of direct view from fluorescent and LED lighting without protecting the pipe with a UV-blocking material.
- Do not use Uponor PEX piping to convey natural gas.
- Do not solder, braze, weld or fusion-weld within 18" of any Uponor PEX piping in the same water line. Make any heat-related connections prior to making the ProPEX connection.
- Do not install Uponor PEX piping between the tub/shower valve and tub spout.
- Do not use Uponor PEX piping for an electrical ground.
- Do not spray on or allow organic chemicals, strong acids or strong bases to come into contact with Uponor PEX piping.
- Do not use petroleum or solvent-based paints, greases or sealants on Uponor PEX piping.
- Use only approved and appropriate firestop materials with Uponor PEX piping.
- Do not allow rodents, insects or other pests to come into contact with Uponor PEX piping.
- Do not subject Uponor PEX piping to blunt impact.
- Do not install Uponor PEX piping in soil environments contaminated with solvents, fuels, organic compounds, pesticides or other detrimental materials that may cause permeation, corrosion, degradation or structural failure of the piping. In areas where such conditions are suspected, perform a chemical analysis of the soil or groundwater to ascertain the acceptability of Uponor PEX piping for the specific installation. Check local codes for additional requirements.
- Do not press standard ProPEX LF brass fittings or standard brass (i.e., copper press). Only press Uponor ProPEX copper press adapters.
- Do not install Uponor PEX pipe in steel-stud applications without the use of grommets to protect the pipe from abrasion.

Note: When transitioning from PEX to other piping materials, follow the appropriate installation instructions for that product

Uncoiling PEX

An Uponor uncoiler is recommended for convenient uncoiling when the piping is not in the Punch&Pull™ packaging.

Bending PEX

The minimum bend radius of Uponor PEX pipe is six times the outside diameter of the pipe. Use bend supports for $\frac{3}{8}$ ", $\frac{1}{2}$ ", $\frac{5}{8}$ ", $\frac{3}{4}$ ", and 1" piping to facilitate 90-degree rigid bends. Use large-diameter PVC conduit to facilitate 90-degree bends in larger-diameter Uponor PEX piping.

To alleviate stress on ProPEX connections and fittings, take care to not change direction immediately after a ProPEX connection. To determine whether or not the directional change is too soon, refer to **Table 6-1** and **Figures 6-2** and **6-3**. Uponor recommends a minimum of two times the O.D. of the pipe as the minimum distance before changing direction.

Pipe size (in)	Pipe O.D. (in)	Min. bend radius (in)	2 x O.D. (in)
$\frac{1}{2}$ "	0.625	3 $\frac{3}{4}$	1 $\frac{1}{4}$
$\frac{3}{4}$ "	0.875	5 $\frac{1}{4}$	1 $\frac{3}{4}$
1"	1.125	6 $\frac{3}{4}$	2 $\frac{1}{4}$

Table 6-1: Minimum bend radius

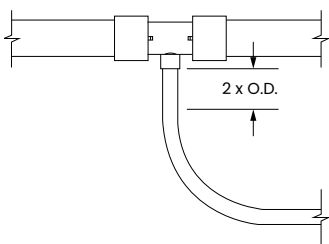


Figure 6-2: Correct bending

Note: When a proper bend cannot be achieved, use a ProPEX elbow.

Reforming kinked piping

If the piping is kinked and hinders flow, easily make repairs following the steps below.

1. Make sure the system is not pressurized.
2. Straighten the kinked portion of the piping.
3. Heat the kinked area to approximately 265°F/129.4°C with an electric heat gun (approximately 450 watts of power). Apply the heat evenly until the piping returns to its original size and shape. **Do not use an open flame** (see **Figure 6-1**).
4. Allow the repaired piping to cool undisturbed to room temperature. When the piping returns to its opaque appearance, the repair is complete.



Figure 6-1: Reforming kinked piping

Caution: The piping surface temperature must not exceed 338°F/170°C. Do not apply direct flame to Uponor PEX piping. Uponor PEX piping repaired according to these recommendations will return to its original shape and strength. If the piping is sliced, punctured or otherwise damaged beyond the capacity of the crosslinked memory, install a ProPEX coupling. Uponor PEX piping cannot be welded or repaired with adhesives.

Thawing frozen piping

Uponor PEX can withstand extreme freeze-thaw cycles better than other piping materials. In 2015, Uponor worked in partnership with standards developing organizations (SDOs) to establish a test method for performance under freeze/thaw conditions and subsequently developed a new standard for PEX piping applications. The test methodology included Uponor PEX pipe, ProPEX rings and ProPEX fitting assemblies and subjected them to repeated freeze/thaw cycles. The assemblies

were then evaluated for leaks under pressure after every cycle. Based on the samples provided and the testing performed, Uponor $\frac{1}{2}$ " PEX pipe, ProPEX rings, and ProPEX EP couplings passed the freeze/thaw cycling and subsequent burst tests without failure in accordance with the test method.

If freezing occurs, the installer should advise the end user to correct the lack of insulation or heat to eliminate the problem from reoccurring. Should Uponor PEX piping experience an ice blockage, thaw the piping using one or more of the following methods.

- Pour hot water over the affected portion of piping.
- Wrap hot towels around the affected portion of piping.
- Place a small portable heating unit in the area to heat the space and thaw the ice blockage from the piping.
- Slowly heat the affected area with a hair dryer. Rub a hand over the area while heating to ensure the piping does not get too hot.

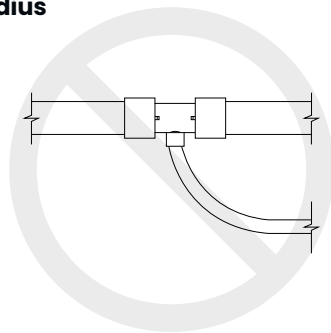


Figure 6-3: Incorrect bending

Supporting Uponor PEX piping systems

When determining support-types and distances, it is important to take into account both the local code requirements, as well as the specific manufacturer's requirements for their product. This is because the manufacturer may have requirements above and beyond code to protect

the integrity of the piping system due to its unique properties (e.g., thermal expansion or contraction control).

General requirements for supporting PEX pipe

- Use copper tube size (CTS) supports and clamps whenever possible.
- Use supports and clamps that are free of any sharp edges.

- Do not overtighten clamps.
- Isolate piping from other mechanical, electrical and plumbing (MEP) systems.
- Do not strap pipe directly to DWV piping systems.

Code requirements

As a minimum, follow local code requirements when supporting Uponor PEX piping. Note that these code requirements do not

account for linear growth or movement due to expansion or contraction. See **Table 6-2**.

Note: In fire-rated assemblies, the penetration is not acting as support for the pipe. The pipe will still need to be supported per **Table 6-2**.

Nominal pipe size	Maximum horizontal spacing		Maximum vertical spacing		
	IPC/IMC/UPC/UMC	National Plumbing Code of Canada	IPC/IMC	UPC/UMC	National Plumbing Code of Canada
PEX pipe 1" and smaller	32 inches	0.8 m	10 feet ¹	Base and each floor; provide mid-story guides	Support at the base and at the floor of alternate stories; not to exceed 7.5 m ²
PEX pipe 1¼" and larger	4 feet				

Table 6-2: Support requirements for crosslinked polyethylene (PEX) pipe by code

¹For sizes 2 inch and smaller, a guide shall be installed midway between required vertical supports. Such guide shall prevent pipe movement in a direction perpendicular to the axis of the pipe.

²Although not required by the National Plumbing Code of Canada, Uponor recommends the use of vertical supports at five feet for sizes 2 inch and smaller to minimize pipe movement.

Supporting large-diameter valves

Nominal pipe size	Valve type	Maximum support distance "A"
1¼"-2"	Ball	18" (45.7 cm)
2½"-3"	Butterfly	7" (17.7 cm)

Table 6-3: Support requirements for large-diameter valves

Note: For ball valves larger than 2", support within 7" (17.7 cm).

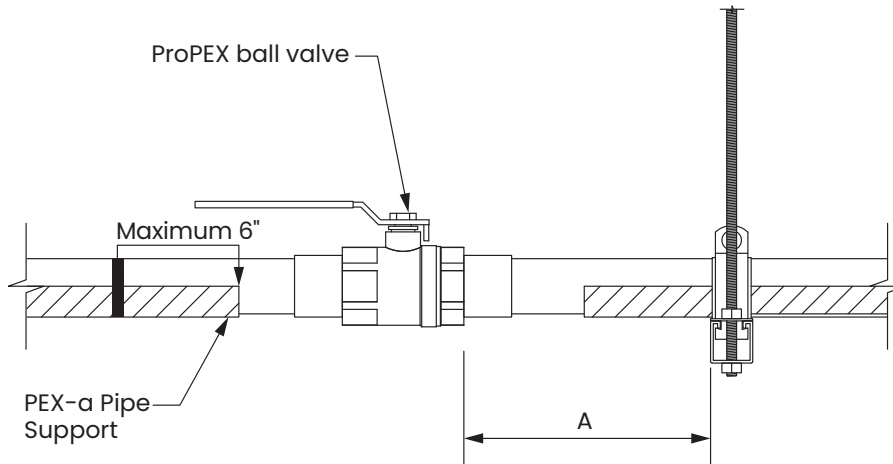


Figure 6-4: Supporting 1¼" to 2" ball valves

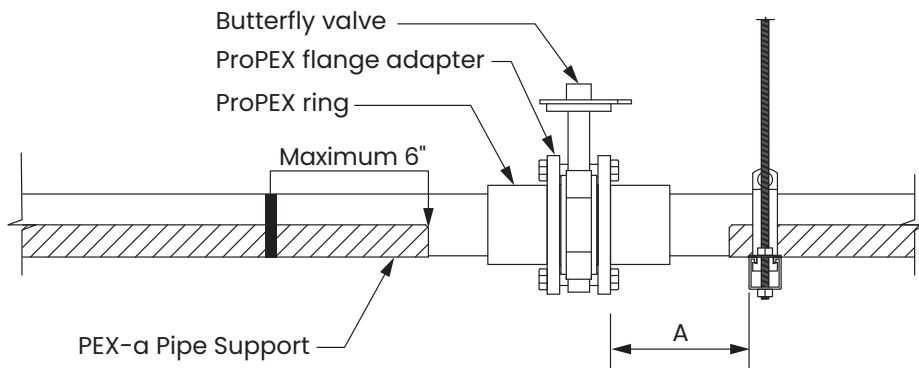


Figure 6-5: Supporting 2½" to 3" butterfly valves

Uponor PEX-a Pipe Support

PEX-a Pipe Support is a 23-gauge galvanized-steel channel for PEX piping with a CTS (copper tube size) controlled outside diameter. It features a profile that is over half-round, making it self-gripping. It provides continuous, uninterrupted support of PEX piping, allowing increased hanger spacing over bare PEX.

Product offering

PEX-a Pipe Support is available in 9-foot (3 m) lengths in the following sizes:

- ½" • 1¼" • 2½"
- ¾" • 1½" • 3"
- 1" • 2"

Nylon strapping

Each bundle of PEX-a Pipe Support includes a package of nylon straps. The straps carry a 120-lb. tensile rating and are tested for the appropriate applications.

Insulating PEX-a Pipe Support

The low profile of PEX-a Pipe Support allows insulation with typical CTS pipe insulation.

Important tips for installing PEX-a Pipe Support

- Always follow local code for general piping support requirements.
- Use the included 120-lb. nylon straps to secure the support channel to the pipe. If the included straps are misplaced, use a nylon strap of equal or greater strength.
- Due to expansion characteristics of Uponor PEX piping, it is important to use a minimum 120-lb. nylon cable tie or equivalent for securing the support to the piping. Ensure ties are intended for applications up to 180°F (82.2°C) and are UV-rated.

Tips for cutting PEX-a Pipe Support

- Always cut the PEX-a Pipe Support starting from the round side.
- When using a reciprocating or band saw to cut the PEX-a Pipe Support, either place the support flat-side down to make a clean cut or place a scrap piece of pipe into the support before cutting.
- When using a hand tool such as tin snips to cut the PEX-a Pipe Support, place the support flat-side down and mark a line on the support to follow.
- When cutting a support, take care not to bend it.
- After cutting PEX-a Pipe Support, taper and smooth any sharp edges.

Nominal pipe size	Min. distance to fitting (A)
½"	1¼"
¾"	1¾"
1"	2¼"
1¼"	2¾"
1½"	3"
2"	4"
2½"	5"
3"	6"

Table 6-4: Uponor PEX-a Pipe Support minimum distance to fittings

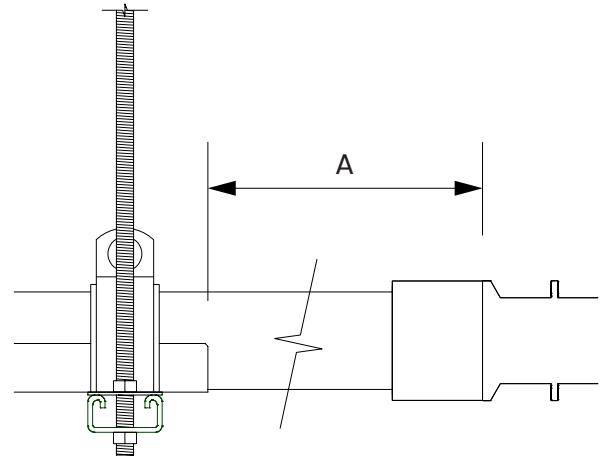


Figure 6-6: Minimum distance to fitting

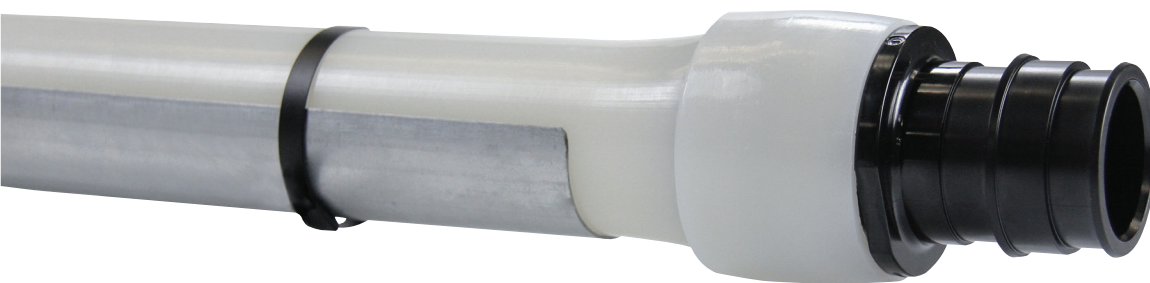


Figure 6-7: Uponor PEX-a Pipe Support with nylon strapping

Increasing horizontal support spacing distances

Horizontal support spacing distances for Uponor PEX may be increased up to 8 feet (2.4 m) with the use of Uponor’s PEX-a Pipe Support and straps (see **Table 6-5**). PEX-a Pipe Support is a 23-gauge galvanized-steel channel that is secured onto the bottom of Uponor PEX pipe and provides a continuous, rigid support.

Additionally, PEX-a Pipe Support, when used with clamps and fixed points, helps to reduce linear expansion (or contraction) in the piping system. Together, you get all the benefits of a polymer piping system with aesthetics similar to those of a metallic piping system. Refer to ICC PMG-1006 for more information and applicable code approvals.

System type	Maximum support spacing with PEX-a Pipe Support	Fixed points
ΔT less than or equal to 40°F (22.2°C) (e.g. domestic cold water; chilled water) ¹	8 feet (2.4 m); clamps not required	Not required
ΔT greater than 40°F (22.2°C) (e.g. domestic hot water; domestic hot-water return; heating hot water) ¹	8 feet (2.4 m) with clamps every 32 feet (9.7 m) max. ²	See Table 6-7

Table 6-5: Horizontal support recommendations with PEX-a Pipe Support

¹System examples are for reference only. Delta T (ΔT) shall determine actual support requirements.

²Fittings 1½" and smaller require support within 12 inches (0.3m) to prevent sagging. Tees may be supported from their respective branch pipe.

Note: Delta T as referenced in the above table refers to the temperature difference between the ambient air temperature and the system water temperature.

PEX-a Pipe Support straps

Uponor PEX-a Pipe Support is secured to the bottom of the PEX pipe using the three (3) included straps. The straps are nylon and feature a 120-lb. tensile rating. If the straps are misplaced, use straps of equal or greater strength in their place. Straps should be spaced every 3 feet (0.9 m) maximum. Refer to **Figure 6-8** for strapping at overlaps.

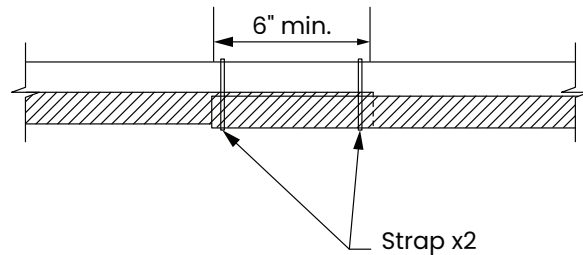


Figure 6-8: Strapping overlaps

Supporting Uponor multiport tees

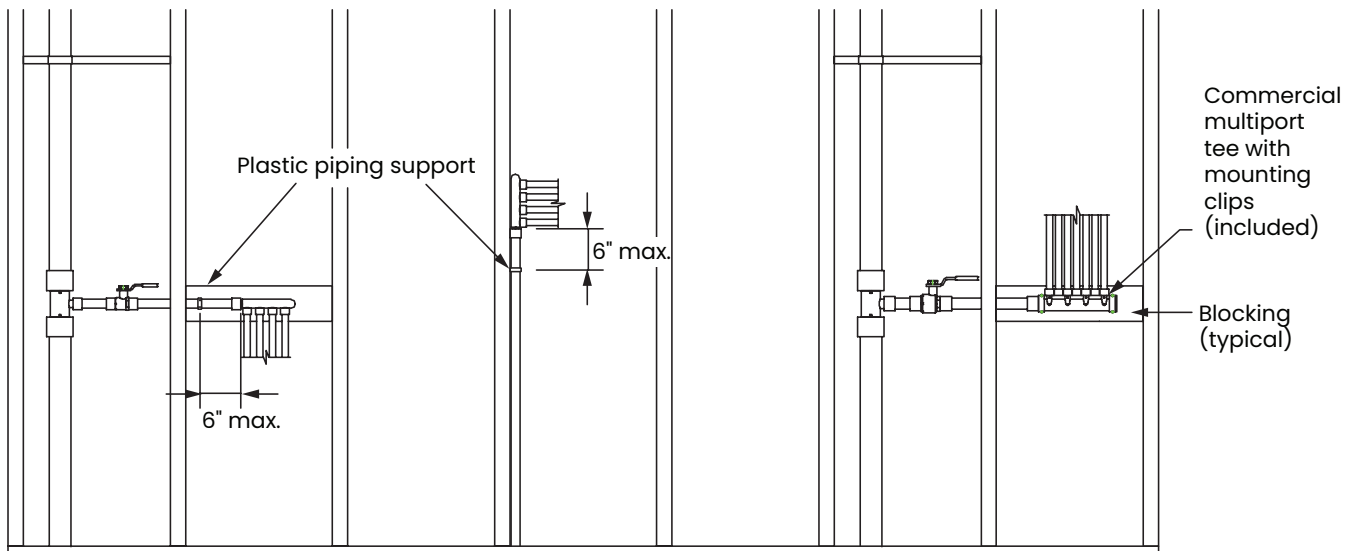


Figure 6-9: In-wall supports for multiport tees

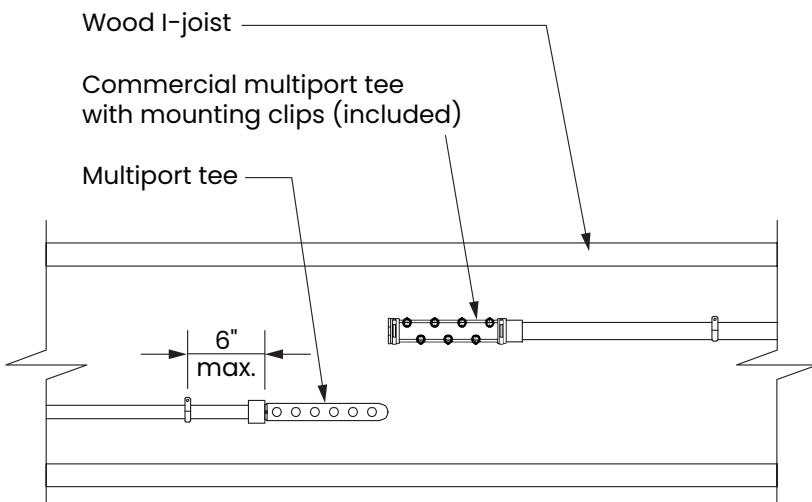


Figure 6-10: Supporting multiport tees on wood I-joists

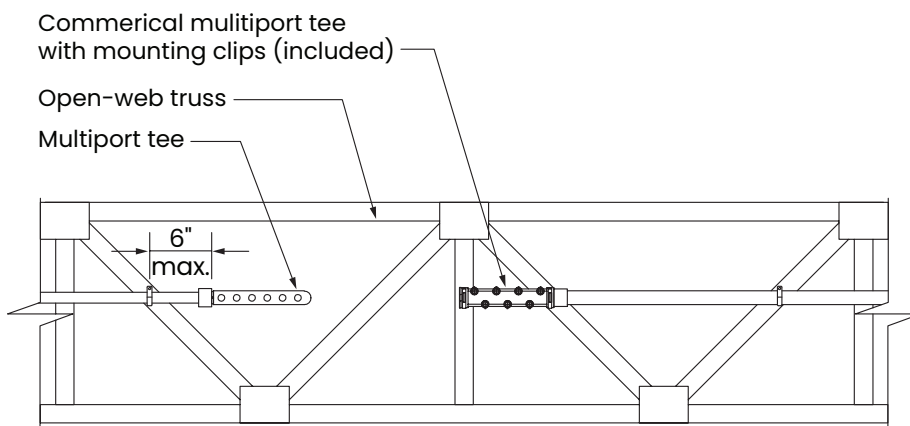


Figure 6-11: Supporting multiport tees on open-web wood trusses

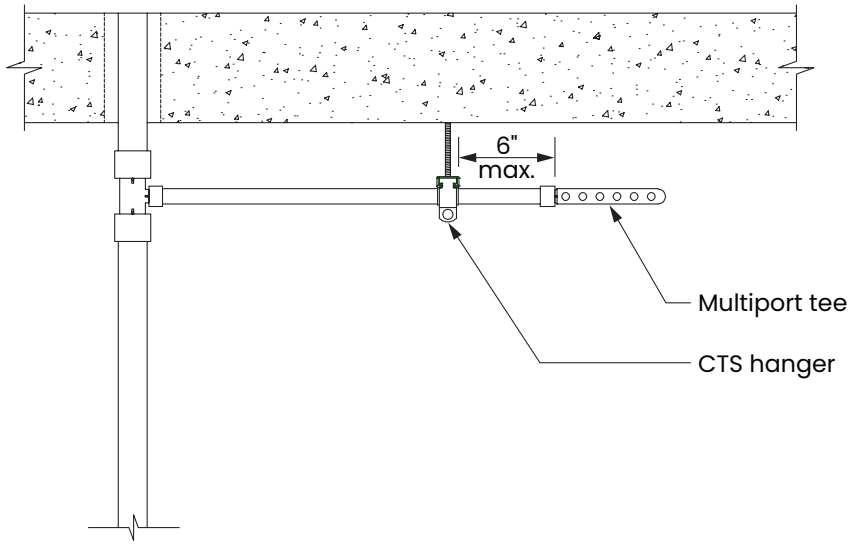


Figure 6-12: Supporting multiport tees in suspended applications

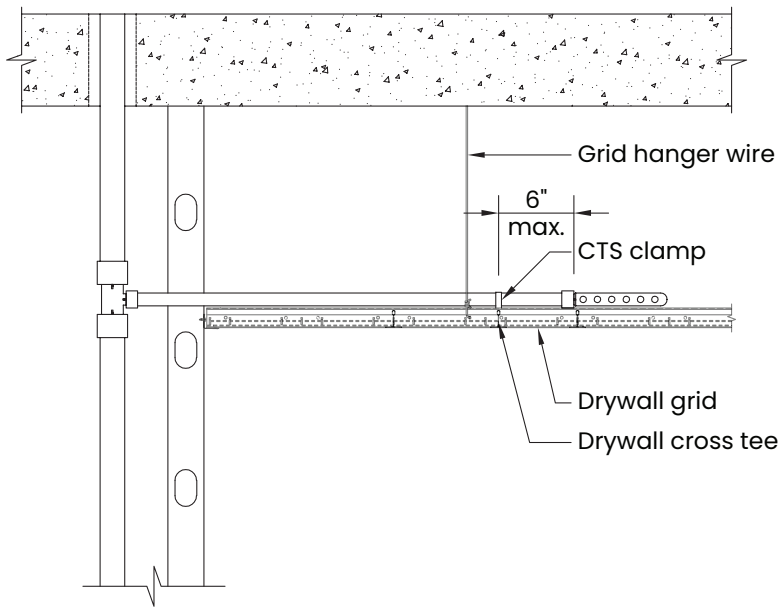


Figure 6-13: Supporting multiport tees on drywall grid

Linear expansion and contraction

An important consideration when supporting Uponor PEX piping systems are the effects of linear expansion or contraction due to the temperature difference (ΔT) between the ambient temperature of the space and the fluid operating temperature (e.g., ambient space temperature of 70°F and a fluid operating temperature of 140°F equals

a 70°F ΔT). Generally, the greater the ΔT , the more the pipe will expand or contract. To help minimize this movement or growth, Uponor recommends the use of our PEX-a Pipe Support and straps, along with the requirements set forth in **Tables 6-5** and **6-7**.

Test validation

Through internal testing, Uponor has determined that the combination of the PEX-a Pipe Support, clamps and fixed points, help to greatly reduce the amount of linear growth and movement (snaking) in long, straight PEX piping runs without the use of expansion loops (see **Table 6-6**). This applies to both horizontal and vertical applications.

Nominal pipe size tested	Delta T (ΔT) ¹	Length of run (feet)	PEX-a Pipe Support	Support spacing (feet)	Clamp spacing (feet)	Fixed point spacing (feet)	Measured linear expansion (inches)	Coefficient of linear expansion (inches/10°F ΔT /100 feet)*
1"	100°F	200	Yes	8	32	195	0.63	0.032
1½"							2.16	0.108
3"							5.12	0.256

Table 6-6: Test results for Uponor PEX in suspended horizontal applications

*For reference, the coefficient of linear expansion for copper tubing is 0.11"/10°F ΔT /100 feet.

¹Delta T is the temperature difference between the ambient temperature of the space and the fluid operating temperature.

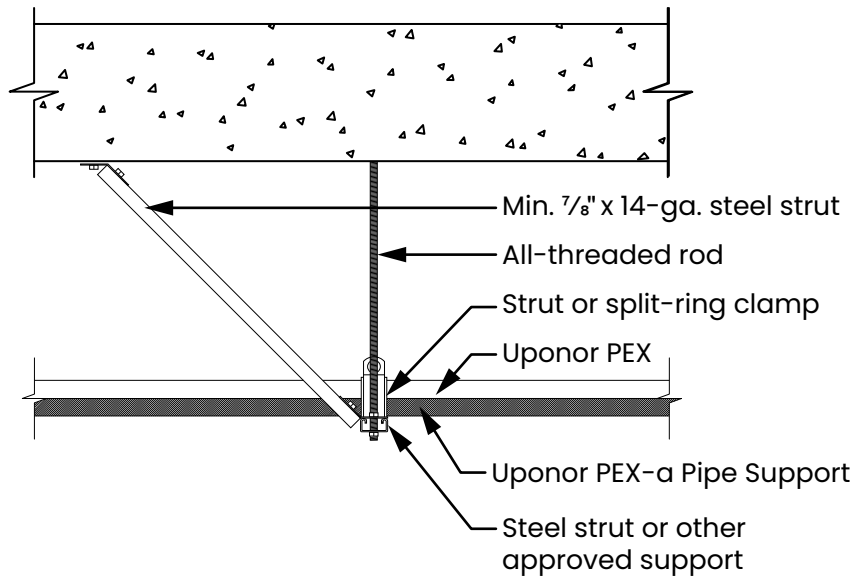


Figure 6-14: Fixed point

Length of straight piping run	Number of fixed points*	Fixed point spacing
0 - 63 ft. (0 - 19.2 m)	0	N/A
64 - 128 ft. (19.5 - 39 m)	1	Closest support with clamps to center
129 - 192 ft. (39 - 58.5 m)	2	Min. 64 ft. (19.5 m) apart
193 - 256 ft. (58.8 - 78 m)	3	
257 - 320 ft. (78.3 - 97.5 m)	4	

Table 6-7: Fixed point recommendations for linear expansion/contraction control in horizontal applications

*Pipes 1" and smaller do not require fixed points.

Linear expansion and contraction in underground applications

For direct-burial applications, mitigate the effects of linear expansion with a proper installation that provides adequate resistance to axial stress. Per PPI TR-21 *Thermal Expansion and Contraction in Plastic Piping Systems*, restrain a buried or concrete-encased pipe from both lateral and axial movement with surrounding embedment material. The magnitude

of the frictional restraining force is dependent on the nature of the soil and on the installation and operating conditions.

For example, the extent of compaction near the pipe can affect the quality of contact between the pipe and surrounding soil. The anchoring or restraining effect of surrounding soil on pipe movement can be significantly augmented by external pipe geometry. Tees, lateral connections and changes in direction all help to anchor a pipe in the surrounding soil.

Linear expansion/contraction and fire-rated penetrations

To protect the integrity of both horizontal and vertical fire penetrations, fixed points should be used to help minimize pipe movement through the penetration. This applies to 1/4" and larger PEX pipes with a ΔT greater than 40°F (22.2°C). See **Figures 6-15, 6-17, and 6-18.**

Note that this applies primarily to assemblies utilizing intumescent caulking.

Certain assemblies and cast-in-place devices, such as the HILTI CP 680-P, are designed to allow some movement, while still maintaining the assembly's integrity. Refer to the respective fire-stop manufacturer's information regarding allowable pipe movement.

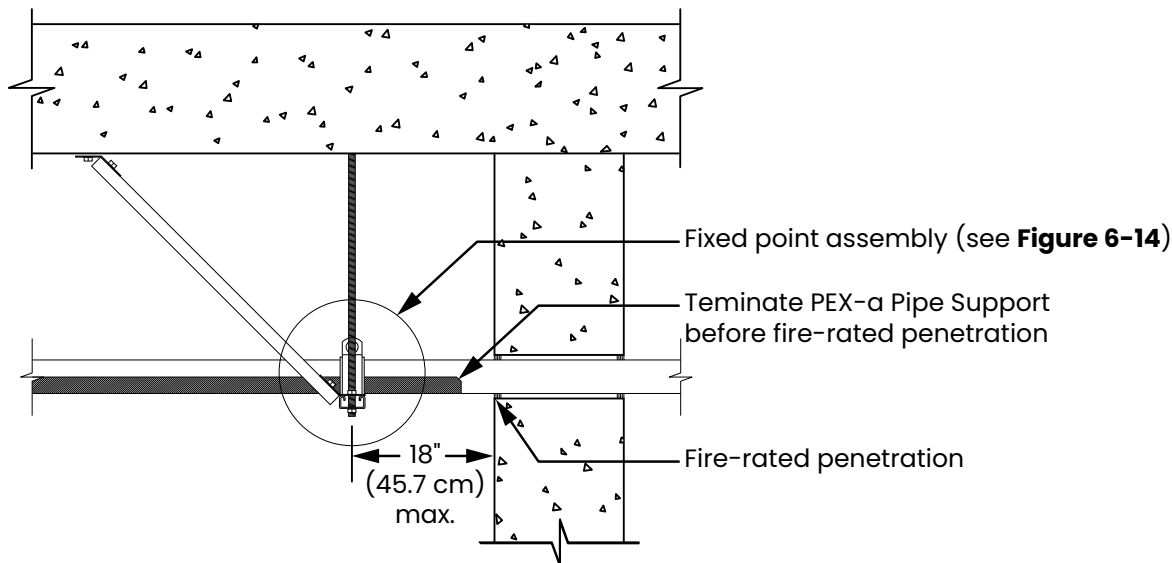


Figure 6-15: Fixed points near a fire-penetration (horizontal)

Note: Fixed point is only required on one side of the penetration.

Vertical support requirements

Vertical runs of pipe fall into two categories: in wall and risers. For general support requirements by code, refer to **Table 6-2**.

In-wall piping is typically smaller in diameter (<1"), and does not pass through multiple stories like a riser. It is most often the dedicated supply piping to the fixture.

Riser piping is typically larger in diameter (>1") and passes through multiple stories, often requiring fire-penetration sealants.

Note: The two categories above are not mutually exclusive. Use best judgment when determining which supports are necessary.

Vertical expansion and contraction mitigation

To help minimize expansion and contraction in vertical applications and protect the integrity of fire-penetrations, Uponor recommends the methods set forth in **Table 6-8**. These are in addition to the code minimums shown previously in **Table 6-2**.

Note: PEX-a Pipe Support may be used in vertical applications to help reduce expansion/contraction and maintain alignment, but its use does not eliminate the need for fixed points and mid-story guides.

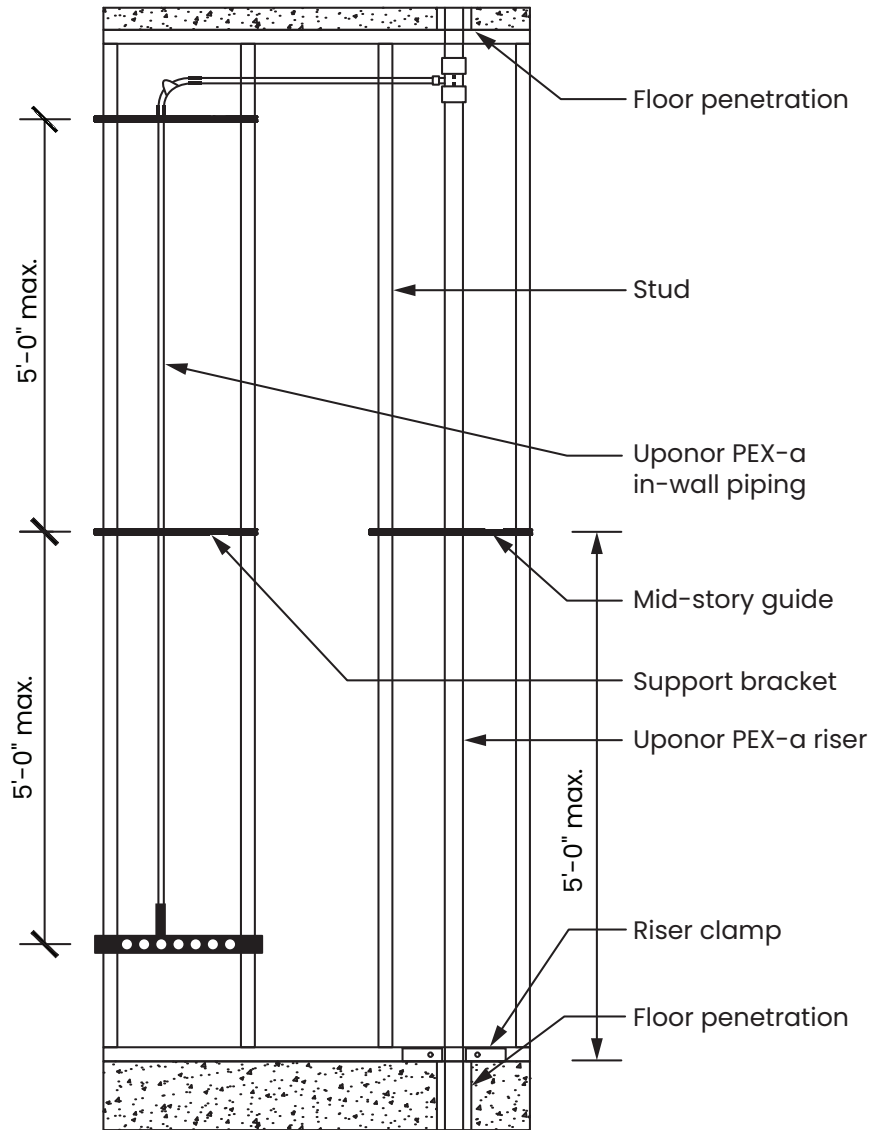


Figure 6-16: In-wall versus riser piping

System type	Additional support recommendations
ΔT less than or equal to 40°F (22.2°C) (e.g. domestic cold water; chilled water) ¹	N/A
ΔT greater than 40°F (22.2°C) (e.g. domestic hot water; domestic hot water return; heating hot water) ¹	Fixed-point at the first floor penetration and every third floor thereafter ² (see Figures 6-17 and 6-18)

Table 6-8: Minimizing expansion and contraction for vertical piping

¹ System examples are for reference only. Delta T (ΔT) shall determine actual support requirements.

² Based on internal testing, this limits linear expansion to approximately 0.5" (1.27 cm) over 30 feet (2" PEX at a 100°F ΔT).

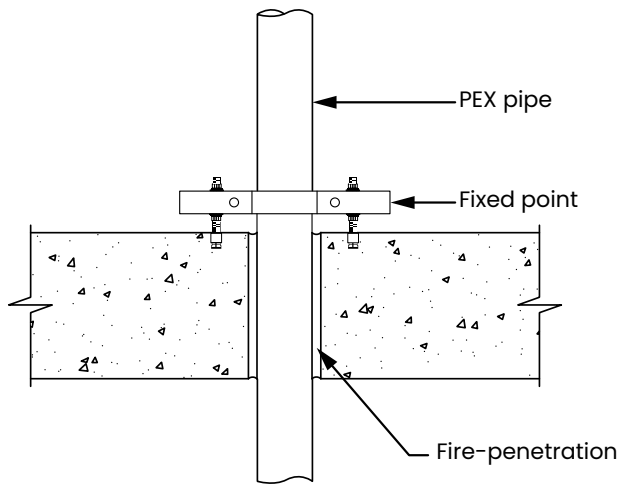


Figure 6-17: Fixed point example 1 (vertical)

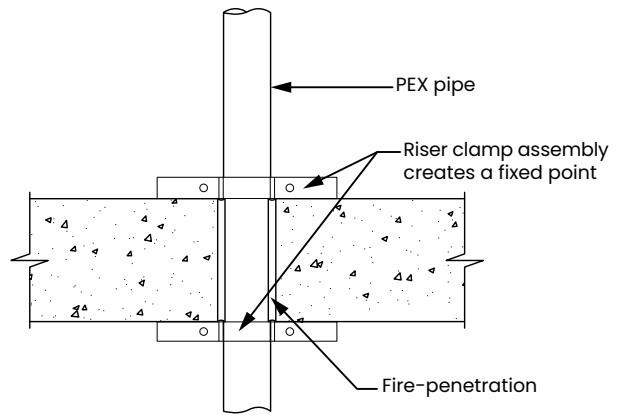


Figure 6-18: Fixed point example 2 (vertical)

Protection of ProPEX fittings from clamps

To prevent damage to ProPEX fittings, Uponor recommends the following minimum distances between clamps and ProPEX fittings.

Nominal pipe size	2 x O.D.
½"	1¼" (32 mm)
⅝"	1½" (38 mm)
¾"	1¾" (44 mm)
1"	2¼" (57 mm)
1¼"	2¾" (70 mm)
1½"	3¼" (83 mm)
2"	4¼" (108 mm)
2½"	4¾" (133 mm)
3"	6¼" (159 mm)
4"	8¼" (210 mm)

Table 6-9: Distance to clamps

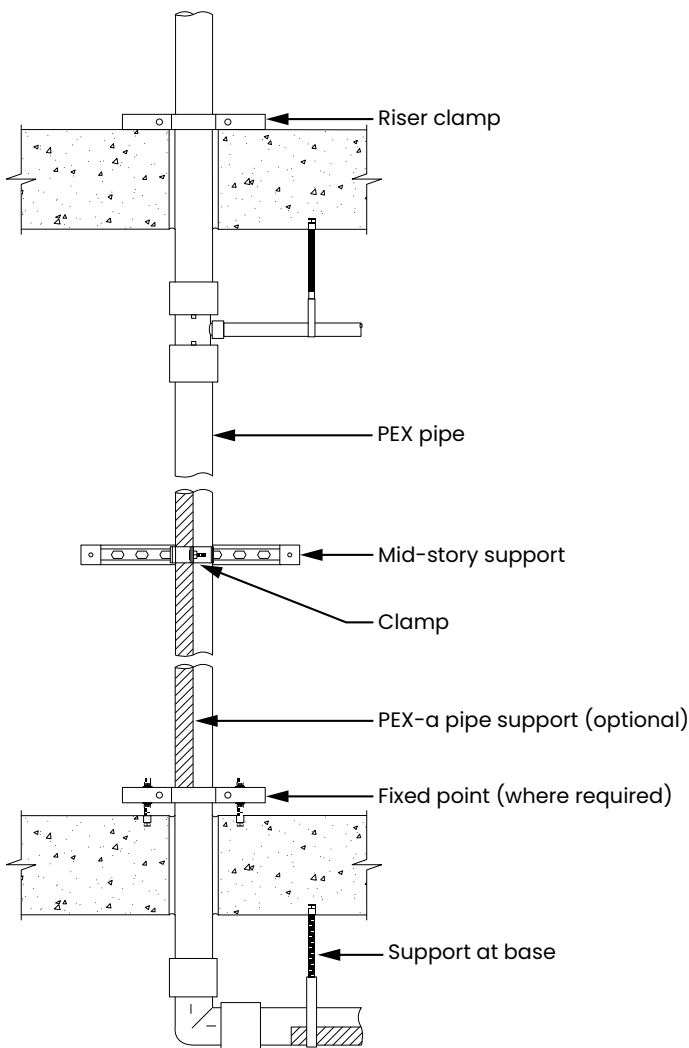


Figure 6-19: PEX riser detail

Note: PEX-a Pipe Support must not pass through the fire penetration, unless approved by the AHJ.

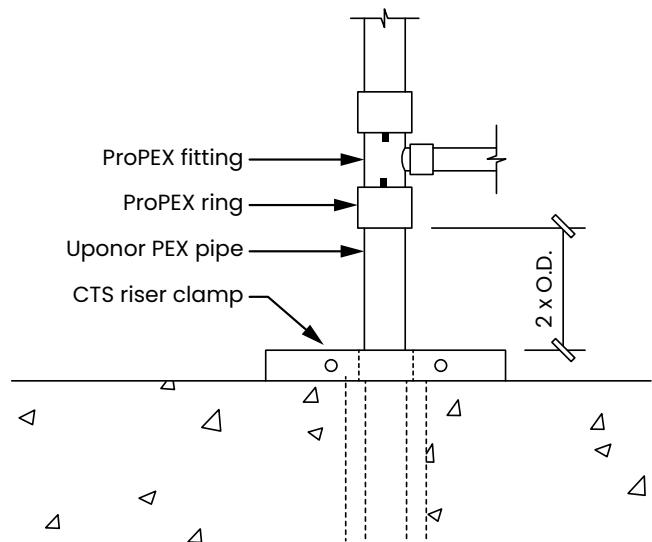


Figure 6-20: Clamp distance example

Below-grade and in-slab installation

Alternative methods to overhead piping include below-grade and in-slab piping. In these installations, the pipe is laid in a trench or secured to steel-reinforcing bar (rebar) or wire mesh and routed to the desired locations. The piping system is pressurized (usually 20 psi above working pressure) and buried. Because PEX piping is available in long, continuous lengths, it is an ideal material for running below grade or in-slab without fittings. (See **page 87** for proper trench preparation.) Always follow local code when burying Uponor PEX pipe as some jurisdictions require additional sleeving and protection.

Fittings for below-grade and in-slab

Uponor EP and LF brass fittings are all approved for use in below-grade and in-slab applications. Uponor recommends EP fittings for in-slab applications where required.

Uponor's LF brass is approved for direct burial in soil per NSF/ANSI Standard 14 testing which established minimum performance criteria for dezincification resistance (DZR) and stress-corrosion cracking (SCC) resistance for PEX fittings intended for potable water. Standard Uponor brass fittings (non-LF) are not approved for direct burial).

Termiticides and pesticides

Uponor PEX piping for hot- and cold-water distribution is approved for installation directly in soil (below-grade) or in concrete (in-slab) where soil termiticide/pesticide treatment is required. This is especially useful in slab-on-grade construction. See **page 92** for information about termiticides.

Pre-insulated Uponor PEX piping

Pre-insulated Uponor PEX piping is approved for use in below-grade and in-slab applications. For below-grade applications, Uponor recommends the use of pre-insulated PEX with a minimum 1"-thick insulation due to static soil loads.

Protect piping where it enters and exits a concrete slab with 0.025" (0.064mm) thick protective material, such as HDPE wrapping, closed-cell pipe insulation, PVC elbows and sleeves or equivalent, that allow expansion and contraction of the piping. Ensure proper placement where piping exits the slab. These products are described as slab-penetration protection devices.

Pre-sleeved Uponor PEX piping

When using pre-sleeved Uponor PEX piping or a protection sleeve, an annular gap between these protection devices and the

PEX piping will exist. In such installations, fill the annular gap between the protection device and the PEX piping at the exposed ends to help prevent pathways for pests and the mistaken application of harmful chemicals into the space between the PEX piping and the protection device. Use only sealants that are compatible with PEX piping.

Note: The following products are appropriate for use when sealing PEX piping and slab-penetration protection devices:

- Latex caulk
- Latex foam
- Silicone sealant
- Polyurethane expanding foam

Note: Misapplication of these products could result in pooling or puddling of the products around the PEX piping, which is prohibited.

Caution:

- If applying termiticides/pesticides while the installed PEX piping still has exposed open ends that are not yet connected to plumbing fixtures, cap, plug or close the ends of the piping to prevent these chemicals from entering the piping.
- Do not allow organic (petroleum-based) chemicals, petroleum distillates, termiticides or pesticides to come into direct contact with PEX piping.

- Fill the annular gap between PEX piping and slab-penetration protection devices (sleeving or PVC bend guides) at the ends of the piping to help prevent pathways for pests and the mistaken application of harmful chemicals into the space between the PEX piping and the protection device. Use only sealants that are compatible with PEX piping.
- When PEX piping is continuously sleeved below or above a slab (such as when using pre-sleeved Uponor PEX piping), never fill the space between the PEX piping and the sleeving with any liquid chemical, including pesticides or termiticides. Prevent pooling or puddling of these liquids around PEX piping.
- When it is necessary to re-treat soil near PEX piping, prevent the puddling or pooling of the termiticide/pesticide.

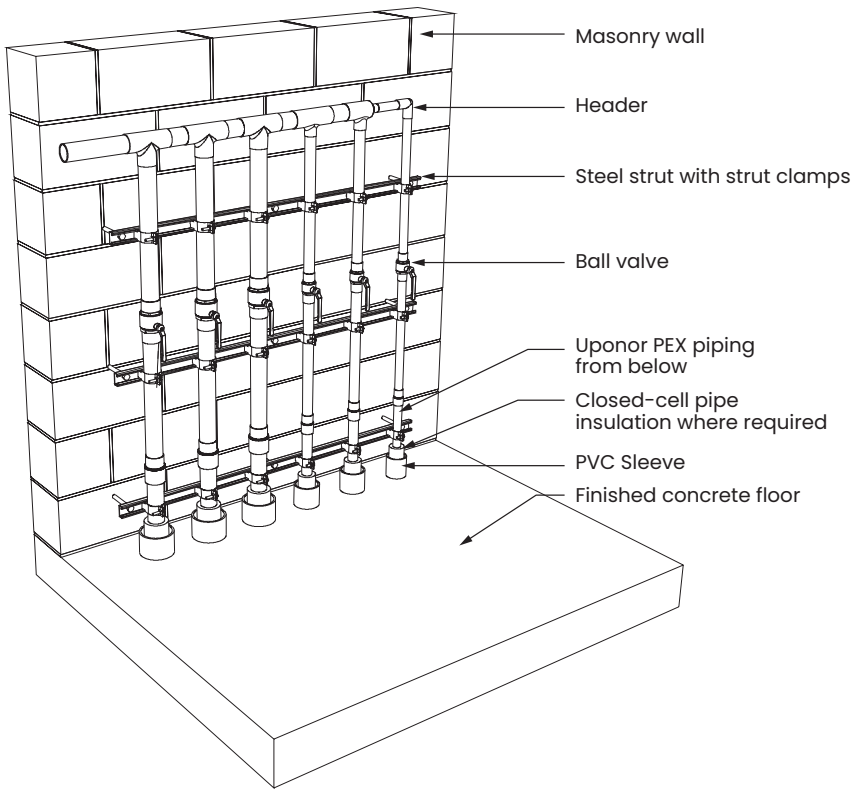


Figure 6-21: Mechanical room transition (below-grade piping)

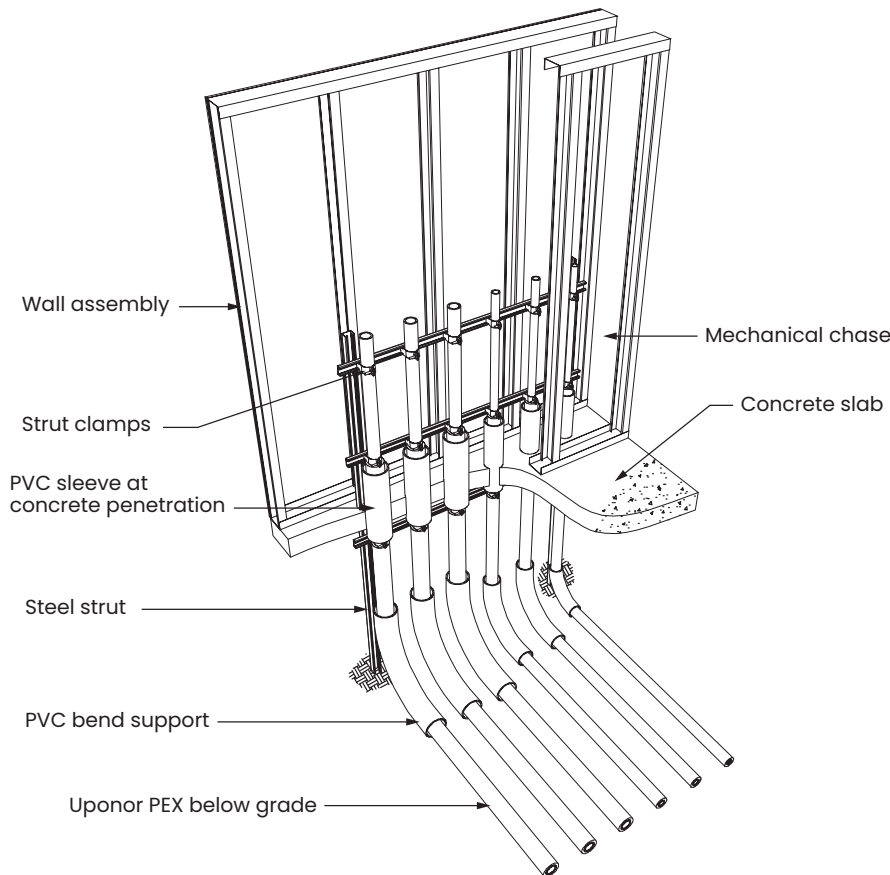


Figure 6-22: Wet-wall chase transition (below-grade piping)

Water service

Uponor ServicePEX pipe and ProPEX fittings are approved for use in water service applications. The pipe is certified to the AWWA C904 Standard and is listed to IPC, IRC, and UPC requirements. For design considerations, refer to the ServicePEX section in **Chapter 1** as well as **Table 4-1** in **Chapter 4**.

Compression fittings

Use only SDR9 compression fittings (with appropriate insert stiffeners) listed in compliance with AWWA C800 as referenced in AWWA C904 for water service applications when transitioning from curb stops or corporation stops to Uponor PEX piping. Commonly available SDR9 compression fitting manufacturers include Ford Meter Box Company, Inc., Mueller Company®, A.Y. McDonald Mfg. Co., and Philmac®.

For inline connections, use Uponor ProPEX EP or LF brass fittings, which are approved for direct burial with 4 to 6 mil poly wrap. For $\frac{5}{8}$ " to 1" water meter connections, Uponor offers direct ProPEX to NPSM swivel adapters in straight, elbow, and valved configurations. Refer to the Uponor Product Catalog for more information.



Figure 6-23: Uponor ServicePEX pipe

Trace wire

Uponor recommends the use of trace wire to facilitate the detection of underground pipe systems. Trace wire should be 14-gauge minimum solid copper with thermoplastic insulation suitable for direct burial. Refer to local code for further requirements.

Trench bottom preparation

To achieve a satisfactory installation, it is essential that the soil provides stable and continuous support for the piping.

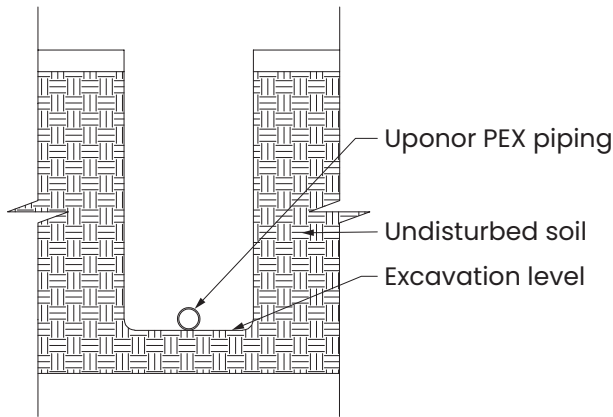


Figure 6-24: Good soil conditions — If the trench is dug smoothly, install the piping directly on the prepared bottom. The bottom must be flat with no hollows, lumps or rocks.

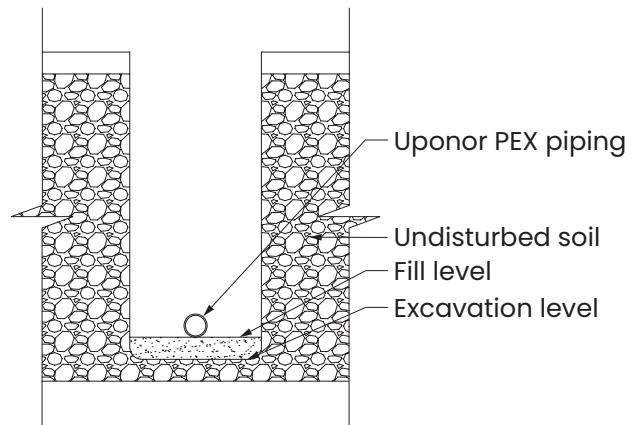


Figure 6-25: Poor soil conditions — With rocky, clay, muddy or other poor soil conditions, it may be necessary to prepare the trench bottom using granular material of such size and grading to provide a stable base. See local code for additional requirements.

Piping embedment

Proper soil selection, placement and compaction are essential in the area around the piping. Backfill around the piping with sand or gravel that has a maximum particle size of $\frac{3}{4}$ ".

Compact the initial backfill around the piping to provide adequate piping support and prevent settling. It is particularly important to adequately compact the soil around the tap connection. Uponor recommends pressurizing the piping prior to backfilling to reveal any damage. In heavy vehicular traffic areas, compact backfill to 90 percent of maximum soil density.

Do not use highly plastic clays, silts, organic materials, or sharp or large rocks as backfill in the immediate vicinity of the piping. Compact the backfill from the subgrade to a

level per local code that will cover the piping 4" to 6" to provide protection around the piping and to prevent settling that puts stress on the fittings and the piping.

Installation

Install Uponor PEX piping underground in a manner that ensures external loads will not subsequently cause a decrease in the vertical dimension of the cross section of the piping that exceeds 5 percent of the outside diameter. Install Uponor PEX piping in a snaking pattern with sufficient slack in the line to allow for contraction of the line due to temperature change prior to backfilling. The linear expansion rate for Uponor PEX piping is approximately 1.1" per 10°F temperature change per 100 ft. of piping (27.94 mm per 5.56°C temperature change per 30.48 m of piping).

Note: Do not use blocking to support the piping or change the piping grade. Do not install potable-water service piping in, under or above cesspools, septic tanks, septic-tank drainage fields or pits.

Caution: Do not install Uponor PEX piping in soil environments contaminated with solvents, fuels, organic compounds, pesticides or other detrimental materials that may cause permeation, corrosion, degradation or structural failure of the piping. In areas where such conditions are suspected, perform a chemical analysis of the soil or groundwater to ascertain the acceptability of Uponor PEX piping for the specific installation. Check local codes for additional requirements.

Handling and repairs

Although Uponor PEX piping is highly resistant to kinking and abrasion, take care while handling and installing the piping to prevent damage and possible failure of the piping. If damage occurs during installation, cut out the damaged area and repair before backfilling.

To reform kinked piping, see "Reforming kinked piping" on **page 74**. If the piping is damaged beyond its thermal-memory capacity, use a ProPEX coupling. Do not reuse or reclaim EP fittings.

H-20 loads

When installing Uponor PEX under a roadway, follow the same procedures as previously indicated with the following exception: Ensure the top of the piping is 16" below the bottom of the roadbed material as specified. You can also use a suitable steel or structural conduit to sleeve the Uponor PEX pipe.

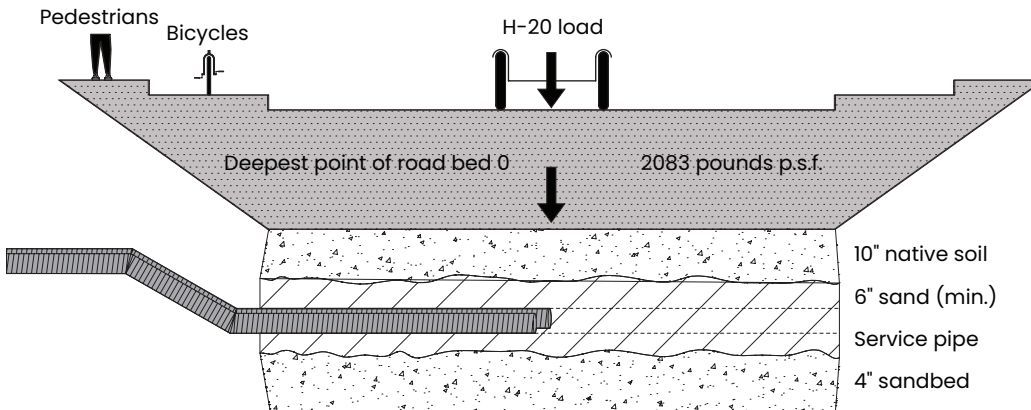


Figure 6-26: Traffic loads

Horizontal directional drilling (HDD)

Horizontal directional drilling is used when trenching or excavation is not practical. A surface-launched drilling rig provides a steerable, trenchless method of installing underground pipes along a shallow arc bore path, resulting in minimal impact to surrounding areas. It is suitable for a variety of soil conditions.

HDD is further categorized into the following types:

- Mini-HDD
 - Distances less than 600 ft.
 - Depths up to 15 ft.
 - Pipe diameters up to 12"
- Equipment pullback capability of up to 20,000 lbs. and torque less than 950 ft-lbs.
- Maxi-HDD
 - Distances greater than 600 ft.
 - Depths up to 200 ft.

- Pipe diameters up to 48"
- Equipment pullback capability of up to 100,000 lbs. and torque up to 80,000 ft-lbs.

Criteria for Uponor PEX piping in HDD applications

- Use Uponor PEX only as the follow pipe.
- Take precautionary steps to ensure piping does not come in contact with sharp objects.
- Do not exceed minimum bend radius of 6 times the O.D. of the piping
- Pressure test installed piping after installation to ensure the integrity of the piping has not been compromised.

For HDD applications using Uponor PEX piping, reference PPI TR-46 *Guidelines for Use of Mini-Horizontal Directional Drilling for Placement of High Density Polyethylene Pipe.*

Joining methods and fittings

Use ProPEX or approved compression fittings to connect piping to itself or to the corporation and curb stops. Approved manufactures are Ford Meter Box Company, Mueller Company, A.Y. McDonald Mfg. Co. and Philmac.

When using compression fittings with Uponor PEX piping, a plastic or stainless-steel insert stiffener is required on the inside of the piping at the connection.

For applications requiring direct burial, use Uponor ProPEX EP or LF brass fittings for large-dimension Uponor PEX piping up to 3".

SDR9 Uponor PEX 12-hour pull		
Nominal pipe size	Tensile yield design (safety) factor	Allowable tensile load at 73°F/22.8°C - lbs (N)
½"	0.4	128 (569)
¾"	0.4	248 (1,103)
1"	0.4	411 (1,828)
1¼"	0.4	615 (2,735)
1½"	0.4	859 (3,821)
2"	0.4	1,465 (6,516)
2½"	0.4	2,239 (9,960)
3"	0.4	3,169 (14,096)

Table 6-10: Safe pull force

Note: The method set forth in ASTM F1804 determines the allowable tensile load.

System flushing

Uponor **recommends flushing** the plumbing system and all potable-water fixtures with fresh, potable water prior to occupancy. Consult local codes as additional requirements may apply.

Water system disinfection

When system disinfection is required, treatment can be accomplished through thermal or chemical disinfection methods.

Thermal disinfection – For “thermal disinfection”, raise the hot-water temperature to 160°F (71°C) and maintain while flushing for a minimum of five minutes, not to exceed 24 hours on a monthly basis. Care should be taken to prevent

scalding at elevated temperatures.

Chemical disinfection – When adding chemicals to a plumbing system, disinfection chemicals are strong oxidizing agents and have the potential to reduce system life of the piping system. See **Table 6-11** for recommended maximum concentration of common chemicals used for disinfection, and corresponding duration and temperature.

Note: Flush the system with clean, potable water after disinfection.

Thermal and chemical disinfection treatment methods should not exceed 80 psi system pressure or the maximum guidelines stated in **Table 6-11**.

Chlorine dioxide

Uponor **does not** recommend use of its PEX pipe and ProPEX fittings as part of any potable-water distribution system in buildings where chlorine dioxide is used for secondary disinfection or where injection systems using chlorine dioxide are present. This is based on the limited industry data available for the long-term effects of chlorine dioxide on PEX piping systems at allowable controlled levels.



Important system disinfection notes

- Uponor does NOT recommend long-term or continuous-dosing chemical treatments.
- Do not use chemical disinfection/shock

treatment on a monthly basis. Limit chemical disinfection to four cycles over the life of the piping system.

- Do not use especially high oxidizing agents, such as ozone, chlorine dioxide, etc.
- These guidelines are for disinfection treatment and do not supersede normal operating parameters.

These guidelines are set forth for informational purposes only, and it remains the responsibility of the facility manager, water management contractor and end-user to maintain system health and to ensure compatibility and effectiveness of the disinfection treatment with the entirety of the plumbing system. If other treatments or chemicals not included in this document are intended for use, contact Uponor Technical Services for compatibility prior to system exposure. If necessary, have the chemical manufacturer approve the suitability of the disinfectant for all components of the plumbing system and installation. Note that these guidelines are subject to change. Please contact Uponor Technical Services at 888.594.7726 to confirm the latest guidelines.

Chemical	Symbol	Concentration of free chlorine	Maximum		
			Duration	Temperature	
Sodium hypochlorite	NaOCl	200 mg/L (ppm)	3 hours	77°F (25°C)	
		50 mg/L (ppm)	24 hours		
		200 mg/L (ppm)	3 hours		
Chlorine (liquid or gas)	Cl ₂	50 mg/L (ppm)	24 hours		140°F (60°C)
		4 mg/L (ppm)	72 hours		
		Hydrogen peroxide	H ₂ O ₂		200 mg/L (ppm)
50 mg/L (ppm)	24 hours				
Chloramines	NH ₂ Cl			200 mg/L (ppm)	3 hours
		50 mg/L (ppm)	24 hours		
		4 mg/L (ppm)	72 hours		

Table 6-11: Uponor disinfection guidelines

Water additive guidelines

The building industry widely uses Uponor PEX-based systems in hydronic piping applications, mostly for conveying water between water heating/cooling devices (e.g., boilers, chillers) and terminal units such as fan coils. Uponor PEX pipe offers

advantages such as light weight, corrosion resistance, ease-of-assembly and cost-effectiveness. In addition to Uponor PEX pipe, these applications also use various configurations of Uponor ProPEX fittings (e.g., tees, ells, couplings, etc.) made from brass or EP for connection purposes.

Most hydronic piping systems incorporate metallic components supplied by third parties, which require corrosion protection. Consideration must also be given to external factors, such as temperature and induced stresses, in addition to water conditions, such as pH level, impurity control, and pH buffering.

Thus, various additives are typically added to the water being conveyed throughout hydronic piping systems. To avoid damage to Uponor PEX pipe and ProPEX fittings, all of these variables must be considered, and only additives that are chemically compatible with the Uponor components should be employed.

As a means of providing guidance in selecting an additive that is chemically compatible with Uponor PEX pipe and ProPEX fittings, we recommend that the attributes of the treated water should be in the ranges indicated in **Table 6-12**.

Attribute	Low	High
pH	7	9.1
Nitrite	0 ppm	≤2,000 ppm
Soluble metal – iron	0 ppm	≤ 2 ppm
Soluble metal – copper	0 ppm	≤ 1 ppm
Azole – TTA	0 ppm	≤ 100 ppm
Molybdate	0 ppm	≤ 500 ppm

Table 6-12: Recommended attributes of treated water

It is also important to give consideration when selecting a cleaning agent. Cleaning the hydronic system is common upon initial startup. With Uponor PEX-based systems, the cleaning process should:

- Not exceed 72 hours
- Use non-petroleum-based cleaners
- Not exceed a pH of 11
- Have water temperatures less than 140°F (60°C)

Prior to cleaning the hydronic system, ensure the water management contractor is informed of the above guidelines.

Note that these guidelines are subject to change. Please contact Uponor Technical Services at 888.594.7726 to confirm the latest guidelines information.

These guidelines are set forth for informational purposes only, and it

remains the responsibility of the additive supplier, water management contractor, and the end-user to assure compatibility and effectiveness of the treated hydronic water with the entirety of the hydronic piping system.

Pressure-testing procedures

It is important to properly pressure test an Uponor piping system in accordance with local code. If testing with air, it is important the system pressure not exceed 120 psi.

The following procedure is acceptable for testing with air, water or a mixture of both for Uponor PEX piping and ProPEX fittings or hybrid systems combined with metallic piping.



Important: When pressure testing hybrid systems (i.e., those that include both thermoplastic piping materials, such as CPVC or PP-R, and Uponor PEX and ProPEX fittings), isolate the Uponor system from the other thermoplastic materials in the system before following the recommended procedure.

Also, consult the appropriate pipe manufacturer’s installation recommendations when testing systems comprised of other thermoplastic materials.

The intent of pressure testing a domestic-water piping system is to meet local code requirements while ensuring the system is free from leaks. Pressure testing is not a substitute for the correct installation of an Uponor PEX piping system. It is essential the Uponor system is accurately sized, supported and protected while also accounting for thermal movement during installation.

Importance of conditioning PEX-a pipe

Uponor recommends conditioning the system at 1.5 times the test pressure, or 120 psi. The following

conditioning procedure is unique to PEX-a pipe due to the high degree of crosslinking and associated thermal and elastic properties of the pipe.

When pressure is applied against the inner wall of PEX-a pipe, the internal diameter (I.D.) of the pipe will slightly increase, causing the pressure to drop while the system equalizes. After a period of 30 minutes, the PEX piping will be sufficiently conditioned to start the pressure test.

Conditioning and sustained pressure-testing procedure

Visually confirm all connections are properly made per Uponor installation guidelines.

1. Ensure all components, fixtures and equipment not rated for the test pressure are isolated from the test system.
2. Ensure all other thermoplastic piping materials are isolated from the test system.
3. Fill the system with potable water, air or a mixture of both.
4. Condition the system to 1.5 times the required test pressure for 30 minutes. This will require constant pumping or cycling the valve and compressor to maintain a pressure of 1.5 times the test pressure. If cycling the valve and compressor, apply additional pressure once the psi has dropped 10 lbs.

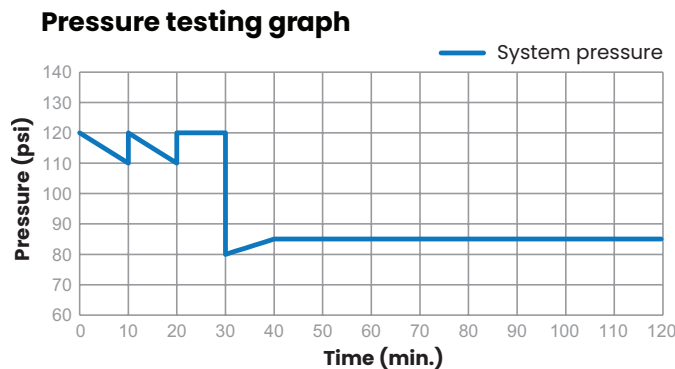


Figure 6-28: Pressure testing graph

5. After conditioning the system for 30 minutes, quickly relieve excess pressure by opening the valve. Close the valve when the system has reached the desired test pressure.

Note: Uponor recommends a test pressure of 80 psi (unless local code dictates higher pressures).


6. Once the valve is closed, confirm a slight rise in pressure (3 to 6 psi). This increase will occur as the pipe's I.D. is shrinking from its conditioned state to equalize at the lower pressure.

7. Visually check for leakage and monitor the pressure for the duration specified by local code. (A typical pressure test can range from 2 to 24 hours.)

8. If there is no reduction in pressure, the system is presumed to be free from leaks.

Note: Slight fluctuations of pressure are normal due to ambient temperature changes, especially during long durations (e.g., 24 hours).

9. Flush the system as required by code.

 **Important:** If using water to pressure test the system, purge all water from the system prior to the ambient air temperatures falling to 32°F (0°C). Failing to remove the water from the system during freezing temperatures can result in damage to the piping and associated equipment.

Icynene® spray foam insulation

Direct contact with Icynene® LD-C-50™ and MD-C-200™ spray foam insulation will not compromise the performance of Uponor PEX piping or EP fittings.

Icynene LD-C-50 is a light-density, open-cell, flexible and 100% water-blown polyurethane foam insulation. The spray formula has a nominal 0.5 lbs/ft³ density and is a free-rise material.

Icynene MD-C-200 is a medium-density, open-cell, flexible and 100% water-blown polyurethane foam insulation. The spray formula has a nominal 2 lbs/ft³ density and is a free-rise material.

Successful chemical compatibility testing has been performed on all Uponor PEX piping as well as all Uponor EP fitting materials, including Udel® GF-120, Udel® P-1700, Acudel® 22000 and Radel R® 5100. The compatibility evaluation showed no signs of cracking, crazing or reduction in ductility.

Icynene LD-C-50 and MD-C-200 must be installed by an Icynene-licensed dealer and factory-trained installer. For further information, refer to the Icynene installer's manual or contact Uponor Technical Services.

Closed-cell spray foams

Closed-cell spray foam insulation will not compromise the performance of the Uponor PEX piping or brass fittings,

nor will it void the warranty as long as a maximum temperature of 250°F/121.1°C is not exceeded during the chemical reaction process of installation.

The majority of closed-cell spray foams on the market are polyurethane-based. Polyurethane, the harshest of all bases, is chemically compatible with both Uponor PEX piping and brass fittings.

The primary concern in using spray foams with Uponor PEX piping is the temperature limitations of the piping relative to the temperature outputs of the chemical reaction during application of the spray foam. **Table 6-13** shows temperatures with relation to the lift or depth of foam.

As shown in **Table 6-13**, an application of 1" of foam creates a maximum of 130°F/54.4°C. As the material is applied more generously, the reaction temperature increases. If more than 2" of lift is required, Uponor recommends using a two-lift application. Apply the first layer, 2" or less. Wait 15 minutes (the time required for the heat from a 2" lift to dissipate). Then, apply the second layer.

Depth of lift	Temperature
1"	130°F/54.4°C
2"	200°F/93.3°C
3"	320°F/160°C

Table 6-13: Closed-cell spray foam temperatures in relation to depth of lift

Note: Place an initial layer of spray foam over the PEX piping prior to the entirety of the foaming to insulate the lines from the heat generated by the chemicals.

Uponor recommends closed-cell insulation for use with Uponor PEX piping and brass fittings. EP fittings require an overwrap of 4 to 6 mil poly or other suitable waterproof protection where contact is possible.

Contact Uponor Technical Services at 888.594.7726 for questions when using other foam-types or brands.

Recessed light fixtures

Do not install Uponor PEX within 12" (30.4 cm) of any recessed lighting fixtures unless the piping is protected with a suitable insulation, such as closed-cell polyurethane, polyethylene and polyolefin-based products, or the light fixture is I.C.-rated.

In an application using I.C.-rated light fixtures, the minimum clearance to the PEX pipe is 2" (5 cm) unless protected with a suitable insulation, such as closed-cell polyurethane, polyethylene and polyolefin-based products. Refer to PPI TN-56 for more information.

Painting Uponor PEX

It is acceptable to use latex and acrylic-based paint, such as 100 percent acrylic exterior latex house paint, with Uponor PEX. These products will not harm the molecular structure or integrity of the PEX piping or ProPEX fittings (EP or brass).

Pipe identification

Uponor testing allows the use of pipe tapes, adhesive tapes, and markers to identify Uponor PEX piping products.

Termiticides/pesticides

Liquid termiticides/pesticides are often applied to treat the soil below the concrete slabs of slab-on-grade structures. The treatment creates a barrier to prevent termites and pests from infiltrating the floor of the structure. PEX piping for plumbing applications is often installed within slabs or below slabs (in trenches in the soil) below the soil that is treated. Liquid termiticides/pesticides use a liquid solvent to carry the active ingredients. These solvents can be categorized as one of two types: organic solvent-based (also known as petroleum solvent-based) and water-based (water solvent-based).

The type of solvent used in a termiticide/pesticide will affect its ability to permeate through various materials. Organic-based termiticides/pesticides have largely disappeared from the North American marketplace for this application, and the majority of products available today are water-based. Water-based products are generally safer for the environment and pose less risk of infiltration into PEX piping.

Available data indicates the solvents used in liquid termiticides/pesticides will soak into the ground and/or evaporate before they can pass through the wall of polyethylene piping. The data also indicates these solvents are prevented from passing through the wall of polyethylene piping because of the large size of the water- or organic-solvent molecules, relative to the size of the molecules in the piping itself. Once liquid solvents have dissipated or evaporated, the solids that remain behind cannot permeate through the walls of polyethylene or PEX piping because of the molecular size.

Additional research shows that water-based termiticides/pesticides are of sufficiently large molecular size to completely prevent permeation through polyethylene and PEX piping. Instances of water-based termiticides/pesticides permeating through polyethylene or PEX piping are not known. Pesticides have not been found to be corrosive or have polymer degradation.

Although all research data and anecdotal evidence strongly suggest there are no permeation issues with water-based termiticides/pesticides and PEX, take extra caution to ensure safe installation of PEX piping and to prevent misapplication or pooling/puddling of the liquid termiticides/pesticides around PEX piping.

Supporting research

A study done in 2001 in Australia, titled "Investigating the Possible Permeation of Organic Chemicals Commonly Used in Termiticide Barrier Treatments through Polyethylene Water Pipes," indicated that "migration of pesticide constituents and their associated solvents, through the polyethylene pipe, did not occur, indicating that the concentration of solvents (even in the saturated soil) was not high enough to cause permeation of the solvents through the polyethylene pipe wall (within the 16-week period of study)." The study also stated "this indicates that the concentration of these constituents in the soil in contact with the pipes was not high enough to develop a positive diffusion pressure and cause the constituents to be detected in the water." The study was conducted using organic solvent-based pesticides, which are known to be more aggressive than water-based pesticides. Therefore, the results are valid for organic solvent-based pesticides and water-based pesticides.

Research conducted by Dr. Michael R. Hoffman of the California Institute of Technology (2005) indicates that the ability of a chemical compound to permeate a material is correlated directly with the octanol-water partition coefficients of the individual organic chemicals. The octanol-

water partition coefficient is a relative measure of the hydrophobic nature of the organic compounds. In spite of a measurable tendency to partition into plastic material, the ability of these compounds is retarded substantially given the low measured diffusion coefficients for selected chemicals. For example, a PEX piping wall thickness of 5mm and a typical diffusion coefficient for organic compound migration of $1.0 \times 10^{-12} \text{ cm}^2/\text{s}$, the time to permeate through the walls, would be $2.5 \times 1,011$ seconds or approximately 8,000 years. If the wall thickness was reduced to 2mm, then the time to permeate completely through the pipe wall would be reduced to 1,300 years.

Note: PEX piping is assumed to behave similarly to polyethylene water piping.

Chapter 7

Commissioning, Operation, and Maintenance

The purpose of this section is to provide minimum commissioning, maintenance, and inspection requirements to help the Uponor PEX plumbing system meet or exceed its service life expectancy. Reviewing the commissioning report and confirming the design recommendations in this manual can help drive long-term system success.

Uponor has created a **PEX Domestic Water Systems Startup and Maintenance Checklist** that can be accessed on uponor.com. Note that the checklist is a guide only and is not intended to be an exhaustive list of all responsibilities, duties, or requirements associated with the installation of Uponor PEX piping products, nor does it replace governing codes, specifications, and/or standards.

Uponor recommends saving the completed checklist as it may be helpful in resolving any warranty issues.

Operation and maintenance plan

Uponor recommends a licensed contractor develop and document a thorough operation and maintenance plan that includes all equipment involved in regulating system temperature, pressure,

and velocity. The program must include the following Uponor recommendations as well as manufacturer recommendations for the other equipment installed in the piping system.

Note that proper documentation of the system operation and maintenance plan is important for future reference, should a performance issue arise.

Preventive maintenance guidelines

Refer to each section for proper preventive maintenance guidelines.

Initial commissioning

For commercial projects, Uponor recommends a licensed professional perform and document a formal commissioning of the piping system. If, after initial commissioning, any changes are made to the piping system which may impact temperature, pressure, or velocity, Uponor recommends documenting the changes and recommissioning the system not only to help ensure consistent performance but also for reference in the event of a performance issue. This includes, but is not limited to, changes in system operating conditions as well as system components.

Plan requirements

Uponor recommends that the party responsible for the maintenance of the system develop a plan to ensure regular inspections/monitoring and maintenance of the system and its components. Inspection should include, but is not limited to, all equipment involved in regulating system temperature, pressure, and velocity. Maintenance should include, but is not limited to, Uponor and other manufacturers' recommendations for all system components.

System inspection and monitoring

For commercial projects, integrate data points for temperature, pressure, and velocity into the building management system (BMS). This will trigger an alarm when system conditions are outside the proper operating parameters.

It is also necessary to inspect and monitor the system to ensure it is operating in conformity with all code requirements regarding proper system and equipment maintenance and operation, including, but not limited to, temperature and pressure. In instances where there is a difference between Uponor recommendations and local or national code requirements, follow the more restrictive guidelines.

Temperature

Perform regular checks to ensure temperature-control devices, such as aquastats, mixing valves, etc., are functioning properly and are delivering the correct water temperature to the system. Ensure the water temperature supply does not exceed the design and safety (anti-scald) limits without proper review and/or justification and does not exceed the maximum recommended temperature for the pipe or other components and materials. Refer to **Table 4-1** for Uponor PEX piping systems temperature and pressure requirements.

Pressure

Review system pressure gauges to ensure system pressure has not increased without explanation. Do not exceed the maximum operating pressure of 80 psi for the system.

Refer to **Table 4-1** to review Uponor PEX piping systems temperature and pressure requirements.

Pressure surges resulting from thermal expansion, water hammer, pump cycling, and variable incoming water supply, etc., can reduce the service life of system components. This includes, but is not limited to, pumps, pressure-reducing valves (PRVs), valves, piping, fittings, etc.

Uponor provides the following recommendations to prevent pressure surges from damaging components of a PEX piping system:

- **Diaphragm expansion tanks** – Ensure the bladder (or diaphragm) is in working condition and the tank is maintaining the correct fill pressure.
- **Compression expansion tanks** – Check the expansion tank to ensure it is maintaining the air cushion and has not become waterlogged.
- **Relief valves** – Check and cycle all relief valves installed within the system. If a secondary relief valve is installed, make sure the adjustable setting does not exceed 80 psi.
- **Backflow preventers**
 - Test the backflow preventer and check for changes in gauge movement.**Important:** Residential systems with backflow preventers require an expansion tank or secondary relief valve (set to 80 psi maximum) to prevent over pressurization. This is necessary as city water mains are no longer able to absorb system volume expansion.
- **Water hammer** – If the system is experiencing water hammer, install water hammer arrestors.

- **Valves (shutoff, balancing, etc.)** – Balance and exercise pressure balancing valves periodically, and make sure the adjustable setting does not exceed 80 psi in the system. Operate valves in the piping system to ensure proper operation and confirm their ability to close and isolate the piping system during an emergency. Also, ensure valves have not seized up due to scale buildup.
- **Booster pumps** – Review and test booster pump operation for optimal performance and regulation to the set pressure (not to exceed 80 psi). In commercial installations, verify the pressure is below the code pressure limit of 80 psi at the lowest level of each pressure zone. Uponor recommends pressure consistency from the pumps for best system performance.

Domestic hot water recirculation and velocity

Review the recirculation pump operation and verify water flow in the continuous-flow portion of the recirculation line does not exceed 2 feet per second (fps). Ensure the water temperature within that line does not exceed the maximum temperature of 140°F (60°C). If a circuit

setter or other balancing device is not installed, Uponor recommends installing pressure gauges on the inlet and the outlet of the recirculating pump. The gauges will provide data as to where the pump is operating on its curve.

For example:

Outlet pressure gauge reads 22 psi

Inlet pressure gauge reads 13 psi

Pressure differential is 9 psi (22 psi – 13 psi = 9)

- Multiply differential pressure by 2.3066 for feet of head = 20.8 ft.
- Refer to the recirculation manufacturer's pump curve. Find 20.8 ft. on the curve and look for the resulting gallons per minute (gpm). For this example, we will assume 8 gpm.
- Recirculation line is 1" Uponor AquaPEX
- Convert gpm to feet per second (V):
 - $V = (0.4085 \times \text{gpm}) / \text{pipe diameter ID}^2$
 - $V = (0.4085 \times 8) / (0.862)^2$
 - $V = (3.3) / (0.74)$
 - $V = 4.6$ feet per second (fps)
- This recirculation line is operating **above** the recommended limit of 2 fps and, the flow rate must be reduced.

Leaks

Check for signs of leaks, including dried water spots under relief valves, as well as moisture, mold, and mildew on or around the piping system.

System disinfection

Uponor does not recommend automatic disinfection (or dosing) systems that increase and maintain a higher level of chlorine or other system agents. Verify the disinfection process, chemical agents, and limits align with local or national code along with the water system disinfection guidelines on **page 89** of this manual. Also, reference the most recent version of the **Uponor AquaPEX Plumbing System Disinfection Guidelines** found on uponor.com.

Appendix A

Fluid Properties

100% Water

Temperature °F (°C)	Heat loss (btu/hr-ft)	Dynamic viscosity [lbm/ (ft·sec)]
	ρ	μ
40 (4.44)	62.42	1.31E-03
45 (7.22)	62.42	1.09E-03
50 (10)	62.41	8.78E-04
55 (12.78)	62.39	8.16E-04
60 (15.56)	62.36	7.54E-04
65 (18.33)	62.33	7.05E-04
70 (21.11)	62.30	6.56E-04
80 (26.67)	62.22	5.76E-04
90 (32.22)	62.12	5.12E-04
100 (37.77)	62.00	4.58E-04
110 (43.33)	61.86	4.13E-04
120 (48.89)	61.71	3.74E-04
130 (54.44)	61.55	3.42E-04
140 (60)	61.38	3.14E-04
150 (65.56)	61.19	2.89E-04
160 (71.11)	60.99	2.68E-04
170 (76.67)	60.79	2.48E-04
180 (82.22)	60.57	2.32E-04
190 (87.78)	60.35	2.17E-04
200 (93.33)	60.12	2.04E-04

30% Propylene glycol

Temperature °F (°C)	Heat loss (btu/hr-ft)	Dynamic viscosity [lbm/ (ft·sec)]	Feet of water conversion
	ρ	μ	
40 (4.44)	64.67	3.86E-03	1.0360
45 (7.22)	64.60	3.45E-03	1.0350
50 (10)	64.53	3.04E-03	1.0340
55 (12.78)	64.46	2.73E-03	1.0333
60 (15.56)	64.39	2.43E-03	1.0326
65 (18.33)	64.32	2.20E-03	1.0318
70 (21.11)	64.24	1.98E-03	1.0311
80 (26.67)	64.08	1.63E-03	1.0299
90 (32.22)	63.91	1.37E-03	1.0288
100 (37.77)	63.73	1.16E-03	1.0279
110 (43.33)	63.54	1.00E-03	1.0272
120 (48.89)	63.33	8.72E-04	1.0263
130 (54.44)	63.12	7.67E-04	1.0255
140 (60)	62.90	6.78E-04	1.0248
150 (65.56)	62.67	6.11E-04	1.0242
160 (71.11)	62.43	5.50E-04	1.0236
170 (76.67)	62.18	4.97E-04	1.0229
180 (82.22)	61.92	4.56E-04	1.0223
190 (87.78)	61.65	4.17E-04	1.0215
200 (93.33)	61.37	3.89E-04	1.0208

40% Propylene glycol

Temperature °F (°C)	Heat loss (btu/hr·ft)	Dynamic viscosity [lbm/ (ft·sec)]	Feet of water conversion
	ρ	μ	
40 (4.44)	65.21	6.45E-03	1.0360
45 (7.22)	65.14	5.65E-03	1.0350
50 (10)	65.06	4.84E-03	1.0340
55 (12.78)	64.98	4.29E-03	1.0333
60 (15.56)	64.90	3.74E-03	1.0326
65 (18.33)	64.82	3.34E-03	1.0318
70 (21.11)	64.73	2.94E-03	1.0311
80 (26.67)	64.55	2.37E-03	1.0299
90 (32.22)	64.36	1.94E-03	1.0288
100 (37.77)	64.16	1.61E-03	1.0279
110 (43.33)	63.95	1.36E-03	1.0272
120 (48.89)	63.74	1.16E-03	1.0263
130 (54.44)	63.51	1.01E-03	1.0255
140 (60)	63.27	8.81E-04	1.0248
150 (65.56)	63.02	7.81E-04	1.0242
160 (71.11)	62.76	7.00E-04	1.0236
170 (76.67)	62.49	6.25E-04	1.0229
180 (82.22)	62.22	5.72E-04	1.0223
190 (87.78)	61.93	5.17E-04	1.0215
200 (93.33)	61.63	4.78E-04	1.0208

50% Propylene glycol

Temperature °F (°C)	Heat loss (btu/hr·ft)	Dynamic viscosity [lbm/ (ft·sec)]	Feet of water conversion
	ρ	μ	
40 (4.44)	65.67	9.54E-03	1.0521
45 (7.22)	65.59	8.33E-03	1.0508
50 (10)	65.50	7.12E-03	1.0495
55 (12.78)	65.42	6.28E-03	1.0486
60 (15.56)	65.33	5.44E-03	1.0476
65 (18.33)	65.24	4.84E-03	1.0466
70 (21.11)	65.14	4.24E-03	1.0456
80 (26.67)	64.95	3.37E-03	1.0439
90 (32.22)	64.74	2.73E-03	1.0422
100 (37.77)	64.53	2.24E-03	1.0408
110 (43.33)	64.30	1.88E-03	1.0394
120 (48.89)	64.06	1.59E-03	1.0381
130 (54.44)	63.82	1.36E-03	1.0369
140 (60)	63.57	1.18E-03	1.0357
150 (65.56)	63.30	1.03E-03	1.0345
160 (71.11)	63.03	9.08E-04	1.0334
170 (76.67)	62.74	8.06E-04	1.0321
180 (82.22)	62.45	7.19E-04	1.0310
190 (87.78)	62.14	6.53E-04	1.0297
200 (93.33)	61.83	5.92E-04	1.0284

Appendix B

Uponor PEX Friction Loss Tables

1/2" Uponor AquaPEX (100% water)

psi loss per 100 feet of tubing									
Velocity (ft/s)	gpm	40°F 4°C	60°F 16°C	80°F 27°C	100°F 38°C	120°F 49°C	140°F 60°C	160°F 71°C	180°F 82°C
1.5	0.21	4.18	3.50	3.22	3.00	2.82	2.68	2.55	2.45
1.6	0.23	4.65	3.90	3.59	3.35	3.16	3.00	2.86	2.74
1.7	0.24	5.15	4.32	3.98	3.72	3.50	3.33	3.17	3.04
1.8	0.26	5.67	4.76	4.39	4.10	3.87	3.67	3.51	3.36
1.9	0.27	6.20	5.22	4.82	4.50	4.25	4.03	3.85	3.70
2.0	0.28	6.76	5.70	5.26	4.92	4.64	4.41	4.21	4.04
2.1	0.30	7.34	6.19	5.72	5.35	5.05	4.80	4.59	4.40
2.2	0.31	7.93	6.70	6.20	5.80	5.47	5.21	4.98	4.78
2.3	0.33	8.55	7.23	6.69	6.26	5.91	5.63	5.38	5.16
2.4	0.34	9.19	7.78	7.20	6.74	6.37	6.06	5.80	5.57
2.5	0.36	9.84	8.34	7.72	7.23	6.84	6.51	6.23	5.98
2.6	0.37	10.52	8.92	8.26	7.74	7.32	6.97	6.67	6.41
2.7	0.38	11.21	9.52	8.82	8.27	7.82	7.45	7.13	6.85
2.8	0.40	11.92	10.13	9.39	8.81	8.33	7.94	7.60	7.30
2.9	0.41	12.65	10.76	9.98	9.36	8.86	8.44	8.08	7.77
3.0	0.43	13.40	11.41	10.58	9.93	9.40	8.96	8.58	8.25
3.1	0.44	14.17	12.07	11.20	10.51	9.95	9.49	9.09	8.74
3.2	0.46	14.95	12.75	11.83	11.11	10.52	10.03	9.61	9.24
3.3	0.47	15.76	13.44	12.48	11.72	11.10	10.59	10.15	9.76
3.4	0.48	16.58	14.15	13.14	12.35	11.70	11.16	10.69	10.29
3.5	0.50	17.42	14.88	13.82	12.99	12.31	11.74	11.26	10.83
3.6	0.51	18.27	15.62	14.51	13.64	12.93	12.34	11.83	11.39
3.7	0.53	19.15	16.37	15.22	14.31	13.57	12.95	12.42	11.95
3.8	0.54	20.04	17.15	15.95	15.00	14.22	13.58	13.02	12.53
3.9	0.55	20.95	17.94	16.68	15.69	14.89	14.21	13.63	13.13
4.0	0.57	21.88	18.74	17.44	16.41	15.56	14.86	14.26	13.73
4.1	0.58	22.82	19.56	18.20	17.13	16.25	15.52	14.90	14.35
4.2	0.60	23.78	20.39	18.98	17.87	16.96	16.20	15.55	14.98
4.3	0.61	24.76	21.24	19.78	18.62	17.68	16.89	16.21	15.62
4.4	0.63	25.75	22.11	20.59	19.39	18.41	17.59	16.88	16.27
4.5	0.64	26.76	22.99	21.41	20.17	19.15	18.30	17.57	16.94
4.6	0.65	27.79	23.88	22.25	20.96	19.91	19.03	18.27	17.61
4.7	0.67	28.83	24.79	23.11	21.77	20.68	19.77	18.99	18.30
4.8	0.68	29.90	25.71	23.97	22.59	21.46	20.52	19.71	19.00
4.9	0.70	30.97	26.65	24.85	23.43	22.26	21.29	20.45	19.72
5.0	0.71	32.07	27.61	25.75	24.28	23.07	22.07	21.20	20.44
5.1	0.73	33.18	28.58	26.66	25.14	23.89	22.86	21.96	21.18
5.2	0.74	34.30	29.56	27.58	26.01	24.73	23.66	22.73	21.93
5.3	0.75	35.45	30.56	28.52	26.90	25.58	24.47	23.52	22.69
5.4	0.77	36.61	31.57	29.47	27.80	26.44	25.30	24.32	23.46
5.5	0.78	37.78	32.60	30.43	28.72	27.31	26.14	25.13	24.24
5.6	0.80	38.97	33.64	31.41	29.64	28.20	26.99	25.95	25.04
5.7	0.81	40.18	34.69	32.40	30.58	29.10	27.86	26.78	25.85
5.8	0.82	41.40	35.76	33.41	31.54	30.01	28.73	27.63	26.67
5.9	0.84	42.64	36.85	34.43	32.51	30.93	29.62	28.49	27.50
6.0	0.85	43.90	37.94	35.46	33.49	31.87	30.52	29.36	28.34
6.1	0.87	45.17	39.06	36.50	34.48	32.82	31.44	30.24	29.19
6.2	0.88	46.45	40.18	37.56	35.49	33.78	32.36	31.13	30.06
6.3	0.90	47.75	41.33	38.64	36.50	34.76	33.30	32.04	30.94
6.4	0.91	49.07	42.48	39.72	37.54	35.74	34.25	32.95	31.82
6.5	0.92	50.41	43.65	40.82	38.58	36.74	35.21	33.88	32.73
6.6	0.94	51.75	44.83	41.94	39.64	37.76	36.18	34.82	33.64
6.7	0.95	53.12	46.03	43.06	40.71	38.78	37.17	35.78	34.56

3/4" Uponor AquaPEX (100% water)

psi loss per 100 feet of tubing									
Velocity (ft/s)	gpm	40°F 4°C	60°F 16°C	80°F 27°C	100°F 38°C	120°F 49°C	140°F 60°C	160°F 71°C	180°F 82°C
6.8	0.97	54.50	47.24	44.20	41.79	39.82	38.17	36.74	35.49
6.9	0.98	55.89	48.47	45.36	42.89	40.87	39.18	37.72	36.44
7.0	1.00	57.30	49.70	46.52	44.00	41.93	40.20	38.70	37.40
7.1	1.01	58.73	50.96	47.70	45.12	43.00	41.23	39.70	38.37
7.2	1.02	60.17	52.22	48.90	46.25	44.09	42.28	40.71	39.35
7.3	1.04	61.63	53.50	50.10	47.40	45.19	43.34	41.74	40.34
7.4	1.05	63.10	54.80	51.32	48.56	46.30	44.41	42.77	41.34
7.5	1.07	64.58	56.10	52.55	49.73	47.42	45.49	43.82	42.36
7.6	1.08	66.09	57.43	53.80	50.92	48.55	46.58	44.87	43.38
7.7	1.09	67.60	58.76	55.06	52.12	49.70	47.69	45.94	44.42
7.8	1.11	69.13	60.11	56.33	53.33	50.86	48.80	47.02	45.47
7.9	1.12	70.68	61.47	57.61	54.55	52.03	49.93	48.11	46.53
8.0	1.14	72.24	62.85	58.91	55.78	53.22	51.07	49.22	47.60
8.1	1.15	73.82	64.24	60.22	57.03	54.41	52.23	50.33	48.68
8.2	1.17	75.41	65.64	61.54	58.29	55.62	53.39	51.46	49.77
8.3	1.18	77.02	67.05	62.88	59.56	56.84	54.56	52.59	50.87
8.4	1.19	78.64	68.48	64.23	60.85	58.07	55.75	53.74	51.99
8.5	1.21	80.27	69.93	65.59	62.14	59.31	56.95	54.90	53.12
8.6	1.22	81.92	71.38	66.96	63.45	60.57	58.16	56.08	54.25
8.7	1.24	83.59	72.85	68.35	64.77	61.84	59.38	57.26	55.40
8.8	1.25	85.27	74.34	69.75	66.11	63.12	60.62	58.45	56.56
8.9	1.27	86.96	75.83	71.16	67.45	64.41	61.86	59.66	57.73
9.0	1.28	88.67	77.34	72.59	68.81	65.71	63.12	60.88	58.92
9.1	1.29	90.40	78.86	74.03	70.18	67.03	64.39	62.11	60.11
9.2	1.31	92.14	80.40	75.48	71.57	68.35	65.67	63.35	61.31
9.3	1.32	93.89	81.95	76.94	72.96	69.69	66.96	64.60	62.53
9.4	1.34	95.66	83.51	78.42	74.37	71.04	68.27	65.86	63.76
9.5	1.35	97.44	85.09	79.91	75.79	72.41	69.58	67.13	64.99
9.6	1.37	99.24	86.68	81.41	77.22	73.78	70.91	68.42	66.24
9.7	1.38	101.05	88.28	82.92	78.67	75.17	72.25	69.71	67.50
9.8	1.39	102.87	89.89	84.45	80.12	76.57	73.60	71.02	68.77
9.9	1.41	104.71	91.52	85.99	81.59	77.98	74.96	72.34	70.05
10.0	1.42	106.57	93.16	87.54	83.07	79.40	76.33	73.67	71.35
10.1	1.44	108.43	94.82	89.10	84.56	80.83	77.72	75.01	72.65
10.2	1.45	110.32	96.49	90.68	86.07	82.28	79.11	76.36	73.96
10.3	1.46	112.21	98.17	92.27	87.58	83.73	80.52	77.73	75.29
10.4	1.48	114.12	99.86	93.87	89.11	85.20	81.94	79.10	76.63
10.5	1.49	116.05	101.57	95.49	90.65	86.68	83.37	80.49	77.97
10.6	1.51	117.99	103.28	97.11	92.21	88.18	84.81	81.89	79.33
10.7	1.52	119.94	105.02	98.75	93.77	89.68	86.26	83.29	80.70
10.8	1.54	121.91	106.76	100.40	95.35	91.19	87.72	84.71	82.08
10.9	1.55	123.89	108.52	102.07	96.94	92.72	89.20	86.14	83.47
11.0	1.56	125.89	110.29	103.74	98.54	94.26	90.69	87.58	84.87
11.1	1.58	127.90	112.07	105.43	100.15	95.81	92.18	89.04	86.29
11.2	1.59	129.92	113.87	107.13	101.77	97.37	93.69	90.50	87.71
11.3	1.61	131.96	115.68	108.85	103.41	98.95	95.21	91.98	89.14
11.4	1.62	134.01	117.50	110.57	105.06	100.53	96.75	93.46	90.59
11.5	1.64	136.08	119.34	112.31	106.72	102.13	98.29	94.96	92.05
11.6	1.65	138.16	121.19	114.06	108.39	103.74	99.84	96.47	93.51
11.7	1.66	140.25	123.05	115.82	110.08	105.36	101.41	97.99	94.99
11.8	1.68	142.36	124.92	117.60	111.77	106.99	102.99	99.52	96.48
11.9	1.69	144.49	126.81	119.38	113.48	108.63	104.57	101.06	97.98
12.0	1.71	146.62	128.70	121.18	115.20	110.28	106.17	102.61	99.49

3/8" Uponor AquaPEX (100% water)

psi loss per 100 feet of tubing									
Velocity (ft/s)	gpm	40°F 4°C	60°F 16°C	80°F 27°C	100°F 38°C	120°F 49°C	140°F 60°C	160°F 71°C	180°F 82°C
1.5	0.45	2.54	2.14	1.98	1.85	1.74	1.66	1.58	1.52
1.6	0.48	2.83	2.39	2.21	2.07	1.95	1.85	1.77	1.70
1.7	0.51	3.14	2.65	2.45	2.29	2.17	2.06	1.97	1.89
1.8	0.54	3.45	2.92	2.70	2.53	2.39	2.27	2.17	2.09
1.9	0.57	3.78	3.21	2.97	2.78	2.63	2.50	2.39	2.29
2.0	0.60	4.13	3.50	3.24	3.04	2.87	2.73	2.61	2.51
2.1	0.63	4.48	3.81	3.53	3.31	3.13	2.98	2.85	2.73
2.2	0.66	4.85	4.12	3.82	3.59	3.39	3.23	3.09	2.97
2.3	0.69	5.23	4.45	4.13	3.87	3.66	3.49	3.34	3.21
2.4	0.72	5.62	4.79	4.44	4.17	3.95	3.76	3.60	3.46
2.5	0.75	6.03	5.14	4.77	4.48	4.24	4.04	3.87	3.72
2.6	0.78	6.44	5.50	5.11	4.79	4.54	4.33	4.14	3.98
2.7	0.81	6.87	5.87	5.45	5.12	4.85	4.62	4.43	4.26
2.8	0.84	7.31	6.25	5.81	5.46	5.17	4.93	4.72	4.54
2.9	0.87	7.76	6.64	6.17	5.80	5.50	5.24	5.02	4.83
3.0	0.90	8.22	7.04	6.55	6.15	5.83	5.57	5.33	5.13
3.1	0.93	8.70	7.45	6.93	6.52	6.18	5.90	5.65	5.44
3.2	0.96	9.18	7.87	7.33	6.89	6.53	6.24	5.98	5.75
3.3	0.99	9.68	8.30	7.73	7.27	6.90	6.58	6.31	6.08
3.4	1.02	10.19	8.75	8.14	7.66	7.27	6.94	6.65	6.41
3.5	1.05	10.71	9.20	8.56	8.06	7.65	7.30	7.00	6.74
3.6	1.08	11.24	9.66	9.00	8.47	8.04	7.68	7.36	7.09
3.7	1.11	11.78	10.13	9.44	8.89	8.43	8.06	7.73	7.44
3.8	1.14	12.33	10.61	9.89	9.31	8.84	8.45	8.10	7.80
3.9	1.17	12.89	11.10	10.35	9.75	9.25	8.84	8.49	8.17
4.0	1.20	13.47	11.60	10.81	10.19	9.68	9.25	8.88	8.55
4.1	1.23	14.05	12.11	11.29	10.64	10.11	9.66	9.27	8.93
4.2	1.26	14.65	12.63	11.78	11.10	10.55	10.08	9.68	9.33
4.3	1.29	15.25	13.16	12.27	11.57	10.99	10.51	10.09	9.73
4.4	1.32	15.87	13.69	12.78	12.05	11.45	10.95	10.51	10.13
4.5	1.35	16.50	14.24	13.29	12.54	11.91	11.39	10.94	10.55
4.6	1.38	17.13	14.80	13.81	13.03	12.39	11.85	11.38	10.97
4.7	1.41	17.78	15.36	14.35	13.53	12.87	12.31	11.82	11.40
4.8	1.44	18.44	15.94	14.89	14.05	13.36	12.78	12.28	11.84
4.9	1.47	19.11	16.52	15.43	14.57	13.85	13.25	12.73	12.28
5.0	1.50	19.79	17.12	15.99	15.10	14.36	13.74	13.20	12.73
5.1	1.53	20.48	17.72	16.56	15.63	14.87	14.23	13.68	13.19
5.2	1.56	21.18	18.33	17.13	16.18	15.39	14.73	14.16	13.66
5.3	1.59	21.89	18.95	17.72	16.73	15.92	15.24	14.65	14.13
5.4	1.62	22.61	19.58	18.31	17.29	16.46	15.75	15.15	14.61
5.5	1.65	23.34	20.22	18.91	17.86	17.00	16.28	15.65	15.10
5.6	1.68	24.08	20.87	19.52	18.44	17.55	16.81	16.16	15.60
5.7	1.71	24.83	21.53	20.14	19.03	18.11	17.35	16.68	16.10
5.8	1.74	25.59	22.20	20.77	19.62	18.68	17.89	17.21	16.61
5.9	1.77	26.36	22.87	21.40	20.23	19.26	18.45	17.74	17.13
6.0	1.80	27.13	23.56	22.04	20.84	19.84	19.01	18.28	17.65
6.1	1.83	27.92	24.25	22.70	21.46	20.44	19.58	18.83	18.18
6.2	1.86	28.72	24.95	23.36	22.09	21.04	20.16	19.39	18.72
6.3	1.89	29.53	25.66	24.03	22.72	21.64	20.74	19.95	19.27
6.4	1.92	30.35	26.38	24.70	23.36	22.26	21.33	20.53	19.82
6.5	1.95	31.18	27.11	25.39	24.02	22.88	21.93	21.10	20.38
6.6	1.98	32.02	27.85	26.08	24.68	23.51	22.54	21.69	20.95
6.7	2.01	32.87	28.59	26.79	25.34	24.15	23.15	22.28	21.52

3/8" Uponor AquaPEX (100% water)

psi loss per 100 feet of tubing									
Velocity (ft/s)	gpm	40°F 4°C	60°F 16°C	80°F 27°C	100°F 38°C	120°F 49°C	140°F 60°C	160°F 71°C	180°F 82°C
6.8	2.04	33.73	29.35	27.50	26.02	24.80	23.77	22.88	22.10
6.9	2.07	34.59	30.11	28.22	26.70	25.45	24.40	23.49	22.69
7.0	2.10	35.47	30.88	28.94	27.39	26.11	25.04	24.10	23.29
7.1	2.13	36.36	31.66	29.68	28.09	26.78	25.68	24.73	23.89
7.2	2.16	37.25	32.45	30.42	28.80	27.46	26.33	25.36	24.50
7.3	2.19	38.16	33.25	31.17	29.51	28.14	26.99	25.99	25.12
7.4	2.22	39.08	34.06	31.94	30.24	28.84	27.66	26.64	25.74
7.5	2.25	40.00	34.87	32.70	30.97	29.54	28.33	27.29	26.37
7.6	2.28	40.93	35.70	33.48	31.71	30.24	29.01	27.94	27.01
7.7	2.31	41.88	36.53	34.26	32.45	30.96	29.70	28.61	27.65
7.8	2.34	42.83	37.37	35.06	33.21	31.68	30.40	29.28	28.30
7.9	2.37	43.79	38.22	35.86	33.97	32.41	31.10	29.96	28.96
8.0	2.40	44.77	39.08	36.67	34.74	33.15	31.81	30.65	29.63
8.1	2.43	45.75	39.94	37.48	35.52	33.89	32.53	31.34	30.30
8.2	2.46	46.74	40.82	38.31	36.30	34.64	33.25	32.04	30.98
8.3	2.49	47.74	41.70	39.14	37.09	35.40	33.98	32.75	31.66
8.4	2.52	48.75	42.59	39.98	37.90	36.17	34.72	33.46	32.36
8.5	2.55	49.77	43.49	40.83	38.70	36.94	35.47	34.18	33.06
8.6	2.58	50.79	44.40	41.69	39.52	37.73	36.22	34.91	33.76
8.7	2.61	51.83	45.32	42.55	40.34	38.52	36.98	35.65	34.48
8.8	2.64	52.88	46.24	43.43	41.17	39.31	37.75	36.39	35.20
8.9	2.67	53.93	47.17	44.31	42.01	40.12	38.53	37.14	35.92
9.0	2.70	55.00	48.11	45.20	42.86	40.93	39.31	37.90	36.66
9.1	2.73	56.07	49.06	46.09	43.71	41.75	40.10	38.66	37.40
9.2	2.76	57.15	50.02	47.00	44.58	42.57	40.89	39.43	38.14
9.3	2.79	58.24	50.99	47.91	45.45	43.41	41.70	40.21	38.90
9.4	2.82	59.34	51.96	48.83	46.32	44.25	42.51	40.99	39.66
9.5	2.85	60.45	52.94	49.76	47.21	45.10	43.33	41.78	40.43
9.6	2.88	61.57	53.94	50.69	48.10	45.95	44.15	42.58	41.20
9.7	2.91	62.70	54.93	51.64	49.00	46.82	44.98	43.39	41.98
9.8	2.94	63.84	55.94	52.59	49.91	47.69	45.82	44.20	42.77
9.9	2.97	64.98	56.96	53.55	50.82	48.56	46.67	45.02	43.57
10.0	3.00	66.14	57.98	54.52	51.74	49.45	47.52	45.84	44.37
10.1	3.03	67.30	59.01	55.49	52.67	50.34	48.38	46.67	45.18
10.2	3.06	68.48	60.05	56.47	53.61	51.24	49.25	47.51	45.99
10.3	3.09	69.66	61.10	57.46	54.55	52.15	50.12	48.36	46.81
10.4	3.12	70.85	62.15	58.46	55.51	53.06	51.01	49.21	47.64
10.5	3.15	72.05	63.22	59.47	56.47	53.98	51.89	50.07	48.48
10.6	3.18	73.26	64.29	60.48	57.43	54.91	52.79	50.94	49.32
10.7	3.21	74.47	65.37	61.50	58.41	55.84	53.69	51.82	50.17
10.8	3.24	75.70	66.46	62.53	59.39	56.79	54.60	52.70	51.02
10.9	3.27	76.93	67.55	63.57	60.38	57.74	55.52	53.58	51.89
11.0	3.30	78.18	68.66	64.61	61.37	58.69	56.44	54.48	52.75
11.1	3.33	79.43	69.77	65.67	62.38	59.66	57.37	55.38	53.63
11.2	3.36	80.69	70.89	66.73	63.39	60.63	58.31	56.29	54.51
11.3	3.39	81.96	72.02	67.79	64.41	61.61	59.25	57.20	55.40
11.4	3.42	83.24	73.16	68.87	65.43	62.59	60.21	58.12	56.30
11.5	3.45	84.53	74.30	69.95	66.47	63.59	61.16	59.05	57.20
11.6	3.48	85.83	75.45	71.04	67.51	64.59	62.13	59.99	58.11
11.7	3.51	87.13	76.61	72.14	68.56	65.59	63.10	60.93	59.02
11.8	3.54	88.45	77.78	73.25	69.61	66.61	64.08	61.88	59.94
11.9	3.57	89.77	78.96	74.36	70.68	67.63	65.07	62.83	60.87
12.0	3.60	91.10	80.14	75.48	71.75	68.66	66.06	63.79	61.81

½" Uponor AquaPEX (100% water)

psi loss per 100 feet of tubing									
Velocity (ft/s)	gpm	40°F 4°C	60°F 16°C	80°F 27°C	100°F 38°C	120°F 49°C	140°F 60°C	160°F 71°C	180°F 82°C
1.5	0.83	1.70	1.44	1.33	1.25	1.18	1.12	1.07	1.03
1.6	0.88	1.89	1.61	1.49	1.40	1.32	1.26	1.20	1.15
1.7	0.94	2.10	1.79	1.66	1.55	1.47	1.40	1.34	1.28
1.8	0.99	2.31	1.97	1.83	1.71	1.62	1.54	1.48	1.42
1.9	1.05	2.54	2.16	2.01	1.88	1.78	1.70	1.62	1.56
2.0	1.10	2.77	2.36	2.19	2.06	1.95	1.86	1.78	1.71
2.1	1.16	3.01	2.57	2.39	2.24	2.12	2.02	1.94	1.86
2.2	1.22	3.26	2.78	2.59	2.43	2.30	2.19	2.10	2.02
2.3	1.27	3.51	3.01	2.80	2.63	2.49	2.37	2.27	2.19
2.4	1.33	3.78	3.24	3.01	2.83	2.68	2.56	2.45	2.36
2.5	1.38	4.05	3.47	3.23	3.04	2.88	2.75	2.63	2.53
2.6	1.44	4.33	3.72	3.46	3.25	3.09	2.94	2.82	2.71
2.7	1.49	4.62	3.97	3.70	3.48	3.30	3.15	3.02	2.90
2.8	1.55	4.92	4.23	3.94	3.71	3.51	3.35	3.22	3.10
2.9	1.60	5.23	4.49	4.19	3.94	3.74	3.57	3.42	3.29
3.0	1.66	5.54	4.77	4.44	4.18	3.97	3.79	3.63	3.50
3.1	1.71	5.86	5.05	4.70	4.43	4.20	4.02	3.85	3.71
3.2	1.77	6.19	5.33	4.97	4.68	4.45	4.25	4.07	3.92
3.3	1.82	6.53	5.63	5.25	4.94	4.69	4.48	4.30	4.14
3.4	1.88	6.87	5.93	5.53	5.21	4.95	4.73	4.54	4.37
3.5	1.93	7.22	6.23	5.82	5.48	5.21	4.98	4.78	4.60
3.6	1.99	7.58	6.55	6.11	5.76	5.47	5.23	5.02	4.84
3.7	2.04	7.95	6.87	6.41	6.04	5.74	5.49	5.27	5.08
3.8	2.10	8.32	7.19	6.72	6.34	6.02	5.76	5.53	5.33
3.9	2.15	8.71	7.53	7.03	6.63	6.30	6.03	5.79	5.58
4.0	2.21	9.10	7.87	7.35	6.93	6.59	6.30	6.05	5.84
4.1	2.26	9.49	8.22	7.68	7.24	6.89	6.59	6.33	6.10
4.2	2.32	9.90	8.57	8.01	7.56	7.19	6.88	6.60	6.37
4.3	2.38	10.31	8.93	8.35	7.88	7.49	7.17	6.89	6.64
4.4	2.43	10.73	9.30	8.69	8.20	7.80	7.47	7.17	6.92
4.5	2.49	11.15	9.67	9.04	8.54	8.12	7.77	7.47	7.20
4.6	2.54	11.59	10.05	9.40	8.88	8.44	8.08	7.77	7.49
4.7	2.60	12.03	10.44	9.76	9.22	8.77	8.40	8.07	7.78
4.8	2.65	12.48	10.83	10.13	9.57	9.11	8.72	8.38	8.08
4.9	2.71	12.93	11.23	10.50	9.92	9.45	9.04	8.69	8.39
5.0	2.76	13.39	11.63	10.88	10.29	9.79	9.37	9.01	8.69
5.1	2.82	13.86	12.04	11.27	10.65	10.14	9.71	9.34	9.01
5.2	2.87	14.34	12.46	11.66	11.02	10.50	10.05	9.67	9.33
5.3	2.93	14.82	12.88	12.06	11.40	10.86	10.40	10.00	9.65
5.4	2.98	15.31	13.31	12.47	11.79	11.23	10.75	10.34	9.98
5.5	3.04	15.80	13.75	12.88	12.18	11.60	11.11	10.69	10.31
5.6	3.09	16.31	14.19	13.29	12.57	11.98	11.47	11.04	10.65
5.7	3.15	16.82	14.64	13.72	12.97	12.36	11.84	11.39	11.00
5.8	3.20	17.34	15.10	14.14	13.38	12.75	12.22	11.75	11.34
5.9	3.26	17.86	15.56	14.58	13.79	13.14	12.59	12.12	11.70
6.0	3.31	18.39	16.02	15.02	14.21	13.54	12.98	12.49	12.06
6.1	3.37	18.93	16.50	15.46	14.63	13.95	13.37	12.86	12.42
6.2	3.42	19.47	16.98	15.91	15.06	14.36	13.76	13.24	12.79
6.3	3.48	20.02	17.46	16.37	15.50	14.77	14.16	13.63	13.16
6.4	3.54	20.58	17.95	16.83	15.94	15.19	14.56	14.02	13.54
6.5	3.59	21.14	18.45	17.30	16.38	15.62	14.97	14.41	13.92
6.6	3.65	21.72	18.95	17.78	16.83	16.05	15.39	14.81	14.31
6.7	3.70	22.29	19.46	18.26	17.29	16.49	15.81	15.22	14.70

½" Uponor AquaPEX (100% water)

psi loss per 100 feet of tubing									
Velocity (ft/s)	gpm	40°F 4°C	60°F 16°C	80°F 27°C	100°F 38°C	120°F 49°C	140°F 60°C	160°F 71°C	180°F 82°C
6.8	3.76	22.88	19.98	18.74	17.75	16.93	16.23	15.63	15.10
6.9	3.81	23.47	20.50	19.23	18.22	17.37	16.66	16.04	15.50
7.0	3.87	24.07	21.03	19.73	18.69	17.83	17.10	16.46	15.91
7.1	3.92	24.67	21.56	20.23	19.17	18.28	17.54	16.89	16.32
7.2	3.98	25.28	22.10	20.74	19.65	18.75	17.98	17.32	16.73
7.3	4.03	25.90	22.64	21.25	20.14	19.21	18.43	17.75	17.16
7.4	4.09	26.52	23.19	21.77	20.63	19.69	18.89	18.19	17.58
7.5	4.14	27.15	23.75	22.30	21.13	20.17	19.35	18.64	18.01
7.6	4.20	27.79	24.31	22.83	21.64	20.65	19.82	19.09	18.45
7.7	4.25	28.43	24.88	23.37	22.15	21.14	20.29	19.54	18.89
7.8	4.31	29.08	25.46	23.91	22.66	21.63	20.76	20.00	19.33
7.9	4.36	29.74	26.04	24.46	23.18	22.13	21.24	20.47	19.78
8.0	4.42	30.40	26.62	25.01	23.71	22.63	21.73	20.93	20.24
8.1	4.47	31.07	27.21	25.57	24.24	23.14	22.22	21.41	20.70
8.2	4.53	31.75	27.81	26.13	24.78	23.66	22.71	21.89	21.16
8.3	4.58	32.43	28.41	26.70	25.32	24.18	23.21	22.37	21.63
8.4	4.64	33.12	29.02	27.27	25.87	24.70	23.72	22.86	22.10
8.5	4.70	33.81	29.64	27.85	26.42	25.23	24.23	23.35	22.58
8.6	4.75	34.51	30.26	28.44	26.98	25.76	24.74	23.85	23.06
8.7	4.81	35.22	30.88	29.03	27.54	26.30	25.26	24.35	23.55
8.8	4.86	35.93	31.52	29.63	28.11	26.85	25.79	24.86	24.04
8.9	4.92	36.65	32.15	30.23	28.68	27.40	26.32	25.37	24.54
9.0	4.97	37.38	32.80	30.84	29.26	27.95	26.85	25.89	25.04
9.1	5.03	38.11	33.45	31.45	29.85	28.51	27.39	26.41	25.54
9.2	5.08	38.85	34.10	32.07	30.44	29.08	27.93	26.93	26.05
9.3	5.14	39.59	34.76	32.69	31.03	29.65	28.48	27.46	26.57
9.4	5.19	40.34	35.43	33.32	31.63	30.22	29.04	28.00	27.09
9.5	5.25	41.10	36.10	33.96	32.23	30.80	29.60	28.54	27.61
9.6	5.30	41.86	36.77	34.60	32.84	31.39	30.16	29.08	28.14
9.7	5.36	42.63	37.46	35.24	33.46	31.98	30.73	29.63	28.67
9.8	5.41	43.41	38.14	35.89	34.08	32.57	31.30	30.19	29.21
9.9	5.47	44.19	38.84	36.55	34.70	33.17	31.88	30.75	29.75
10.0	5.52	44.98	39.54	37.21	35.33	33.78	32.46	31.31	30.30
10.1	5.58	45.77	40.24	37.88	35.97	34.39	33.05	31.88	30.85
10.2	5.63	46.57	40.95	38.55	36.61	35.00	33.64	32.45	31.41
10.3	5.69	47.38	41.67	39.22	37.26	35.62	34.24	33.03	31.97
10.4	5.74	48.19	42.39	39.91	37.91	36.24	34.84	33.61	32.53
10.5	5.80	49.01	43.12	40.59	38.56	36.87	35.45	34.20	33.10
10.6	5.86	49.84	43.85	41.29	39.22	37.51	36.06	34.79	33.68
10.7	5.91	50.67	44.59	41.99	39.89	38.15	36.68	35.39	34.26
10.8	5.97	51.50	45.33	42.69	40.56	38.79	37.30	35.99	34.84
10.9	6.02	52.35	46.08	43.40	41.24	39.44	37.92	36.60	35.43
11.0	6.08	53.20	46.84	44.11	41.92	40.09	38.55	37.21	36.02
11.1	6.13	54.05	47.60	44.83	42.60	40.75	39.19	37.82	36.62
11.2	6.19	54.91	48.36	45.56	43.29	41.42	39.83	38.44	37.22
11.3	6.24	55.78	49.13	46.29	43.99	42.08	40.47	39.07	37.82
11.4	6.30	56.65	49.91	47.02	44.69	42.76	41.12	39.69	38.43
11.5	6.35	57.53	50.69	47.76	45.40	43.44	41.78	40.33	39.05
11.6	6.41	58.42	51.48	48.51	46.11	44.12	42.44	40.97	39.67
11.7	6.46	59.31	52.27	49.26	46.83	44.81	43.10	41.61	40.29
11.8	6.52	60.21	53.07	50.01	47.55	45.50	43.77	42.25	40.92
11.9	6.57	61.11	53.87	50.77	48.27	46.20	44.44	42.91	41.55
12.0	6.63	62.02	54.68	51.54	49.01	46.90	45.12	43.56	42.19

¾" Uponor AquaPEX (100% water)

psi loss per 100 feet of tubing									
Velocity (ft/s)	gpm	40°F 4°C	60°F 16°C	80°F 27°C	100°F 38°C	120°F 49°C	140°F 60°C	160°F 71°C	180°F 82°C
1.5	1.65	1.08	0.92	0.86	0.81	0.76	0.73	0.70	0.67
1.6	1.76	1.21	1.03	0.96	0.90	0.85	0.81	0.78	0.75
1.7	1.87	1.34	1.15	1.07	1.00	0.95	0.90	0.87	0.83
1.8	1.98	1.48	1.27	1.18	1.11	1.05	1.00	0.96	0.92
1.9	2.09	1.62	1.39	1.29	1.22	1.15	1.10	1.05	1.01
2.0	2.20	1.77	1.52	1.41	1.33	1.26	1.20	1.15	1.11
2.1	2.31	1.92	1.65	1.54	1.45	1.37	1.31	1.26	1.21
2.2	2.43	2.08	1.79	1.67	1.57	1.49	1.42	1.37	1.31
2.3	2.54	2.25	1.94	1.81	1.70	1.61	1.54	1.48	1.42
2.4	2.65	2.42	2.09	1.94	1.83	1.74	1.66	1.59	1.53
2.5	2.76	2.60	2.24	2.09	1.97	1.87	1.78	1.71	1.65
2.6	2.87	2.78	2.40	2.24	2.11	2.00	1.91	1.83	1.77
2.7	2.98	2.97	2.56	2.39	2.25	2.14	2.04	1.96	1.89
2.8	3.09	3.16	2.73	2.55	2.40	2.28	2.18	2.09	2.02
2.9	3.20	3.36	2.90	2.71	2.55	2.43	2.32	2.23	2.15
3.0	3.31	3.56	3.08	2.88	2.71	2.58	2.46	2.37	2.28
3.1	3.42	3.77	3.26	3.05	2.87	2.73	2.61	2.51	2.42
3.2	3.53	3.98	3.45	3.22	3.04	2.89	2.76	2.65	2.56
3.3	3.64	4.20	3.64	3.40	3.21	3.05	2.92	2.80	2.70
3.4	3.75	4.42	3.83	3.58	3.38	3.22	3.08	2.95	2.85
3.5	3.86	4.65	4.03	3.77	3.56	3.39	3.24	3.11	3.00
3.6	3.97	4.88	4.24	3.96	3.74	3.56	3.40	3.27	3.15
3.7	4.08	5.12	4.44	4.16	3.93	3.74	3.57	3.43	3.31
3.8	4.19	5.36	4.66	4.36	4.12	3.92	3.75	3.60	3.47
3.9	4.30	5.61	4.87	4.56	4.31	4.10	3.93	3.77	3.64
4.0	4.41	5.86	5.10	4.77	4.51	4.29	4.11	3.95	3.81
4.1	4.52	6.12	5.32	4.98	4.71	4.48	4.29	4.12	3.98
4.2	4.63	6.38	5.55	5.20	4.91	4.68	4.48	4.31	4.15
4.3	4.74	6.65	5.79	5.42	5.12	4.88	4.67	4.49	4.33
4.4	4.85	6.92	6.02	5.64	5.34	5.08	4.87	4.68	4.51
4.5	4.96	7.20	6.27	5.87	5.55	5.29	5.06	4.87	4.70
4.6	5.07	7.48	6.51	6.10	5.77	5.50	5.27	5.07	4.89
4.7	5.18	7.76	6.77	6.34	6.00	5.71	5.47	5.26	5.08
4.8	5.29	8.05	7.02	6.58	6.23	5.93	5.68	5.47	5.27
4.9	5.40	8.35	7.28	6.82	6.46	6.15	5.90	5.67	5.47
5.0	5.51	8.65	7.54	7.07	6.69	6.38	6.11	5.88	5.68
5.1	5.62	8.95	7.81	7.33	6.93	6.61	6.33	6.09	5.88
5.2	5.73	9.26	8.08	7.58	7.18	6.84	6.56	6.31	6.09
5.3	5.84	9.57	8.36	7.84	7.42	7.08	6.78	6.53	6.30
5.4	5.95	9.89	8.64	8.11	7.67	7.32	7.01	6.75	6.52
5.5	6.06	10.21	8.93	8.37	7.93	7.56	7.25	6.97	6.73
5.6	6.17	10.54	9.21	8.65	8.19	7.81	7.48	7.20	6.96
5.7	6.28	10.87	9.51	8.92	8.45	8.06	7.73	7.44	7.18
5.8	6.39	11.21	9.80	9.20	8.71	8.31	7.97	7.67	7.41
5.9	6.50	11.55	10.10	9.48	8.98	8.57	8.22	7.91	7.64
6.0	6.61	11.89	10.41	9.77	9.26	8.83	8.47	8.15	7.87
6.1	6.72	12.24	10.72	10.06	9.53	9.09	8.72	8.40	8.11
6.2	6.83	12.60	11.03	10.36	9.81	9.36	8.98	8.65	8.35
6.3	6.94	12.96	11.35	10.65	10.10	9.63	9.24	8.90	8.60
6.4	7.05	13.32	11.67	10.96	10.38	9.91	9.51	9.15	8.84
6.5	7.17	13.68	11.99	11.26	10.68	10.19	9.77	9.41	9.09
6.6	7.28	14.06	12.32	11.57	10.97	10.47	10.05	9.67	9.35
6.7	7.39	14.43	12.65	11.89	11.27	10.75	10.32	9.94	9.60

¾" Uponor AquaPEX (100% water)

psi loss per 100 feet of tubing									
Velocity (ft/s)	gpm	40°F 4°C	60°F 16°C	80°F 27°C	100°F 38°C	120°F 49°C	140°F 60°C	160°F 71°C	180°F 82°C
6.8	7.50	14.81	12.99	12.20	11.57	11.04	10.60	10.21	9.86
6.9	7.61	15.20	13.33	12.52	11.88	11.34	10.88	10.48	10.13
7.0	7.72	15.59	13.67	12.85	12.18	11.63	11.16	10.75	10.39
7.1	7.83	15.98	14.02	13.18	12.50	11.93	11.45	11.03	10.66
7.2	7.94	16.38	14.37	13.51	12.81	12.23	11.74	11.31	10.93
7.3	8.05	16.78	14.73	13.84	13.13	12.54	12.04	11.60	11.21
7.4	8.16	17.18	15.09	14.18	13.46	12.85	12.34	11.89	11.49
7.5	8.27	17.59	15.45	14.53	13.78	13.16	12.64	12.18	11.77
7.6	8.38	18.01	15.82	14.87	14.11	13.48	12.94	12.47	12.06
7.7	8.49	18.43	16.19	15.22	14.45	13.80	13.25	12.77	12.34
7.8	8.60	18.85	16.56	15.58	14.78	14.12	13.56	13.07	12.63
7.9	8.71	19.28	16.94	15.94	15.12	14.45	13.87	13.37	12.93
8.0	8.82	19.71	17.32	16.30	15.47	14.78	14.19	13.68	13.23
8.1	8.93	20.14	17.71	16.66	15.81	15.11	14.51	13.99	13.53
8.2	9.04	20.58	18.10	17.03	16.17	15.45	14.84	14.30	13.83
8.3	9.15	21.03	18.49	17.40	16.52	15.78	15.16	14.62	14.13
8.4	9.26	21.48	18.89	17.78	16.88	16.13	15.49	14.94	14.44
8.5	9.37	21.93	19.29	18.16	17.24	16.47	15.83	15.26	14.76
8.6	9.48	22.38	19.70	18.54	17.60	16.82	16.16	15.58	15.07
8.7	9.59	22.85	20.11	18.93	17.97	17.18	16.50	15.91	15.39
8.8	9.70	23.31	20.52	19.32	18.34	17.53	16.85	16.24	15.71
8.9	9.81	23.78	20.94	19.71	18.72	17.89	17.19	16.58	16.04
9.0	9.92	24.25	21.36	20.11	19.10	18.26	17.54	16.92	16.36
9.1	10.03	24.73	21.78	20.51	19.48	18.62	17.89	17.26	16.69
9.2	10.14	25.21	22.21	20.91	19.86	18.99	18.25	17.60	17.03
9.3	10.25	25.70	22.64	21.32	20.25	19.36	18.61	17.95	17.36
9.4	10.36	26.18	23.07	21.73	20.65	19.74	18.97	18.30	17.70
9.5	10.47	26.68	23.51	22.15	21.04	20.12	19.34	18.65	18.05
9.6	10.58	27.18	23.95	22.56	21.44	20.50	19.71	19.01	18.39
9.7	10.69	27.68	24.40	22.99	21.84	20.89	20.08	19.37	18.74
9.8	10.80	28.18	24.85	23.41	22.25	21.28	20.45	19.73	19.09
9.9	10.91	28.69	25.30	23.84	22.66	21.67	20.83	20.10	19.45
10.0	11.02	29.21	25.76	24.27	23.07	22.06	21.21	20.46	19.80
10.1	11.13	29.72	26.22	24.71	23.48	22.46	21.60	20.84	20.17
10.2	11.24	30.25	26.68	25.15	23.90	22.86	21.98	21.21	20.53
10.3	11.35	30.77	27.15	25.59	24.33	23.27	22.37	21.59	20.89
10.4	11.46	31.30	27.62	26.04	24.75	23.68	22.77	21.97	21.26
10.5	11.57	31.84	28.10	26.49	25.18	24.09	23.17	22.35	21.64
10.6	11.68	32.37	28.58	26.94	25.61	24.50	23.57	22.74	22.01
10.7	11.79	32.92	29.06	27.40	26.05	24.92	23.97	23.13	22.39
10.8	11.91	33.46	29.55	27.86	26.49	25.34	24.37	23.52	22.77
10.9	12.02	34.01	30.04	28.32	26.93	25.77	24.78	23.92	23.16
11.0	12.13	34.57	30.53	28.79	27.37	26.20	25.20	24.32	23.54
11.1	12.24	35.12	31.03	29.26	27.82	26.63	25.61	24.72	23.93
11.2	12.35	35.68	31.53	29.73	28.28	27.06	26.03	25.13	24.33
11.3	12.46	36.25	32.03	30.21	28.73	27.50	26.45	25.53	24.72
11.4	12.57	36.82	32.54	30.69	29.19	27.94	26.88	25.94	25.12
11.5	12.68	37.39	33.05	31.17	29.65	28.38	27.30	26.36	25.52
11.6	12.79	37.97	33.56	31.66	30.12	28.83	27.74	26.78	25.93
11.7	12.90	38.55	34.08	32.15	30.59	29.28	28.17	27.20	26.33
11.8	13.01	39.14	34.60	32.64	31.06	29.73	28.61	27.62	26.75
11.9	13.12	39.73	35.13	33.14	31.53	30.19	29.05	28.04	27.16
12.0	13.23	40.32	35.66	33.64	32.01	30.65	29.49	28.47	27.58

1" Uponor AquaPEX (100% water)

psi loss per 100 feet of tubing									
Velocity (ft/s)	gpm	40°F 4°C	60°F 16°C	80°F 27°C	100°F 38°C	120°F 49°C	140°F 60°C	160°F 71°C	180°F 82°C
1.5	2.73	0.78	0.67	0.62	0.59	0.56	0.53	0.51	0.49
1.6	2.91	0.87	0.75	0.70	0.66	0.62	0.59	0.57	0.55
1.7	3.09	0.97	0.83	0.78	0.73	0.69	0.66	0.63	0.61
1.8	3.27	1.07	0.92	0.86	0.81	0.77	0.73	0.70	0.68
1.9	3.46	1.17	1.01	0.94	0.89	0.84	0.81	0.77	0.74
2.0	3.64	1.28	1.11	1.03	0.97	0.92	0.88	0.85	0.81
2.1	3.82	1.40	1.21	1.12	1.06	1.01	0.96	0.92	0.89
2.2	4.00	1.51	1.31	1.22	1.15	1.09	1.04	1.00	0.96
2.3	4.18	1.63	1.41	1.32	1.24	1.18	1.13	1.08	1.04
2.4	4.37	1.76	1.52	1.42	1.34	1.27	1.22	1.17	1.13
2.5	4.55	1.89	1.63	1.53	1.44	1.37	1.31	1.26	1.21
2.6	4.73	2.02	1.75	1.64	1.54	1.47	1.40	1.35	1.30
2.7	4.91	2.16	1.87	1.75	1.65	1.57	1.50	1.44	1.39
2.8	5.09	2.30	1.99	1.86	1.76	1.67	1.60	1.54	1.48
2.9	5.28	2.44	2.12	1.98	1.87	1.78	1.70	1.63	1.58
3.0	5.46	2.59	2.25	2.10	1.99	1.89	1.81	1.74	1.67
3.1	5.64	2.74	2.38	2.23	2.10	2.00	1.92	1.84	1.77
3.2	5.82	2.90	2.52	2.36	2.23	2.12	2.03	1.95	1.88
3.3	6.00	3.06	2.66	2.49	2.35	2.24	2.14	2.06	1.98
3.4	6.19	3.22	2.80	2.62	2.48	2.36	2.26	2.17	2.09
3.5	6.37	3.39	2.95	2.76	2.61	2.48	2.38	2.29	2.20
3.6	6.55	3.56	3.10	2.90	2.74	2.61	2.50	2.40	2.32
3.7	6.73	3.73	3.25	3.04	2.88	2.74	2.63	2.52	2.43
3.8	6.91	3.91	3.41	3.19	3.02	2.87	2.75	2.65	2.55
3.9	7.09	4.09	3.56	3.34	3.16	3.01	2.88	2.77	2.68
4.0	7.28	4.27	3.73	3.49	3.31	3.15	3.02	2.90	2.80
4.1	7.46	4.46	3.89	3.65	3.45	3.29	3.15	3.03	2.93
4.2	7.64	4.65	4.06	3.81	3.60	3.43	3.29	3.17	3.06
4.3	7.82	4.85	4.23	3.97	3.76	3.58	3.43	3.30	3.19
4.4	8.00	5.05	4.41	4.14	3.92	3.73	3.58	3.44	3.32
4.5	8.19	5.25	4.59	4.30	4.07	3.88	3.72	3.58	3.46
4.6	8.37	5.46	4.77	4.47	4.24	4.04	3.87	3.73	3.60
4.7	8.55	5.66	4.95	4.65	4.40	4.20	4.02	3.87	3.74
4.8	8.73	5.88	5.14	4.83	4.57	4.36	4.18	4.02	3.88
4.9	8.91	6.09	5.33	5.01	4.74	4.52	4.34	4.17	4.03
5.0	9.10	6.31	5.53	5.19	4.91	4.69	4.49	4.33	4.18
5.1	9.28	6.54	5.72	5.37	5.09	4.86	4.66	4.48	4.33
5.2	9.46	6.76	5.92	5.56	5.27	5.03	4.82	4.64	4.48
5.3	9.64	6.99	6.13	5.75	5.45	5.20	4.99	4.80	4.64
5.4	9.82	7.22	6.33	5.95	5.64	5.38	5.16	4.97	4.80
5.5	10.01	7.46	6.54	6.14	5.82	5.56	5.33	5.13	4.96
5.6	10.19	7.70	6.75	6.34	6.01	5.74	5.51	5.30	5.12
5.7	10.37	7.94	6.97	6.55	6.21	5.92	5.68	5.47	5.29
5.8	10.55	8.19	7.19	6.75	6.40	6.11	5.86	5.65	5.46
5.9	10.73	8.44	7.41	6.96	6.60	6.30	6.05	5.82	5.63
6.0	10.92	8.69	7.63	7.17	6.80	6.49	6.23	6.00	5.80
6.1	11.10	8.95	7.86	7.39	7.01	6.69	6.42	6.18	5.97
6.2	11.28	9.21	8.09	7.60	7.21	6.89	6.61	6.37	6.15
6.3	11.46	9.47	8.32	7.82	7.42	7.09	6.80	6.55	6.33
6.4	11.64	9.74	8.56	8.05	7.63	7.29	7.00	6.74	6.51
6.5	11.82	10.01	8.79	8.27	7.85	7.49	7.19	6.93	6.70
6.6	12.01	10.28	9.04	8.50	8.06	7.70	7.39	7.12	6.89
6.7	12.19	10.56	9.28	8.73	8.28	7.91	7.60	7.32	7.07

1" Uponor AquaPEX (100% water)

psi loss per 100 feet of tubing									
Velocity (ft/s)	gpm	40°F 4°C	60°F 16°C	80°F 27°C	100°F 38°C	120°F 49°C	140°F 60°C	160°F 71°C	180°F 82°C
6.8	12.37	10.83	9.53	8.96	8.51	8.12	7.80	7.52	7.27
6.9	12.55	11.12	9.78	9.20	8.73	8.34	8.01	7.72	7.46
7.0	12.73	11.40	10.03	9.44	8.96	8.56	8.22	7.92	7.66
7.1	12.92	11.69	10.29	9.68	9.19	8.78	8.43	8.12	7.85
7.2	13.10	11.98	10.55	9.92	9.42	9.00	8.65	8.33	8.06
7.3	13.28	12.28	10.81	10.17	9.66	9.23	8.86	8.54	8.26
7.4	13.46	12.57	11.07	10.42	9.89	9.45	9.08	8.75	8.46
7.5	13.64	12.88	11.34	10.67	10.14	9.69	9.30	8.97	8.67
7.6	13.83	13.18	11.61	10.93	10.38	9.92	9.53	9.19	8.88
7.7	14.01	13.49	11.88	11.19	10.62	10.15	9.76	9.40	9.09
7.8	14.19	13.80	12.16	11.45	10.87	10.39	9.98	9.63	9.31
7.9	14.37	14.11	12.44	11.71	11.12	10.63	10.22	9.85	9.53
8.0	14.55	14.43	12.72	11.98	11.38	10.88	10.45	10.08	9.74
8.1	14.74	14.75	13.00	12.25	11.63	11.12	10.69	10.30	9.97
8.2	14.92	15.07	13.29	12.52	11.89	11.37	10.93	10.54	10.19
8.3	15.10	15.40	13.58	12.79	12.15	11.62	11.17	10.77	10.42
8.4	15.28	15.73	13.87	13.07	12.42	11.87	11.41	11.00	10.64
8.5	15.46	16.06	14.17	13.35	12.68	12.13	11.66	11.24	10.87
8.6	15.64	16.39	14.47	13.63	12.95	12.39	11.90	11.48	11.11
8.7	15.83	16.73	14.77	13.91	13.22	12.65	12.16	11.72	11.34
8.8	16.01	17.07	15.07	14.20	13.50	12.91	12.41	11.97	11.58
8.9	16.19	17.42	15.38	14.49	13.77	13.17	12.66	12.22	11.82
9.0	16.37	17.77	15.69	14.78	14.05	13.44	12.92	12.46	12.06
9.1	16.55	18.12	16.00	15.08	14.33	13.71	13.18	12.72	12.30
9.2	16.74	18.47	16.31	15.38	14.62	13.98	13.44	12.97	12.55
9.3	16.92	18.83	16.63	15.68	14.91	14.26	13.71	13.23	12.80
9.4	17.10	19.19	16.95	15.98	15.19	14.54	13.98	13.48	13.05
9.5	17.28	19.55	17.27	16.29	15.49	14.82	14.25	13.74	13.30
9.6	17.46	19.92	17.60	16.60	15.78	15.10	14.52	14.01	13.56
9.7	17.65	20.28	17.93	16.91	16.08	15.38	14.79	14.27	13.81
9.8	17.83	20.66	18.26	17.22	16.38	15.67	15.07	14.54	14.07
9.9	18.01	21.03	18.59	17.54	16.68	15.96	15.35	14.81	14.33
10.0	18.19	21.41	18.93	17.85	16.98	16.25	15.63	15.08	14.60
10.1	18.37	21.79	19.27	18.18	17.29	16.54	15.91	15.36	14.86
10.2	18.56	22.17	19.61	18.50	17.60	16.84	16.20	15.63	15.13
10.3	18.74	22.56	19.96	18.83	17.91	17.14	16.49	15.91	15.40
10.4	18.92	22.95	20.30	19.15	18.22	17.44	16.78	16.19	15.67
10.5	19.10	23.34	20.65	19.49	18.54	17.74	17.07	16.47	15.95
10.6	19.28	23.74	21.01	19.82	18.86	18.05	17.36	16.76	16.23
10.7	19.47	24.14	21.36	20.16	19.18	18.36	17.66	17.05	16.50
10.8	19.65	24.54	21.72	20.50	19.50	18.67	17.96	17.34	16.79
10.9	19.83	24.94	22.08	20.84	19.83	18.98	18.26	17.63	17.07
11.0	20.01	25.35	22.44	21.18	20.16	19.30	18.57	17.92	17.35
11.1	20.19	25.76	22.81	21.53	20.49	19.61	18.87	18.22	17.64
11.2	20.37	26.17	23.18	21.88	20.82	19.93	19.18	18.52	17.93
11.3	20.56	26.59	23.55	22.23	21.16	20.26	19.49	18.82	18.22
11.4	20.74	27.01	23.92	22.58	21.49	20.58	19.81	19.12	18.52
11.5	20.92	27.43	24.30	22.94	21.84	20.91	20.12	19.43	18.81
11.6	21.10	27.85	24.68	23.30	22.18	21.24	20.44	19.74	19.11
11.7	21.28	28.28	25.06	23.66	22.52	21.57	20.76	20.05	19.41
11.8	21.47	28.71	25.45	24.03	22.87	21.90	21.08	20.36	19.72
11.9	21.65	29.14	25.83	24.39	23.22	22.24	21.41	20.67	20.02
12.0	21.83	29.58	26.22	24.76	23.58	22.58	21.73	20.99	20.33

1¼" Uponor AquaPEX (100% water)

psi loss per 100 feet of tubing									
Velocity (ft/s)	gpm	40°F 4°C	60°F 16°C	80°F 27°C	100°F 38°C	120°F 49°C	140°F 60°C	160°F 71°C	180°F 82°C
1.5	4.08	0.60	0.52	0.49	0.46	0.43	0.41	0.40	0.38
1.6	4.35	0.68	0.58	0.54	0.51	0.49	0.46	0.44	0.43
1.7	4.62	0.75	0.65	0.60	0.57	0.54	0.52	0.49	0.48
1.8	4.90	0.83	0.72	0.67	0.63	0.60	0.57	0.55	0.53
1.9	5.17	0.91	0.79	0.73	0.69	0.66	0.63	0.60	0.58
2.0	5.44	0.99	0.86	0.80	0.76	0.72	0.69	0.66	0.64
2.1	5.71	1.08	0.94	0.87	0.82	0.78	0.75	0.72	0.69
2.2	5.98	1.17	1.02	0.95	0.90	0.85	0.81	0.78	0.75
2.3	6.26	1.27	1.10	1.03	0.97	0.92	0.88	0.85	0.81
2.4	6.53	1.36	1.18	1.11	1.04	0.99	0.95	0.91	0.88
2.5	6.80	1.46	1.27	1.19	1.12	1.07	1.02	0.98	0.95
2.6	7.07	1.57	1.36	1.27	1.20	1.14	1.09	1.05	1.01
2.7	7.34	1.67	1.45	1.36	1.29	1.22	1.17	1.12	1.08
2.8	7.62	1.78	1.55	1.45	1.37	1.30	1.25	1.20	1.16
2.9	7.89	1.89	1.65	1.54	1.46	1.39	1.33	1.28	1.23
3.0	8.16	2.01	1.75	1.64	1.55	1.47	1.41	1.36	1.31
3.1	8.43	2.13	1.85	1.74	1.64	1.56	1.50	1.44	1.39
3.2	8.70	2.25	1.96	1.84	1.74	1.65	1.58	1.52	1.47
3.3	8.98	2.37	2.07	1.94	1.83	1.75	1.67	1.61	1.55
3.4	9.25	2.50	2.18	2.04	1.93	1.84	1.76	1.70	1.64
3.5	9.52	2.63	2.29	2.15	2.04	1.94	1.86	1.79	1.72
3.6	9.79	2.76	2.41	2.26	2.14	2.04	1.95	1.88	1.81
3.7	10.06	2.90	2.53	2.37	2.25	2.14	2.05	1.97	1.90
3.8	10.34	3.03	2.65	2.49	2.36	2.25	2.15	2.07	2.00
3.9	10.61	3.18	2.78	2.61	2.47	2.35	2.25	2.17	2.09
4.0	10.88	3.32	2.90	2.73	2.58	2.46	2.36	2.27	2.19
4.1	11.15	3.47	3.03	2.85	2.70	2.57	2.47	2.37	2.29
4.2	11.42	3.62	3.17	2.97	2.81	2.68	2.57	2.48	2.39
4.3	11.70	3.77	3.30	3.10	2.94	2.80	2.68	2.58	2.49
4.4	11.97	3.92	3.44	3.23	3.06	2.92	2.80	2.69	2.60
4.5	12.24	4.08	3.58	3.36	3.18	3.04	2.91	2.80	2.71
4.6	12.51	4.24	3.72	3.49	3.31	3.16	3.03	2.92	2.82
4.7	12.78	4.40	3.86	3.63	3.44	3.28	3.15	3.03	2.93
4.8	13.06	4.57	4.01	3.77	3.57	3.41	3.27	3.15	3.04
4.9	13.33	4.74	4.16	3.91	3.70	3.54	3.39	3.27	3.15
5.0	13.60	4.91	4.31	4.05	3.84	3.67	3.52	3.39	3.27
5.1	13.87	5.08	4.46	4.20	3.98	3.80	3.64	3.51	3.39
5.2	14.14	5.26	4.62	4.34	4.12	3.93	3.77	3.63	3.51
5.3	14.42	5.44	4.78	4.49	4.26	4.07	3.90	3.76	3.63
5.4	14.69	5.62	4.94	4.64	4.41	4.21	4.04	3.89	3.76
5.5	14.96	5.81	5.10	4.80	4.55	4.35	4.17	4.02	3.88
5.6	15.23	5.99	5.27	4.96	4.70	4.49	4.31	4.15	4.01
5.7	15.50	6.18	5.44	5.11	4.85	4.63	4.45	4.29	4.14
5.8	15.78	6.38	5.61	5.27	5.01	4.78	4.59	4.42	4.27
5.9	16.05	6.57	5.78	5.44	5.16	4.93	4.73	4.56	4.41
6.0	16.32	6.77	5.96	5.60	5.32	5.08	4.88	4.70	4.54
6.1	16.59	6.97	6.13	5.77	5.48	5.23	5.02	4.84	4.68
6.2	16.86	7.17	6.31	5.94	5.64	5.39	5.17	4.99	4.82
6.3	17.13	7.38	6.49	6.11	5.80	5.54	5.32	5.13	4.96
6.4	17.41	7.58	6.68	6.29	5.97	5.70	5.48	5.28	5.10
6.5	17.68	7.79	6.87	6.46	6.14	5.86	5.63	5.43	5.25
6.6	17.95	8.01	7.05	6.64	6.31	6.03	5.79	5.58	5.39
6.7	18.22	8.22	7.25	6.82	6.48	6.19	5.95	5.73	5.54

1¼" Uponor AquaPEX (100% water)

psi loss per 100 feet of tubing									
Velocity (ft/s)	gpm	40°F 4°C	60°F 16°C	80°F 27°C	100°F 38°C	120°F 49°C	140°F 60°C	160°F 71°C	180°F 82°C
6.8	18.49	8.44	7.44	7.01	6.65	6.36	6.11	5.89	5.69
6.9	18.77	8.66	7.64	7.19	6.83	6.53	6.27	6.05	5.85
7.0	19.04	8.88	7.83	7.38	7.01	6.70	6.44	6.20	6.00
7.1	19.31	9.11	8.03	7.57	7.19	6.87	6.60	6.37	6.16
7.2	19.58	9.34	8.24	7.76	7.37	7.05	6.77	6.53	6.31
7.3	19.85	9.57	8.44	7.95	7.56	7.22	6.94	6.69	6.47
7.4	20.13	9.80	8.65	8.15	7.74	7.40	7.11	6.86	6.63
7.5	20.40	10.04	8.86	8.35	7.93	7.58	7.29	7.03	6.80
7.6	20.67	10.27	9.07	8.55	8.12	7.77	7.46	7.20	6.96
7.7	20.94	10.51	9.28	8.75	8.31	7.95	7.64	7.37	7.13
7.8	21.21	10.76	9.50	8.95	8.51	8.14	7.82	7.54	7.30
7.9	21.49	11.00	9.72	9.16	8.71	8.33	8.00	7.72	7.47
8.0	21.76	11.25	9.94	9.37	8.90	8.52	8.19	7.90	7.64
8.1	22.03	11.50	10.16	9.58	9.10	8.71	8.37	8.07	7.81
8.2	22.30	11.75	10.38	9.79	9.31	8.90	8.56	8.26	7.99
8.3	22.57	12.01	10.61	10.01	9.51	9.10	8.75	8.44	8.16
8.4	22.85	12.26	10.84	10.22	9.72	9.30	8.94	8.62	8.34
8.5	23.12	12.52	11.07	10.44	9.93	9.50	9.13	8.81	8.52
8.6	23.39	12.79	11.31	10.66	10.14	9.70	9.33	9.00	8.71
8.7	23.66	13.05	11.54	10.89	10.35	9.90	9.52	9.19	8.89
8.8	23.93	13.32	11.78	11.11	10.57	10.11	9.72	9.38	9.08
8.9	24.21	13.59	12.02	11.34	10.78	10.32	9.92	9.57	9.27
9.0	24.48	13.86	12.26	11.57	11.00	10.53	10.12	9.77	9.45
9.1	24.75	14.13	12.51	11.80	11.22	10.74	10.33	9.97	9.65
9.2	25.02	14.41	12.75	12.03	11.45	10.95	10.53	10.17	9.84
9.3	25.29	14.69	13.00	12.27	11.67	11.17	10.74	10.37	10.03
9.4	25.57	14.97	13.25	12.50	11.90	11.39	10.95	10.57	10.23
9.5	25.84	15.25	13.50	12.74	12.13	11.61	11.16	10.77	10.43
9.6	26.11	15.54	13.76	12.99	12.36	11.83	11.38	10.98	10.63
9.7	26.38	15.83	14.02	13.23	12.59	12.05	11.59	11.19	10.83
9.8	26.65	16.12	14.28	13.48	12.82	12.28	11.81	11.40	11.03
9.9	26.93	16.41	14.54	13.72	13.06	12.50	12.03	11.61	11.24
10.0	27.20	16.71	14.80	13.97	13.30	12.73	12.25	11.82	11.45
10.1	27.47	17.00	15.07	14.22	13.54	12.96	12.47	12.04	11.65
10.2	27.74	17.30	15.34	14.48	13.78	13.19	12.70	12.26	11.87
10.3	28.01	17.61	15.61	14.73	14.02	13.43	12.92	12.47	12.08
10.4	28.29	17.91	15.88	14.99	14.27	13.66	13.15	12.69	12.29
10.5	28.56	18.22	16.15	15.25	14.52	13.90	13.38	12.92	12.51
10.6	28.83	18.53	16.43	15.51	14.77	14.14	13.61	13.14	12.72
10.7	29.10	18.84	16.71	15.78	15.02	14.38	13.84	13.37	12.94
10.8	29.37	19.15	16.99	16.04	15.27	14.63	14.08	13.59	13.16
10.9	29.65	19.47	17.27	16.31	15.53	14.87	14.32	13.82	13.39
11.0	29.92	19.79	17.55	16.58	15.79	15.12	14.55	14.05	13.61
11.1	30.19	20.11	17.84	16.85	16.05	15.37	14.79	14.29	13.84
11.2	30.46	20.43	18.13	17.13	16.31	15.62	15.04	14.52	14.06
11.3	30.73	20.76	18.42	17.40	16.57	15.87	15.28	14.76	14.29
11.4	31.01	21.09	18.71	17.68	16.84	16.13	15.53	14.99	14.52
11.5	31.28	21.42	19.01	17.96	17.10	16.39	15.77	15.23	14.75
11.6	31.55	21.75	19.31	18.24	17.37	16.64	16.02	15.48	14.99
11.7	31.82	22.08	19.61	18.53	17.64	16.91	16.27	15.72	15.22
11.8	32.09	22.42	19.91	18.81	17.92	17.17	16.53	15.96	15.46
11.9	32.37	22.76	20.21	19.10	18.19	17.43	16.78	16.21	15.70
12.0	32.64	23.10	20.52	19.39	18.47	17.70	17.04	16.46	15.94

1½" Uponor AquaPEX (100% water)

psi loss per 100 feet of tubing									
Velocity (ft/s)	gpm	40°F 4°C	60°F 16°C	80°F 27°C	100°F 38°C	120°F 49°C	140°F 60°C	160°F 71°C	180°F 82°C
1.5	5.68	0.49	0.42	0.39	0.37	0.35	0.34	0.32	0.31
1.6	6.06	0.55	0.47	0.44	0.42	0.40	0.38	0.36	0.35
1.7	6.44	0.61	0.53	0.49	0.46	0.44	0.42	0.40	0.39
1.8	6.82	0.67	0.58	0.54	0.51	0.49	0.46	0.45	0.43
1.9	7.20	0.74	0.64	0.60	0.56	0.54	0.51	0.49	0.47
2.0	7.58	0.80	0.70	0.65	0.62	0.59	0.56	0.54	0.52
2.1	7.96	0.88	0.76	0.71	0.67	0.64	0.61	0.59	0.57
2.2	8.34	0.95	0.83	0.77	0.73	0.69	0.66	0.64	0.61
2.3	8.71	1.03	0.89	0.83	0.79	0.75	0.72	0.69	0.67
2.4	9.09	1.10	0.96	0.90	0.85	0.81	0.77	0.74	0.72
2.5	9.47	1.19	1.03	0.97	0.91	0.87	0.83	0.80	0.77
2.6	9.85	1.27	1.11	1.04	0.98	0.93	0.89	0.86	0.83
2.7	10.23	1.36	1.18	1.11	1.05	1.00	0.96	0.92	0.89
2.8	10.61	1.45	1.26	1.18	1.12	1.06	1.02	0.98	0.95
2.9	10.99	1.54	1.34	1.26	1.19	1.13	1.08	1.04	1.01
3.0	11.37	1.63	1.42	1.33	1.26	1.20	1.15	1.11	1.07
3.1	11.75	1.73	1.51	1.41	1.34	1.28	1.22	1.18	1.13
3.2	12.12	1.83	1.60	1.50	1.42	1.35	1.29	1.24	1.20
3.3	12.50	1.93	1.68	1.58	1.50	1.43	1.37	1.31	1.27
3.4	12.88	2.03	1.78	1.67	1.58	1.50	1.44	1.39	1.34
3.5	13.26	2.14	1.87	1.75	1.66	1.58	1.52	1.46	1.41
3.6	13.64	2.24	1.96	1.84	1.75	1.66	1.60	1.54	1.48
3.7	14.02	2.35	2.06	1.94	1.83	1.75	1.68	1.61	1.56
3.8	14.40	2.47	2.16	2.03	1.92	1.83	1.76	1.69	1.63
3.9	14.78	2.58	2.26	2.12	2.01	1.92	1.84	1.77	1.71
4.0	15.16	2.70	2.37	2.22	2.11	2.01	1.93	1.85	1.79
4.1	15.53	2.82	2.47	2.32	2.20	2.10	2.01	1.94	1.87
4.2	15.91	2.94	2.58	2.42	2.30	2.19	2.10	2.02	1.96
4.3	16.29	3.06	2.69	2.53	2.40	2.29	2.19	2.11	2.04
4.4	16.67	3.19	2.80	2.63	2.50	2.38	2.29	2.20	2.13
4.5	17.05	3.32	2.91	2.74	2.60	2.48	2.38	2.29	2.21
4.6	17.43	3.45	3.03	2.85	2.70	2.58	2.48	2.38	2.30
4.7	17.81	3.58	3.15	2.96	2.81	2.68	2.57	2.48	2.39
4.8	18.19	3.72	3.27	3.07	2.92	2.78	2.67	2.57	2.49
4.9	18.57	3.86	3.39	3.19	3.03	2.89	2.77	2.67	2.58
5.0	18.94	4.00	3.51	3.31	3.14	2.99	2.87	2.77	2.68
5.1	19.32	4.14	3.64	3.42	3.25	3.10	2.98	2.87	2.77
5.2	19.70	4.28	3.77	3.54	3.36	3.21	3.08	2.97	2.87
5.3	20.08	4.43	3.90	3.67	3.48	3.32	3.19	3.08	2.97
5.4	20.46	4.58	4.03	3.79	3.60	3.44	3.30	3.18	3.07
5.5	20.84	4.73	4.16	3.92	3.72	3.55	3.41	3.29	3.18
5.6	21.22	4.88	4.30	4.05	3.84	3.67	3.52	3.40	3.28
5.7	21.60	5.03	4.44	4.18	3.96	3.79	3.64	3.51	3.39
5.8	21.98	5.19	4.57	4.31	4.09	3.91	3.75	3.62	3.50
5.9	22.35	5.35	4.72	4.44	4.22	4.03	3.87	3.73	3.61
6.0	22.73	5.51	4.86	4.58	4.35	4.15	3.99	3.85	3.72
6.1	23.11	5.67	5.00	4.71	4.48	4.28	4.11	3.96	3.83
6.2	23.49	5.84	5.15	4.85	4.61	4.41	4.23	4.08	3.94
6.3	23.87	6.01	5.30	4.99	4.74	4.53	4.36	4.20	4.06
6.4	24.25	6.18	5.45	5.13	4.88	4.66	4.48	4.32	4.18
6.5	24.63	6.35	5.60	5.28	5.02	4.80	4.61	4.44	4.30
6.6	25.01	6.52	5.76	5.43	5.16	4.93	4.74	4.57	4.42
6.7	25.38	6.70	5.91	5.57	5.30	5.06	4.87	4.69	4.54

1½" Uponor AquaPEX (100% water)

psi loss per 100 feet of tubing									
Velocity (ft/s)	gpm	40°F 4°C	60°F 16°C	80°F 27°C	100°F 38°C	120°F 49°C	140°F 60°C	160°F 71°C	180°F 82°C
6.8	25.76	6.88	6.07	5.72	5.44	5.20	5.00	4.82	4.66
6.9	26.14	7.06	6.23	5.87	5.58	5.34	5.13	4.95	4.79
7.0	26.52	7.24	6.39	6.03	5.73	5.48	5.27	5.08	4.91
7.1	26.90	7.42	6.56	6.18	5.88	5.62	5.40	5.21	5.04
7.2	27.28	7.61	6.72	6.34	6.03	5.76	5.54	5.34	5.17
7.3	27.66	7.80	6.89	6.50	6.18	5.91	5.68	5.48	5.30
7.4	28.04	7.99	7.06	6.66	6.33	6.05	5.82	5.61	5.43
7.5	28.42	8.18	7.23	6.82	6.48	6.20	5.96	5.75	5.56
7.6	28.79	8.37	7.40	6.98	6.64	6.35	6.11	5.89	5.70
7.7	29.17	8.57	7.58	7.15	6.80	6.50	6.25	6.03	5.84
7.8	29.55	8.77	7.76	7.32	6.96	6.66	6.40	6.17	5.97
7.9	29.93	8.97	7.93	7.48	7.12	6.81	6.55	6.32	6.11
8.0	30.31	9.17	8.12	7.66	7.28	6.97	6.70	6.46	6.25
8.1	30.69	9.37	8.30	7.83	7.45	7.13	6.85	6.61	6.40
8.2	31.07	9.58	8.48	8.00	7.61	7.28	7.01	6.76	6.54
8.3	31.45	9.79	8.67	8.18	7.78	7.45	7.16	6.91	6.69
8.4	31.83	10.00	8.85	8.36	7.95	7.61	7.32	7.06	6.83
8.5	32.20	10.21	9.04	8.53	8.12	7.77	7.48	7.21	6.98
8.6	32.58	10.42	9.23	8.72	8.29	7.94	7.63	7.37	7.13
8.7	32.96	10.64	9.43	8.90	8.47	8.10	7.80	7.52	7.28
8.8	33.34	10.86	9.62	9.08	8.64	8.27	7.96	7.68	7.43
8.9	33.72	11.08	9.82	9.27	8.82	8.44	8.12	7.84	7.59
9.0	34.10	11.30	10.02	9.46	9.00	8.62	8.29	8.00	7.74
9.1	34.48	11.53	10.22	9.65	9.18	8.79	8.46	8.16	7.90
9.2	34.86	11.75	10.42	9.84	9.36	8.96	8.62	8.32	8.06
9.3	35.24	11.98	10.62	10.03	9.55	9.14	8.79	8.49	8.22
9.4	35.61	12.21	10.83	10.22	9.73	9.32	8.97	8.66	8.38
9.5	35.99	12.44	11.03	10.42	9.92	9.50	9.14	8.82	8.54
9.6	36.37	12.67	11.24	10.62	10.11	9.68	9.31	8.99	8.71
9.7	36.75	12.91	11.45	10.82	10.30	9.86	9.49	9.16	8.87
9.8	37.13	13.15	11.67	11.02	10.49	10.05	9.67	9.33	9.04
9.9	37.51	13.39	11.88	11.22	10.68	10.23	9.85	9.51	9.21
10.0	37.89	13.63	12.10	11.43	10.88	10.42	10.03	9.68	9.38
10.1	38.27	13.87	12.31	11.63	11.08	10.61	10.21	9.86	9.55
10.2	38.65	14.12	12.53	11.84	11.28	10.80	10.39	10.04	9.72
10.3	39.02	14.36	12.75	12.05	11.48	10.99	10.58	10.22	9.89
10.4	39.40	14.61	12.98	12.26	11.68	11.19	10.77	10.40	10.07
10.5	39.78	14.86	13.20	12.47	11.88	11.38	10.96	10.58	10.25
10.6	40.16	15.12	13.43	12.69	12.08	11.58	11.14	10.76	10.42
10.7	40.54	15.37	13.65	12.90	12.29	11.78	11.34	10.95	10.60
10.8	40.92	15.63	13.88	13.12	12.50	11.98	11.53	11.13	10.78
10.9	41.30	15.89	14.12	13.34	12.71	12.18	11.72	11.32	10.97
11.0	41.68	16.15	14.35	13.56	12.92	12.38	11.92	11.51	11.15
11.1	42.06	16.41	14.58	13.78	13.13	12.58	12.12	11.70	11.33
11.2	42.43	16.67	14.82	14.01	13.35	12.79	12.31	11.89	11.52
11.3	42.81	16.94	15.06	14.24	13.56	13.00	12.51	12.09	11.71
11.4	43.19	17.21	15.30	14.46	13.78	13.21	12.72	12.28	11.90
11.5	43.57	17.48	15.54	14.69	14.00	13.42	12.92	12.48	12.09
11.6	43.95	17.75	15.78	14.92	14.22	13.63	13.12	12.68	12.28
11.7	44.33	18.02	16.03	15.16	14.44	13.84	13.33	12.88	12.47
11.8	44.71	18.30	16.28	15.39	14.67	14.06	13.54	13.08	12.67
11.9	45.09	18.58	16.52	15.62	14.89	14.27	13.75	13.28	12.86
12.0	45.47	18.86	16.77	15.86	15.12	14.49	13.96	13.48	13.06

2" Uponor AquaPEX (100% water)

psi loss per 100 feet of tubing									
Velocity (ft/s)	gpm	40°F 4°C	60°F 16°C	80°F 27°C	100°F 38°C	120°F 49°C	140°F 60°C	160°F 71°C	180°F 82°C
1.5	9.75	0.35	0.30	0.28	0.27	0.25	0.24	0.23	0.22
1.6	10.39	0.39	0.34	0.32	0.30	0.28	0.27	0.26	0.25
1.7	11.04	0.43	0.38	0.35	0.33	0.32	0.30	0.29	0.28
1.8	11.69	0.48	0.41	0.39	0.37	0.35	0.33	0.32	0.31
1.9	12.34	0.52	0.46	0.43	0.40	0.38	0.37	0.35	0.34
2.0	12.99	0.57	0.50	0.47	0.44	0.42	0.40	0.39	0.37
2.1	13.64	0.62	0.54	0.51	0.48	0.46	0.44	0.42	0.41
2.2	14.29	0.68	0.59	0.55	0.52	0.50	0.48	0.46	0.44
2.3	14.94	0.73	0.64	0.60	0.57	0.54	0.52	0.50	0.48
2.4	15.59	0.79	0.69	0.64	0.61	0.58	0.56	0.54	0.52
2.5	16.24	0.85	0.74	0.69	0.66	0.63	0.60	0.58	0.56
2.6	16.89	0.91	0.79	0.74	0.70	0.67	0.64	0.62	0.60
2.7	17.54	0.97	0.85	0.79	0.75	0.72	0.69	0.66	0.64
2.8	18.19	1.03	0.90	0.85	0.80	0.77	0.73	0.71	0.68
2.9	18.84	1.10	0.96	0.90	0.85	0.81	0.78	0.75	0.73
3.0	19.49	1.16	1.02	0.96	0.91	0.87	0.83	0.80	0.77
3.1	20.14	1.23	1.08	1.02	0.96	0.92	0.88	0.85	0.82
3.2	20.79	1.30	1.14	1.07	1.02	0.97	0.93	0.90	0.87
3.3	21.44	1.38	1.21	1.13	1.08	1.03	0.98	0.95	0.91
3.4	22.09	1.45	1.27	1.20	1.13	1.08	1.04	1.00	0.97
3.5	22.74	1.53	1.34	1.26	1.19	1.14	1.09	1.05	1.02
3.6	23.39	1.60	1.41	1.32	1.26	1.20	1.15	1.11	1.07
3.7	24.04	1.68	1.48	1.39	1.32	1.26	1.21	1.16	1.12
3.8	24.69	1.76	1.55	1.46	1.38	1.32	1.27	1.22	1.18
3.9	25.34	1.85	1.62	1.53	1.45	1.38	1.33	1.28	1.24
4.0	25.99	1.93	1.70	1.60	1.52	1.45	1.39	1.34	1.29
4.1	26.64	2.02	1.77	1.67	1.58	1.51	1.45	1.40	1.35
4.2	27.29	2.10	1.85	1.74	1.65	1.58	1.52	1.46	1.41
4.3	27.94	2.19	1.93	1.82	1.72	1.65	1.58	1.52	1.47
4.4	28.59	2.28	2.01	1.89	1.80	1.72	1.65	1.59	1.54
4.5	29.24	2.38	2.09	1.97	1.87	1.79	1.72	1.65	1.60
4.6	29.89	2.47	2.18	2.05	1.95	1.86	1.79	1.72	1.66
4.7	30.54	2.57	2.26	2.13	2.02	1.93	1.86	1.79	1.73
4.8	31.18	2.66	2.35	2.21	2.10	2.01	1.93	1.86	1.80
4.9	31.83	2.76	2.44	2.29	2.18	2.08	2.00	1.93	1.86
5.0	32.48	2.86	2.53	2.38	2.26	2.16	2.07	2.00	1.93
5.1	33.13	2.96	2.62	2.46	2.34	2.24	2.15	2.07	2.00
5.2	33.78	3.07	2.71	2.55	2.42	2.32	2.23	2.15	2.08
5.3	34.43	3.17	2.80	2.64	2.51	2.40	2.30	2.22	2.15
5.4	35.08	3.28	2.90	2.73	2.59	2.48	2.38	2.30	2.22
5.5	35.73	3.39	2.99	2.82	2.68	2.56	2.46	2.37	2.30
5.6	36.38	3.50	3.09	2.91	2.77	2.65	2.54	2.45	2.37
5.7	37.03	3.61	3.19	3.01	2.86	2.73	2.63	2.53	2.45
5.8	37.68	3.72	3.29	3.10	2.95	2.82	2.71	2.61	2.53
5.9	38.33	3.84	3.39	3.20	3.04	2.91	2.80	2.70	2.61
6.0	38.98	3.95	3.49	3.30	3.13	3.00	2.88	2.78	2.69
6.1	39.63	4.07	3.60	3.39	3.23	3.09	2.97	2.86	2.77
6.2	40.28	4.19	3.71	3.50	3.32	3.18	3.06	2.95	2.85
6.3	40.93	4.31	3.81	3.60	3.42	3.27	3.15	3.03	2.94
6.4	41.58	4.43	3.92	3.70	3.52	3.37	3.24	3.12	3.02
6.5	42.23	4.55	4.03	3.80	3.62	3.46	3.33	3.21	3.11
6.6	42.88	4.68	4.14	3.91	3.72	3.56	3.42	3.30	3.19
6.7	43.53	4.81	4.26	4.02	3.82	3.66	3.52	3.39	3.28

2" Uponor AquaPEX (100% water)

psi loss per 100 feet of tubing									
Velocity (ft/s)	gpm	40°F 4°C	60°F 16°C	80°F 27°C	100°F 38°C	120°F 49°C	140°F 60°C	160°F 71°C	180°F 82°C
6.8	44.18	4.93	4.37	4.12	3.92	3.75	3.61	3.48	3.37
6.9	44.83	5.06	4.49	4.23	4.03	3.86	3.71	3.58	3.46
7.0	45.48	5.19	4.60	4.34	4.13	3.96	3.81	3.67	3.55
7.1	46.13	5.33	4.72	4.46	4.24	4.06	3.90	3.77	3.65
7.2	46.78	5.46	4.84	4.57	4.35	4.16	4.00	3.86	3.74
7.3	47.43	5.60	4.96	4.68	4.46	4.27	4.10	3.96	3.83
7.4	48.08	5.73	5.08	4.80	4.57	4.37	4.21	4.06	3.93
7.5	48.73	5.87	5.21	4.92	4.68	4.48	4.31	4.16	4.03
7.6	49.38	6.01	5.33	5.04	4.79	4.59	4.41	4.26	4.12
7.7	50.03	6.15	5.46	5.16	4.91	4.70	4.52	4.36	4.22
7.8	50.68	6.30	5.59	5.28	5.02	4.81	4.63	4.47	4.32
7.9	51.33	6.44	5.72	5.40	5.14	4.92	4.73	4.57	4.42
8.0	51.97	6.59	5.85	5.52	5.26	5.03	4.84	4.68	4.53
8.1	52.62	6.73	5.98	5.65	5.38	5.15	4.95	4.78	4.63
8.2	53.27	6.88	6.11	5.77	5.50	5.26	5.06	4.89	4.73
8.3	53.92	7.03	6.24	5.90	5.62	5.38	5.18	5.00	4.84
8.4	54.57	7.18	6.38	6.03	5.74	5.50	5.29	5.11	4.95
8.5	55.22	7.34	6.52	6.16	5.86	5.62	5.41	5.22	5.05
8.6	55.87	7.49	6.65	6.29	5.99	5.74	5.52	5.33	5.16
8.7	56.52	7.65	6.79	6.42	6.11	5.86	5.64	5.44	5.27
8.8	57.17	7.80	6.93	6.55	6.24	5.98	5.76	5.56	5.38
8.9	57.82	7.96	7.08	6.69	6.37	6.10	5.87	5.67	5.49
9.0	58.47	8.12	7.22	6.82	6.50	6.23	5.99	5.79	5.61
9.1	59.12	8.28	7.36	6.96	6.63	6.35	6.12	5.91	5.72
9.2	59.77	8.45	7.51	7.10	6.76	6.48	6.24	6.02	5.83
9.3	60.42	8.61	7.66	7.24	6.90	6.61	6.36	6.14	5.95
9.4	61.07	8.78	7.81	7.38	7.03	6.74	6.49	6.26	6.07
9.5	61.72	8.94	7.95	7.52	7.17	6.87	6.61	6.39	6.18
9.6	62.37	9.11	8.11	7.66	7.30	7.00	6.74	6.51	6.30
9.7	63.02	9.28	8.26	7.81	7.44	7.13	6.87	6.63	6.42
9.8	63.67	9.45	8.41	7.95	7.58	7.26	6.99	6.76	6.54
9.9	64.32	9.63	8.57	8.10	7.72	7.40	7.12	6.88	6.67
10.0	64.97	9.80	8.72	8.25	7.86	7.53	7.26	7.01	6.79
10.1	65.62	9.98	8.88	8.40	8.00	7.67	7.39	7.14	6.91
10.2	66.27	10.15	9.04	8.55	8.15	7.81	7.52	7.27	7.04
10.3	66.92	10.33	9.20	8.70	8.29	7.95	7.66	7.40	7.16
10.4	67.57	10.51	9.36	8.85	8.44	8.09	7.79	7.53	7.29
10.5	68.22	10.69	9.52	9.01	8.59	8.23	7.93	7.66	7.42
10.6	68.87	10.87	9.68	9.16	8.73	8.37	8.06	7.79	7.55
10.7	69.52	11.06	9.85	9.32	8.88	8.52	8.20	7.93	7.68
10.8	70.17	11.24	10.02	9.48	9.03	8.66	8.34	8.06	7.81
10.9	70.82	11.43	10.18	9.63	9.19	8.81	8.48	8.20	7.94
11.0	71.47	11.62	10.35	9.79	9.34	8.95	8.63	8.33	8.07
11.1	72.12	11.81	10.52	9.96	9.49	9.10	8.77	8.47	8.21
11.2	72.76	12.00	10.69	10.12	9.65	9.25	8.91	8.61	8.34
11.3	73.41	12.19	10.86	10.28	9.80	9.40	9.06	8.75	8.48
11.4	74.06	12.38	11.04	10.45	9.96	9.55	9.20	8.89	8.62
11.5	74.71	12.58	11.21	10.61	10.12	9.71	9.35	9.04	8.76
11.6	75.36	12.78	11.39	10.78	10.28	9.86	9.50	9.18	8.89
11.7	76.01	12.97	11.57	10.95	10.44	10.01	9.65	9.32	9.04
11.8	76.66	13.17	11.74	11.12	10.60	10.17	9.80	9.47	9.18
11.9	77.31	13.37	11.92	11.29	10.77	10.33	9.95	9.62	9.32
12.0	77.96	13.57	12.11	11.46	10.93	10.48	10.10	9.76	9.46

2½" Uponor AquaPEX (100% water)

psi loss per 100 feet of tubing									
Velocity (ft/s)	gpm	40°F 4°C	60°F 16°C	80°F 27°C	100°F 38°C	120°F 49°C	140°F 60°C	160°F 71°C	180°F 82°C
1.5	14.85	0.27	0.23	0.22	0.20	0.19	0.19	0.18	0.17
1.6	15.84	0.30	0.26	0.24	0.23	0.22	0.21	0.20	0.19
1.7	16.83	0.33	0.29	0.27	0.26	0.24	0.23	0.22	0.22
1.8	17.82	0.37	0.32	0.30	0.28	0.27	0.26	0.25	0.24
1.9	18.81	0.40	0.35	0.33	0.31	0.30	0.28	0.27	0.26
2.0	19.80	0.44	0.38	0.36	0.34	0.32	0.31	0.30	0.29
2.1	20.79	0.48	0.42	0.39	0.37	0.35	0.34	0.33	0.32
2.2	21.78	0.52	0.45	0.43	0.40	0.38	0.37	0.35	0.34
2.3	22.77	0.56	0.49	0.46	0.44	0.42	0.40	0.38	0.37
2.4	23.76	0.61	0.53	0.50	0.47	0.45	0.43	0.41	0.40
2.5	24.75	0.65	0.57	0.54	0.51	0.48	0.46	0.45	0.43
2.6	25.74	0.70	0.61	0.57	0.54	0.52	0.50	0.48	0.46
2.7	26.73	0.74	0.65	0.61	0.58	0.55	0.53	0.51	0.49
2.8	27.72	0.79	0.70	0.65	0.62	0.59	0.57	0.55	0.53
2.9	28.71	0.84	0.74	0.70	0.66	0.63	0.60	0.58	0.56
3.0	29.70	0.90	0.79	0.74	0.70	0.67	0.64	0.62	0.60
3.1	30.69	0.95	0.83	0.78	0.74	0.71	0.68	0.66	0.63
3.2	31.68	1.00	0.88	0.83	0.79	0.75	0.72	0.69	0.67
3.3	32.67	1.06	0.93	0.88	0.83	0.79	0.76	0.73	0.71
3.4	33.66	1.12	0.98	0.92	0.88	0.84	0.80	0.77	0.75
3.5	34.65	1.18	1.03	0.97	0.92	0.88	0.85	0.82	0.79
3.6	35.64	1.23	1.09	1.02	0.97	0.93	0.89	0.86	0.83
3.7	36.63	1.30	1.14	1.08	1.02	0.98	0.94	0.90	0.87
3.8	37.62	1.36	1.20	1.13	1.07	1.02	0.98	0.95	0.91
3.9	38.61	1.42	1.25	1.18	1.12	1.07	1.03	0.99	0.96
4.0	39.60	1.49	1.31	1.24	1.17	1.12	1.08	1.04	1.00
4.1	40.59	1.55	1.37	1.29	1.23	1.17	1.13	1.09	1.05
4.2	41.58	1.62	1.43	1.35	1.28	1.22	1.18	1.13	1.10
4.3	42.57	1.69	1.49	1.41	1.34	1.28	1.23	1.18	1.14
4.4	43.57	1.76	1.55	1.47	1.39	1.33	1.28	1.23	1.19
4.5	44.56	1.83	1.62	1.53	1.45	1.39	1.33	1.28	1.24
4.6	45.55	1.90	1.68	1.59	1.51	1.44	1.39	1.34	1.29
4.7	46.54	1.98	1.75	1.65	1.57	1.50	1.44	1.39	1.34
4.8	47.53	2.05	1.82	1.71	1.63	1.56	1.50	1.44	1.39
4.9	48.52	2.13	1.88	1.78	1.69	1.61	1.55	1.50	1.45
5.0	49.51	2.21	1.95	1.84	1.75	1.67	1.61	1.55	1.50
5.1	50.50	2.29	2.02	1.91	1.81	1.74	1.67	1.61	1.56
5.2	51.49	2.37	2.09	1.98	1.88	1.80	1.73	1.67	1.61
5.3	52.48	2.45	2.17	2.04	1.94	1.86	1.79	1.72	1.67
5.4	53.47	2.53	2.24	2.11	2.01	1.92	1.85	1.78	1.73
5.5	54.46	2.61	2.32	2.18	2.08	1.99	1.91	1.84	1.78
5.6	55.45	2.70	2.39	2.26	2.15	2.05	1.97	1.91	1.84
5.7	56.44	2.79	2.47	2.33	2.22	2.12	2.04	1.97	1.90
5.8	57.43	2.87	2.55	2.40	2.29	2.19	2.10	2.03	1.96
5.9	58.42	2.96	2.62	2.48	2.36	2.26	2.17	2.09	2.03
6.0	59.41	3.05	2.71	2.55	2.43	2.33	2.24	2.16	2.09
6.1	60.40	3.14	2.79	2.63	2.50	2.40	2.30	2.22	2.15
6.2	61.39	3.23	2.87	2.71	2.58	2.47	2.37	2.29	2.22
6.3	62.38	3.33	2.95	2.79	2.65	2.54	2.44	2.36	2.28
6.4	63.37	3.42	3.04	2.87	2.73	2.61	2.51	2.43	2.35
6.5	64.36	3.52	3.12	2.95	2.81	2.69	2.58	2.49	2.41
6.6	65.35	3.61	3.21	3.03	2.88	2.76	2.66	2.56	2.48
6.7	66.34	3.71	3.30	3.11	2.96	2.84	2.73	2.64	2.55

2½" Uponor AquaPEX (100% water)

psi loss per 100 feet of tubing									
Velocity (ft/s)	gpm	40°F 4°C	60°F 16°C	80°F 27°C	100°F 38°C	120°F 49°C	140°F 60°C	160°F 71°C	180°F 82°C
6.8	67.33	3.81	3.38	3.20	3.04	2.91	2.80	2.71	2.62
6.9	68.32	3.91	3.47	3.28	3.12	2.99	2.88	2.78	2.69
7.0	69.31	4.01	3.56	3.37	3.21	3.07	2.96	2.85	2.76
7.1	70.30	4.12	3.66	3.45	3.29	3.15	3.03	2.93	2.83
7.2	71.29	4.22	3.75	3.54	3.37	3.23	3.11	3.00	2.91
7.3	72.28	4.33	3.84	3.63	3.46	3.31	3.19	3.08	2.98
7.4	73.27	4.43	3.94	3.72	3.54	3.40	3.27	3.16	3.06
7.5	74.26	4.54	4.03	3.81	3.63	3.48	3.35	3.23	3.13
7.6	75.25	4.65	4.13	3.90	3.72	3.56	3.43	3.31	3.21
7.7	76.24	4.76	4.23	4.00	3.81	3.65	3.51	3.39	3.28
7.8	77.23	4.87	4.33	4.09	3.90	3.73	3.60	3.47	3.36
7.9	78.22	4.98	4.43	4.19	3.99	3.82	3.68	3.55	3.44
8.0	79.21	5.09	4.53	4.28	4.08	3.91	3.76	3.63	3.52
8.1	80.20	5.21	4.63	4.38	4.17	4.00	3.85	3.72	3.60
8.2	81.19	5.32	4.73	4.48	4.27	4.09	3.94	3.80	3.68
8.3	82.18	5.44	4.84	4.58	4.36	4.18	4.02	3.89	3.76
8.4	83.17	5.55	4.94	4.68	4.46	4.27	4.11	3.97	3.85
8.5	84.16	5.67	5.05	4.78	4.55	4.36	4.20	4.06	3.93
8.6	85.15	5.79	5.16	4.88	4.65	4.46	4.29	4.14	4.01
8.7	86.14	5.91	5.27	4.98	4.75	4.55	4.38	4.23	4.10
8.8	87.13	6.04	5.37	5.08	4.85	4.65	4.47	4.32	4.19
8.9	88.12	6.16	5.49	5.19	4.95	4.74	4.57	4.41	4.27
9.0	89.11	6.28	5.60	5.29	5.05	4.84	4.66	4.50	4.36
9.1	90.10	6.41	5.71	5.40	5.15	4.94	4.75	4.59	4.45
9.2	91.09	6.53	5.82	5.51	5.25	5.03	4.85	4.68	4.54
9.3	92.08	6.66	5.94	5.62	5.36	5.13	4.95	4.78	4.63
9.4	93.07	6.79	6.05	5.73	5.46	5.23	5.04	4.87	4.72
9.5	94.06	6.92	6.17	5.84	5.57	5.34	5.14	4.97	4.81
9.6	95.05	7.05	6.28	5.95	5.67	5.44	5.24	5.06	4.90
9.7	96.04	7.18	6.40	6.06	5.78	5.54	5.34	5.16	5.00
9.8	97.03	7.32	6.52	6.17	5.89	5.65	5.44	5.25	5.09
9.9	98.02	7.45	6.64	6.29	6.00	5.75	5.54	5.35	5.19
10.0	99.01	7.58	6.76	6.40	6.11	5.86	5.64	5.45	5.28
10.1	100.00	7.72	6.89	6.52	6.22	5.96	5.74	5.55	5.38
10.2	100.99	7.86	7.01	6.64	6.33	6.07	5.85	5.65	5.48
10.3	101.98	8.00	7.13	6.75	6.44	6.18	5.95	5.75	5.57
10.4	102.97	8.14	7.26	6.87	6.56	6.29	6.06	5.85	5.67
10.5	103.96	8.28	7.38	6.99	6.67	6.40	6.16	5.96	5.77
10.6	104.95	8.42	7.51	7.11	6.79	6.51	6.27	6.06	5.87
10.7	105.94	8.56	7.64	7.23	6.90	6.62	6.38	6.17	5.97
10.8	106.93	8.70	7.77	7.36	7.02	6.73	6.49	6.27	6.08
10.9	107.92	8.85	7.90	7.48	7.14	6.85	6.60	6.38	6.18
11.0	108.91	8.99	8.03	7.60	7.26	6.96	6.71	6.48	6.28
11.1	109.90	9.14	8.16	7.73	7.38	7.08	6.82	6.59	6.39
11.2	110.89	9.29	8.29	7.86	7.50	7.19	6.93	6.70	6.49
11.3	111.88	9.44	8.43	7.98	7.62	7.31	7.04	6.81	6.60
11.4	112.87	9.59	8.56	8.11	7.74	7.43	7.16	6.92	6.71
11.5	113.86	9.74	8.70	8.24	7.86	7.55	7.27	7.03	6.81
11.6	114.85	9.89	8.84	8.37	7.99	7.66	7.39	7.14	6.92
11.7	115.84	10.05	8.97	8.50	8.11	7.79	7.50	7.25	7.03
11.8	116.83	10.20	9.11	8.63	8.24	7.91	7.62	7.37	7.14
11.9	117.82	10.35	9.25	8.77	8.37	8.03	7.74	7.48	7.25
12.0	118.81	10.51	9.39	8.90	8.49	8.15	7.86	7.60	7.36

3" Uponor AquaPEX (100% water)

psi loss per 100 feet of tubing									
Velocity (ft/s)	gpm	40°F 4°C	60°F 16°C	80°F 27°C	100°F 38°C	120°F 49°C	140°F 60°C	160°F 71°C	180°F 82°C
1.5	21.12	0.21	0.19	0.17	0.16	0.16	0.15	0.14	0.14
1.6	22.53	0.24	0.21	0.20	0.18	0.18	0.17	0.16	0.16
1.7	23.93	0.27	0.23	0.22	0.21	0.20	0.19	0.18	0.17
1.8	25.34	0.29	0.26	0.24	0.23	0.22	0.21	0.20	0.19
1.9	26.75	0.32	0.28	0.26	0.25	0.24	0.23	0.22	0.21
2.0	28.16	0.35	0.31	0.29	0.27	0.26	0.25	0.24	0.23
2.1	29.57	0.38	0.34	0.32	0.30	0.29	0.27	0.26	0.25
2.2	30.97	0.42	0.37	0.34	0.33	0.31	0.30	0.29	0.28
2.3	32.38	0.45	0.40	0.37	0.35	0.34	0.32	0.31	0.30
2.4	33.79	0.49	0.43	0.40	0.38	0.36	0.35	0.34	0.32
2.5	35.20	0.52	0.46	0.43	0.41	0.39	0.37	0.36	0.35
2.6	36.60	0.56	0.49	0.46	0.44	0.42	0.40	0.39	0.37
2.7	38.01	0.60	0.53	0.49	0.47	0.45	0.43	0.41	0.40
2.8	39.42	0.64	0.56	0.53	0.50	0.48	0.46	0.44	0.43
2.9	40.83	0.68	0.60	0.56	0.53	0.51	0.49	0.47	0.45
3.0	42.24	0.72	0.63	0.60	0.57	0.54	0.52	0.50	0.48
3.1	43.64	0.76	0.67	0.63	0.60	0.57	0.55	0.53	0.51
3.2	45.05	0.81	0.71	0.67	0.64	0.61	0.58	0.56	0.54
3.3	46.46	0.85	0.75	0.71	0.67	0.64	0.62	0.59	0.57
3.4	47.87	0.90	0.79	0.75	0.71	0.68	0.65	0.63	0.61
3.5	49.28	0.95	0.83	0.79	0.75	0.71	0.69	0.66	0.64
3.6	50.68	0.99	0.88	0.83	0.79	0.75	0.72	0.69	0.67
3.7	52.09	1.04	0.92	0.87	0.82	0.79	0.76	0.73	0.71
3.8	53.50	1.09	0.97	0.91	0.87	0.83	0.79	0.77	0.74
3.9	54.91	1.15	1.01	0.95	0.91	0.87	0.83	0.80	0.78
4.0	56.31	1.20	1.06	1.00	0.95	0.91	0.87	0.84	0.81
4.1	57.72	1.25	1.11	1.04	0.99	0.95	0.91	0.88	0.85
4.2	59.13	1.31	1.15	1.09	1.04	0.99	0.95	0.92	0.89
4.3	60.54	1.36	1.20	1.14	1.08	1.03	0.99	0.96	0.93
4.4	61.95	1.42	1.25	1.18	1.13	1.08	1.03	1.00	0.97
4.5	63.35	1.48	1.31	1.23	1.17	1.12	1.08	1.04	1.01
4.6	64.76	1.53	1.36	1.28	1.22	1.17	1.12	1.08	1.05
4.7	66.17	1.59	1.41	1.33	1.27	1.21	1.17	1.12	1.09
4.8	67.58	1.65	1.47	1.38	1.32	1.26	1.21	1.17	1.13
4.9	68.99	1.72	1.52	1.44	1.37	1.31	1.26	1.21	1.17
5.0	70.39	1.78	1.58	1.49	1.42	1.36	1.30	1.26	1.22
5.1	71.80	1.84	1.63	1.54	1.47	1.40	1.35	1.30	1.26
5.2	73.21	1.91	1.69	1.60	1.52	1.45	1.40	1.35	1.31
5.3	74.62	1.97	1.75	1.65	1.57	1.51	1.45	1.40	1.35
5.4	76.02	2.04	1.81	1.71	1.63	1.56	1.50	1.45	1.40
5.5	77.43	2.11	1.87	1.77	1.68	1.61	1.55	1.49	1.45
5.6	78.84	2.18	1.93	1.82	1.74	1.66	1.60	1.54	1.49
5.7	80.25	2.25	1.99	1.88	1.79	1.72	1.65	1.59	1.54
5.8	81.66	2.32	2.06	1.94	1.85	1.77	1.70	1.64	1.59
5.9	83.06	2.39	2.12	2.00	1.91	1.83	1.76	1.70	1.64
6.0	84.47	2.46	2.19	2.06	1.97	1.88	1.81	1.75	1.69
6.1	85.88	2.53	2.25	2.13	2.03	1.94	1.87	1.80	1.74
6.2	87.29	2.61	2.32	2.19	2.09	2.00	1.92	1.86	1.80
6.3	88.70	2.68	2.39	2.25	2.15	2.06	1.98	1.91	1.85
6.4	90.10	2.76	2.45	2.32	2.21	2.12	2.04	1.97	1.90
6.5	91.51	2.84	2.52	2.38	2.27	2.18	2.09	2.02	1.96
6.6	92.92	2.92	2.59	2.45	2.33	2.24	2.15	2.08	2.01
6.7	94.33	2.99	2.66	2.52	2.40	2.30	2.21	2.14	2.07

3" Uponor AquaPEX (100% water)

psi loss per 100 feet of tubing									
Velocity (ft/s)	gpm	40°F 4°C	60°F 16°C	80°F 27°C	100°F 38°C	120°F 49°C	140°F 60°C	160°F 71°C	180°F 82°C
6.8	95.73	3.08	2.74	2.59	2.46	2.36	2.27	2.19	2.12
6.9	97.14	3.16	2.81	2.65	2.53	2.42	2.33	2.25	2.18
7.0	98.55	3.24	2.88	2.72	2.60	2.49	2.39	2.31	2.24
7.1	99.96	3.32	2.96	2.80	2.66	2.55	2.46	2.37	2.30
7.2	101.37	3.41	3.03	2.87	2.73	2.62	2.52	2.43	2.36
7.3	102.77	3.49	3.11	2.94	2.80	2.68	2.58	2.50	2.42
7.4	104.18	3.58	3.18	3.01	2.87	2.75	2.65	2.56	2.48
7.5	105.59	3.66	3.26	3.09	2.94	2.82	2.71	2.62	2.54
7.6	107.00	3.75	3.34	3.16	3.01	2.89	2.78	2.68	2.60
7.7	108.41	3.84	3.42	3.23	3.08	2.96	2.85	2.75	2.66
7.8	109.81	3.93	3.50	3.31	3.16	3.03	2.91	2.81	2.73
7.9	111.22	4.02	3.58	3.39	3.23	3.10	2.98	2.88	2.79
8.0	112.63	4.11	3.66	3.47	3.30	3.17	3.05	2.95	2.85
8.1	114.04	4.20	3.75	3.54	3.38	3.24	3.12	3.01	2.92
8.2	115.44	4.30	3.83	3.62	3.45	3.31	3.19	3.08	2.99
8.3	116.85	4.39	3.91	3.70	3.53	3.39	3.26	3.15	3.05
8.4	118.26	4.48	4.00	3.78	3.61	3.46	3.33	3.22	3.12
8.5	119.67	4.58	4.08	3.87	3.69	3.54	3.41	3.29	3.19
8.6	121.08	4.68	4.17	3.95	3.77	3.61	3.48	3.36	3.26
8.7	122.48	4.77	4.26	4.03	3.85	3.69	3.55	3.43	3.33
8.8	123.89	4.87	4.35	4.12	3.93	3.76	3.63	3.50	3.40
8.9	125.30	4.97	4.44	4.20	4.01	3.84	3.70	3.58	3.47
9.0	126.71	5.07	4.53	4.29	4.09	3.92	3.78	3.65	3.54
9.1	128.12	5.17	4.62	4.37	4.17	4.00	3.85	3.72	3.61
9.2	129.52	5.28	4.71	4.46	4.25	4.08	3.93	3.80	3.68
9.3	130.93	5.38	4.80	4.55	4.34	4.16	4.01	3.88	3.76
9.4	132.34	5.48	4.90	4.64	4.42	4.24	4.09	3.95	3.83
9.5	133.75	5.59	4.99	4.73	4.51	4.33	4.17	4.03	3.90
9.6	135.15	5.69	5.09	4.82	4.60	4.41	4.25	4.11	3.98
9.7	136.56	5.80	5.18	4.91	4.68	4.49	4.33	4.18	4.05
9.8	137.97	5.91	5.28	5.00	4.77	4.58	4.41	4.26	4.13
9.9	139.38	6.02	5.38	5.09	4.86	4.66	4.49	4.34	4.21
10.0	140.79	6.13	5.47	5.18	4.95	4.75	4.57	4.42	4.29
10.1	142.19	6.24	5.57	5.28	5.04	4.83	4.66	4.50	4.36
10.2	143.60	6.35	5.67	5.37	5.13	4.92	4.74	4.58	4.44
10.3	145.01	6.46	5.77	5.47	5.22	5.01	4.83	4.67	4.52
10.4	146.42	6.57	5.87	5.57	5.31	5.10	4.91	4.75	4.60
10.5	147.83	6.69	5.98	5.66	5.40	5.19	5.00	4.83	4.68
10.6	149.23	6.80	6.08	5.76	5.50	5.28	5.09	4.92	4.77
10.7	150.64	6.92	6.18	5.86	5.59	5.37	5.17	5.00	4.85
10.8	152.05	7.03	6.29	5.96	5.69	5.46	5.26	5.09	4.93
10.9	153.46	7.15	6.39	6.06	5.78	5.55	5.35	5.17	5.02
11.0	154.86	7.27	6.50	6.16	5.88	5.64	5.44	5.26	5.10
11.1	156.27	7.39	6.61	6.26	5.98	5.74	5.53	5.35	5.18
11.2	157.68	7.51	6.71	6.36	6.08	5.83	5.62	5.44	5.27
11.3	159.09	7.63	6.82	6.47	6.17	5.93	5.71	5.53	5.36
11.4	160.50	7.75	6.93	6.57	6.27	6.02	5.81	5.61	5.44
11.5	161.90	7.87	7.04	6.68	6.37	6.12	5.90	5.70	5.53
11.6	163.31	7.99	7.15	6.78	6.47	6.22	5.99	5.80	5.62
11.7	164.72	8.12	7.26	6.89	6.58	6.31	6.09	5.89	5.71
11.8	166.13	8.24	7.38	6.99	6.68	6.41	6.18	5.98	5.80
11.9	167.54	8.37	7.49	7.10	6.78	6.51	6.28	6.07	5.89
12.0	168.94	8.50	7.60	7.21	6.89	6.61	6.37	6.17	5.98

½" Uponor PEX (100% water)

Feet of head per 100 ft. of PEX																					
Velocity (ft/s)	GPM	40°F 4°C	45°F 7°C	50°F 10°C	55°F 13°C	60°F 16°C	65°F 18°C	70°F 21°C	80°F 27°C	90°F 32°C	100°F 38°C	110°F 43°C	120°F 49°C	130°F 54°C	140°F 60°C	150°F 66°C	160°F 71°C	170°F 77°C	180°F 82°C	190°F 88°C	200°F 93°C
1.0	0.55	1.98	1.87	1.74	1.70	1.66	1.63	1.60	1.54	1.49	1.44	1.40	1.36	1.33	1.30	1.27	1.25	1.22	1.20	1.18	1.17
1.2	0.66	2.69	2.54	2.37	2.32	2.27	2.22	2.18	2.10	2.03	1.97	1.92	1.87	1.82	1.78	1.75	1.71	1.68	1.65	1.63	1.60
1.4	0.77	3.48	3.30	3.09	3.02	2.95	2.90	2.84	2.74	2.65	2.57	2.50	2.44	2.38	2.33	2.28	2.24	2.20	2.16	2.13	2.10
1.6	0.88	4.36	4.13	3.88	3.80	3.71	3.64	3.57	3.44	3.33	3.24	3.15	3.07	3.00	2.94	2.88	2.83	2.78	2.73	2.69	2.65
1.8	0.99	5.33	5.05	4.74	4.64	4.54	4.46	4.37	4.22	4.09	3.97	3.87	3.77	3.69	3.61	3.54	3.48	3.41	3.36	3.31	3.26
2.0	1.10	6.38	6.05	5.68	5.57	5.44	5.35	5.24	5.06	4.91	4.77	4.65	4.53	4.43	4.34	4.26	4.18	4.11	4.04	3.98	3.93
2.2	1.22	7.50	7.12	6.69	6.56	6.42	6.30	6.18	5.97	5.79	5.63	5.49	5.35	5.24	5.13	5.03	4.94	4.86	4.78	4.71	4.65
2.4	1.33	8.70	8.27	7.78	7.62	7.46	7.33	7.19	6.95	6.74	6.55	6.39	6.23	6.10	5.98	5.86	5.76	5.66	5.57	5.49	5.42
2.6	1.44	9.98	9.49	8.93	8.75	8.57	8.41	8.26	7.99	7.75	7.53	7.35	7.17	7.02	6.88	6.75	6.63	6.52	6.42	6.33	6.24
2.8	1.55	11.33	10.77	10.15	9.95	9.74	9.57	9.39	9.09	8.82	8.58	8.36	8.17	7.99	7.84	7.69	7.56	7.43	7.32	7.21	7.12
3.0	1.66	12.76	12.13	11.43	11.21	10.98	10.79	10.59	10.25	9.95	9.68	9.44	9.22	9.03	8.85	8.68	8.53	8.39	8.27	8.15	8.04
3.2	1.77	14.25	13.56	12.79	12.54	12.28	12.07	11.85	11.47	11.13	10.84	10.57	10.33	10.11	9.91	9.73	9.57	9.41	9.27	9.14	9.02
3.4	1.88	15.82	15.06	14.20	13.93	13.65	13.41	13.17	12.75	12.38	12.05	11.76	11.49	11.25	11.03	10.83	10.65	10.48	10.32	10.18	10.04
3.6	1.99	17.46	16.63	15.68	15.39	15.08	14.82	14.55	14.09	13.69	13.32	13.00	12.71	12.45	12.21	11.98	11.78	11.59	11.42	11.26	11.12
3.8	2.10	19.17	18.26	17.23	16.91	16.56	16.28	15.99	15.49	15.05	14.65	14.30	13.98	13.69	13.43	13.19	12.97	12.76	12.57	12.40	12.24
4.0	2.21	20.94	19.95	18.84	18.49	18.12	17.81	17.49	16.95	16.47	16.04	15.65	15.30	14.99	14.71	14.44	14.20	13.98	13.77	13.59	13.41
4.2	2.32	22.79	21.72	20.51	20.13	19.73	19.40	19.05	18.46	17.94	17.47	17.06	16.68	16.34	16.03	15.75	15.49	15.24	15.02	14.82	14.63
4.4	2.43	24.69	23.54	22.24	21.83	21.40	21.04	20.67	20.03	19.47	18.97	18.52	18.11	17.74	17.41	17.10	16.82	16.56	16.32	16.10	15.89
4.6	2.54	26.67	25.43	24.03	23.59	23.13	22.74	22.34	21.66	21.05	20.51	20.03	19.59	19.20	18.84	18.51	18.20	17.92	17.66	17.43	17.20
4.8	2.65	28.71	27.39	25.89	25.41	24.91	24.50	24.08	23.34	22.69	22.11	21.59	21.12	20.70	20.32	19.96	19.64	19.33	19.06	18.80	18.56
5.0	2.76	30.82	29.40	27.80	27.29	26.76	26.32	25.86	25.08	24.38	23.76	23.21	22.71	22.25	21.84	21.46	21.11	20.79	20.49	20.22	19.97
5.2	2.87	32.99	31.48	29.77	29.23	28.66	28.20	27.71	26.87	26.13	25.47	24.88	24.34	23.86	23.42	23.01	22.64	22.29	21.98	21.69	21.42
5.4	2.98	35.22	33.62	31.80	31.23	30.63	30.13	29.61	28.72	27.93	27.23	26.60	26.03	25.51	25.04	24.61	24.22	23.85	23.51	23.20	22.91
5.6	3.09	37.52	35.82	33.89	33.28	32.64	32.12	31.57	30.62	29.78	29.03	28.37	27.76	27.21	26.72	26.26	25.84	25.44	25.09	24.76	24.45
5.8	3.20	39.88	38.08	36.04	35.40	34.72	34.16	33.58	32.57	31.69	30.89	30.19	29.55	28.97	28.44	27.95	27.51	27.09	26.71	26.36	26.04
6.0	3.31	42.31	40.40	38.25	37.57	36.85	36.26	35.64	34.58	33.64	32.81	32.06	31.38	30.77	30.21	29.69	29.22	28.78	28.38	28.01	27.67
6.2	3.42	44.79	42.79	40.51	39.79	39.03	38.41	37.76	36.64	35.65	34.77	33.98	33.26	32.61	32.02	31.48	30.99	30.52	30.10	29.71	29.34
6.4	3.54	47.34	45.23	42.83	42.07	41.28	40.62	39.93	38.75	37.71	36.78	35.95	35.19	34.51	33.89	33.32	32.79	32.30	31.86	31.45	31.06
6.6	3.65	49.95	47.73	45.21	44.41	43.57	42.88	42.16	40.92	39.82	38.84	37.97	37.17	36.45	35.80	35.20	34.65	34.13	33.66	33.23	32.82
6.8	3.76	52.62	50.29	47.64	46.80	45.92	45.20	44.44	43.14	41.99	40.96	40.04	39.20	38.44	37.76	37.12	36.55	36.00	35.51	35.06	34.63
7.0	3.87	55.35	52.90	50.13	49.25	48.33	47.57	46.77	45.41	44.20	43.12	42.15	41.28	40.48	39.76	39.10	38.49	37.92	37.41	36.93	36.48
7.2	3.98	58.14	55.58	52.67	51.75	50.79	49.99	49.16	47.73	46.46	45.33	44.32	43.40	42.57	41.81	41.12	40.48	39.88	39.35	38.84	38.38
7.4	4.09	60.99	58.31	55.27	54.31	53.30	52.47	51.60	50.10	48.77	47.59	46.53	45.57	44.70	43.91	43.18	42.52	41.89	41.33	40.80	40.31
7.6	4.20	63.90	61.10	57.93	56.92	55.87	55.00	54.09	52.52	51.14	49.90	48.79	47.79	46.88	46.05	45.29	44.60	43.94	43.35	42.81	42.29
7.8	4.31	66.87	63.95	60.64	59.59	58.49	57.58	56.63	54.99	53.55	52.26	51.10	50.05	49.11	48.24	47.45	46.72	46.04	45.42	44.85	44.32
8.0	4.42	69.89	66.85	63.40	62.31	61.16	60.21	59.22	57.52	56.01	54.66	53.46	52.37	51.38	50.48	49.65	48.89	48.18	47.54	46.94	46.38

Note: For systems with glycol or velocities outside this range, please visit Uponor's online calculator available at uponor.com/calculator.

5/8" Uponor PEX (100% water)

Feet of head per 100 ft. of PEX																					
Velocity (ft/s)	GPM	40°F 4°C	45°F 7°C	50°F 10°C	55°F 13°C	60°F 16°C	65°F 18°C	70°F 21°C	80°F 27°C	90°F 32°C	100°F 38°C	110°F 43°C	120°F 49°C	130°F 54°C	140°F 60°C	150°F 66°C	160°F 71°C	170°F 77°C	180°F 82°C	190°F 88°C	200°F 93°C
1.0	0.81	1.54	1.46	1.36	1.33	1.30	1.28	1.25	1.20	1.16	1.13	1.10	1.07	1.05	1.02	1.00	0.98	0.96	0.95	0.93	0.92
1.2	0.97	2.09	1.98	1.86	1.82	1.78	1.74	1.71	1.65	1.59	1.55	1.51	1.47	1.43	1.40	1.37	1.35	1.32	1.30	1.28	1.26
1.4	1.13	2.72	2.58	2.42	2.37	2.31	2.27	2.23	2.15	2.08	2.02	1.97	1.92	1.87	1.84	1.80	1.77	1.73	1.71	1.68	1.66
1.6	1.29	3.41	3.23	3.04	2.98	2.91	2.86	2.80	2.71	2.62	2.55	2.48	2.42	2.37	2.32	2.27	2.23	2.19	2.16	2.13	2.10
1.8	1.45	4.17	3.96	3.72	3.64	3.57	3.50	3.43	3.32	3.22	3.13	3.05	2.97	2.91	2.85	2.79	2.74	2.70	2.65	2.62	2.58
2.0	1.61	4.99	4.74	4.46	4.37	4.28	4.20	4.12	3.98	3.86	3.76	3.66	3.57	3.50	3.43	3.36	3.30	3.25	3.20	3.15	3.11
2.2	1.77	5.87	5.58	5.26	5.15	5.04	4.95	4.86	4.70	4.56	4.44	4.33	4.22	4.13	4.05	3.97	3.90	3.84	3.78	3.73	3.68
2.4	1.94	6.82	6.49	6.11	5.99	5.86	5.76	5.66	5.47	5.31	5.17	5.04	4.92	4.82	4.72	4.63	4.55	4.48	4.41	4.35	4.29
2.6	2.10	7.83	7.44	7.02	6.88	6.74	6.62	6.50	6.29	6.11	5.94	5.80	5.66	5.54	5.44	5.33	5.24	5.16	5.08	5.01	4.94
2.8	2.26	8.89	8.46	7.98	7.83	7.67	7.53	7.40	7.16	6.95	6.77	6.60	6.45	6.32	6.19	6.08	5.98	5.88	5.79	5.71	5.64
3.0	2.42	10.01	9.53	8.99	8.82	8.64	8.50	8.34	8.08	7.85	7.64	7.45	7.29	7.13	7.00	6.87	6.75	6.65	6.55	6.46	6.37
3.2	2.58	11.19	10.66	10.06	9.87	9.67	9.51	9.34	9.05	8.79	8.56	8.35	8.16	8.00	7.84	7.70	7.57	7.45	7.34	7.24	7.15
3.4	2.74	12.43	11.84	11.18	10.97	10.75	10.57	10.38	10.06	9.77	9.52	9.29	9.09	8.90	8.73	8.57	8.43	8.30	8.18	8.06	7.96
3.6	2.90	13.72	13.08	12.35	12.12	11.88	11.68	11.48	11.12	10.81	10.53	10.28	10.05	9.85	9.66	9.49	9.33	9.18	9.05	8.93	8.81
3.8	3.07	15.06	14.36	13.57	13.32	13.06	12.84	12.62	12.23	11.89	11.58	11.31	11.06	10.83	10.63	10.44	10.27	10.11	9.97	9.83	9.71
4.0	3.23	16.46	15.70	14.84	14.57	14.28	14.05	13.80	13.38	13.01	12.68	12.38	12.11	11.87	11.64	11.44	11.25	11.08	10.92	10.77	10.64
4.2	3.39	17.92	17.09	16.16	15.87	15.56	15.30	15.04	14.58	14.18	13.82	13.49	13.20	12.94	12.70	12.48	12.27	12.08	11.91	11.75	11.60
4.4	3.55	19.42	18.54	17.53	17.21	16.88	16.61	16.32	15.82	15.39	15.00	14.65	14.34	14.05	13.79	13.55	13.33	13.13	12.94	12.77	12.61
4.6	3.71	20.98	20.03	18.95	18.61	18.25	17.95	17.64	17.11	16.64	16.23	15.85	15.51	15.20	14.92	14.67	14.43	14.21	14.01	13.83	13.65
4.8	3.87	22.59	21.57	20.42	20.05	19.66	19.35	19.02	18.45	17.94	17.49	17.09	16.73	16.40	16.10	15.82	15.57	15.33	15.12	14.92	14.73
5.0	4.03	24.26	23.17	21.93	21.54	21.13	20.79	20.43	19.82	19.29	18.80	18.38	17.98	17.63	17.31	17.01	16.75	16.49	16.26	16.05	15.85
5.2	4.19	25.97	24.81	23.49	23.07	22.63	22.27	21.89	21.24	20.67	20.16	19.70	19.28	18.91	18.56	18.25	17.96	17.69	17.44	17.22	17.00
5.4	4.36	27.74	26.50	25.10	24.65	24.19	23.80	23.40	22.71	22.10	21.55	21.06	20.62	20.22	19.85	19.52	19.21	18.92	18.66	18.42	18.19
5.6	4.52	29.55	28.24	26.75	26.28	25.78	25.38	24.95	24.22	23.57	22.99	22.47	22.00	21.57	21.18	20.83	20.50	20.19	19.92	19.66	19.42
5.8	4.68	31.42	30.03	28.45	27.95	27.43	27.00	26.54	25.77	25.08	24.46	23.91	23.41	22.96	22.55	22.17	21.83	21.50	21.21	20.94	20.68
6.0	4.84	33.33	31.87	30.20	29.67	29.12	28.66	28.18	27.36	26.63	25.98	25.40	24.87	24.39	23.96	23.56	23.19	22.85	22.54	22.25	21.98
6.2	5.00	35.30	33.75	31.99	31.43	30.85	30.37	29.86	28.99	28.22	27.54	26.92	26.37	25.86	25.40	24.98	24.59	24.23	23.90	23.60	23.31
6.4	5.16	37.31	35.68	33.83	33.24	32.62	32.12	31.58	30.67	29.86	29.14	28.49	27.90	27.37	26.89	26.44	26.03	25.65	25.30	24.98	24.68
6.6	5.32	39.38	37.66	35.71	35.09	34.44	33.91	33.35	32.39	31.54	30.77	30.09	29.47	28.91	28.41	27.94	27.51	27.10	26.74	26.40	26.08
6.8	5.49	41.49	39.68	37.64	36.99	36.31	35.75	35.16	34.15	33.25	32.45	31.74	31.09	30.50	29.96	29.47	29.02	28.59	28.21	27.86	27.52
7.0	5.65	43.65	41.76	39.61	38.93	38.21	37.63	37.01	35.95	35.01	34.17	33.42	32.74	32.12	31.56	31.04	30.57	30.12	29.72	29.35	29.00
7.2	5.81	45.85	43.87	41.63	40.91	40.16	39.55	38.90	37.79	36.81	35.93	35.14	34.42	33.78	33.19	32.64	32.15	31.68	31.26	30.87	30.51
7.4	5.97	48.11	46.04	43.69	42.94	42.16	41.51	40.83	39.67	38.64	37.72	36.90	36.15	35.47	34.86	34.29	33.77	33.28	32.84	32.43	32.05
7.6	6.13	50.41	48.25	45.79	45.01	44.19	43.52	42.81	41.59	40.52	39.56	38.70	37.91	37.21	36.56	35.97	35.42	34.91	34.45	34.03	33.63
7.8	6.29	52.76	50.50	47.94	47.13	46.27	45.57	44.83	43.56	42.44	41.43	40.53	39.71	38.98	38.30	37.68	37.12	36.58	36.10	35.65	35.24
8.0	6.45	55.16	52.80	50.13	49.28	48.39	47.66	46.89	45.56	44.39	43.34	42.41	41.55	40.78	40.08	39.43	38.84	38.29	37.78	37.32	36.88

Note: For systems with glycol or velocities outside this range, please visit Uponor's online calculator available at uponor.com/calculator.

¾" Uponor PEX (100% water)

Feet of head per 100 ft. of PEX																					
Velocity (ft/s)	GPM	40°F 4°C	45°F 7°C	50°F 10°C	55°F 13°C	60°F 16°C	65°F 18°C	70°F 21°C	80°F 27°C	90°F 32°C	100°F 38°C	110°F 43°C	120°F 49°C	130°F 54°C	140°F 60°C	150°F 66°C	160°F 71°C	170°F 77°C	180°F 82°C	190°F 88°C	200°F 93°C
1.0	1.10	1.25	1.19	1.11	1.09	1.06	1.04	1.02	0.99	0.95	0.93	0.90	0.88	0.86	0.84	0.82	0.81	0.79	0.78	0.77	0.76
1.2	1.32	1.71	1.62	1.52	1.49	1.45	1.43	1.40	1.35	1.31	1.27	1.24	1.20	1.18	1.15	1.13	1.11	1.09	1.07	1.06	1.04
1.4	1.54	2.22	2.10	1.98	1.94	1.89	1.86	1.82	1.76	1.71	1.66	1.61	1.58	1.54	1.51	1.48	1.45	1.43	1.40	1.38	1.36
1.6	1.76	2.79	2.64	2.49	2.44	2.38	2.34	2.30	2.22	2.15	2.09	2.04	1.99	1.95	1.91	1.87	1.84	1.80	1.78	1.75	1.73
1.8	1.98	3.41	3.24	3.05	2.99	2.92	2.87	2.82	2.72	2.64	2.57	2.50	2.44	2.39	2.34	2.30	2.26	2.22	2.19	2.15	2.13
2.0	2.20	4.08	3.88	3.65	3.58	3.51	3.45	3.38	3.27	3.17	3.09	3.01	2.94	2.88	2.82	2.77	2.72	2.67	2.63	2.60	2.56
2.2	2.43	4.81	4.57	4.31	4.23	4.14	4.07	3.99	3.86	3.75	3.65	3.56	3.48	3.40	3.34	3.27	3.22	3.16	3.12	3.07	3.03
2.4	2.65	5.58	5.31	5.01	4.91	4.81	4.73	4.64	4.50	4.37	4.25	4.15	4.05	3.97	3.89	3.82	3.75	3.69	3.64	3.59	3.54
2.6	2.87	6.41	6.10	5.76	5.65	5.53	5.44	5.34	5.17	5.02	4.89	4.77	4.66	4.57	4.48	4.40	4.32	4.25	4.19	4.13	4.08
2.8	3.09	7.28	6.94	6.55	6.43	6.30	6.19	6.08	5.89	5.72	5.57	5.44	5.32	5.21	5.11	5.01	4.93	4.85	4.78	4.71	4.65
3.0	3.31	8.20	7.82	7.38	7.25	7.10	6.98	6.86	6.65	6.46	6.29	6.14	6.00	5.88	5.77	5.67	5.57	5.48	5.40	5.33	5.26
3.2	3.53	9.17	8.75	8.26	8.11	7.95	7.82	7.68	7.44	7.23	7.05	6.88	6.73	6.59	6.47	6.35	6.25	6.15	6.06	5.98	5.90
3.4	3.75	10.19	9.72	9.19	9.02	8.84	8.69	8.54	8.28	8.05	7.84	7.66	7.49	7.34	7.20	7.07	6.96	6.85	6.75	6.66	6.58
3.6	3.97	11.25	10.73	10.15	9.96	9.77	9.61	9.44	9.15	8.90	8.67	8.47	8.29	8.12	7.97	7.83	7.70	7.58	7.48	7.38	7.28
3.8	4.19	12.36	11.79	11.16	10.95	10.74	10.57	10.38	10.07	9.79	9.54	9.32	9.12	8.94	8.77	8.62	8.48	8.35	8.23	8.12	8.02
4.0	4.41	13.51	12.90	12.20	11.98	11.75	11.56	11.36	11.02	10.72	10.45	10.21	9.99	9.79	9.61	9.44	9.29	9.15	9.02	8.90	8.79
4.2	4.63	14.71	14.04	13.29	13.05	12.80	12.60	12.38	12.01	11.68	11.39	11.13	10.89	10.68	10.48	10.30	10.14	9.98	9.84	9.71	9.59
4.4	4.85	15.95	15.23	14.42	14.16	13.89	13.67	13.44	13.04	12.68	12.37	12.09	11.83	11.60	11.39	11.19	11.01	10.85	10.70	10.56	10.43
4.6	5.07	17.23	16.46	15.59	15.31	15.02	14.78	14.53	14.10	13.72	13.38	13.08	12.80	12.55	12.32	12.11	11.92	11.74	11.58	11.43	11.29
4.8	5.29	18.56	17.73	16.80	16.50	16.19	15.93	15.66	15.20	14.79	14.43	14.10	13.81	13.54	13.30	13.07	12.87	12.67	12.50	12.34	12.18
5.0	5.51	19.93	19.05	18.05	17.73	17.40	17.12	16.83	16.34	15.90	15.51	15.16	14.85	14.56	14.30	14.06	13.84	13.63	13.45	13.27	13.11
5.2	5.73	21.34	20.40	19.33	19.00	18.64	18.35	18.04	17.51	17.05	16.63	16.26	15.92	15.61	15.34	15.08	14.84	14.62	14.42	14.24	14.07
5.4	5.95	22.79	21.79	20.66	20.30	19.92	19.61	19.28	18.72	18.23	17.78	17.39	17.03	16.70	16.40	16.13	15.88	15.65	15.43	15.24	15.05
5.6	6.17	24.29	23.23	22.03	21.64	21.24	20.91	20.56	19.97	19.44	18.97	18.55	18.17	17.82	17.51	17.21	16.95	16.70	16.47	16.26	16.07
5.8	6.39	25.83	24.70	23.43	23.02	22.60	22.25	21.88	21.25	20.69	20.19	19.75	19.34	18.97	18.64	18.33	18.05	17.78	17.54	17.32	17.11
6.0	6.61	27.41	26.22	24.87	24.44	23.99	23.62	23.23	22.57	21.98	21.45	20.97	20.54	20.16	19.80	19.48	19.18	18.90	18.64	18.41	18.19
6.2	6.83	29.03	27.77	26.35	25.90	25.42	25.03	24.62	23.92	23.29	22.74	22.24	21.78	21.37	21.00	20.65	20.34	20.04	19.78	19.53	19.29
6.4	7.05	30.69	29.37	27.87	27.39	26.89	26.48	26.05	25.30	24.65	24.06	23.53	23.05	22.62	22.23	21.86	21.53	21.22	20.94	20.67	20.43
6.6	7.28	32.39	31.00	29.42	28.92	28.39	27.96	27.50	26.72	26.03	25.41	24.86	24.35	23.90	23.48	23.10	22.75	22.42	22.13	21.85	21.59
6.8	7.50	34.13	32.67	31.01	30.49	29.93	29.48	29.00	28.18	27.45	26.80	26.22	25.69	25.21	24.77	24.37	24.00	23.66	23.35	23.06	22.79
7.0	7.72	35.91	34.38	32.64	32.09	31.51	31.03	30.53	29.67	28.90	28.22	27.61	27.06	26.55	26.10	25.67	25.29	24.92	24.60	24.29	24.01
7.2	7.94	37.73	36.13	34.31	33.73	33.12	32.62	32.09	31.19	30.39	29.67	29.04	28.45	27.93	27.45	27.00	26.60	26.22	25.88	25.56	25.26
7.4	8.16	39.59	37.91	36.01	35.40	34.77	34.24	33.69	32.75	31.91	31.16	30.49	29.88	29.33	28.83	28.36	27.94	27.54	27.18	26.85	26.54
7.6	8.38	41.49	39.74	37.75	37.11	36.45	35.90	35.33	34.34	33.46	32.68	31.98	31.34	30.77	30.24	29.76	29.31	28.90	28.52	28.17	27.85
7.8	8.60	43.43	41.60	39.52	38.86	38.17	37.59	36.99	35.96	35.05	34.23	33.50	32.83	32.23	31.68	31.18	30.72	30.28	29.89	29.52	29.18
8.0	8.82	45.40	43.50	41.33	40.64	39.92	39.32	38.70	37.62	36.67	35.81	35.05	34.36	33.73	33.16	32.63	32.15	31.69	31.28	30.90	30.55

Note: For systems with glycol or velocities outside this range, please visit Uponor's online calculator available at uponor.com/calculator.

1" Uponor PEX (100% water)

Feet of head per 100 ft. of PEX																					
Velocity (ft/s)	GPM	40°F 4°C	45°F 7°C	50°F 10°C	55°F 13°C	60°F 16°C	65°F 18°C	70°F 21°C	80°F 27°C	90°F 32°C	100°F 38°C	110°F 43°C	120°F 49°C	130°F 54°C	140°F 60°C	150°F 66°C	160°F 71°C	170°F 77°C	180°F 82°C	190°F 88°C	200°F 93°C
1.5	2.73	1.81	1.72	1.62	1.58	1.55	1.52	1.49	1.45	1.40	1.36	1.33	1.30	1.27	1.25	1.22	1.20	1.18	1.16	1.15	1.13
1.6	2.91	2.02	1.92	1.81	1.77	1.73	1.70	1.67	1.62	1.57	1.53	1.49	1.45	1.42	1.40	1.37	1.35	1.32	1.30	1.28	1.27
1.8	3.27	2.47	2.35	2.21	2.17	2.13	2.09	2.05	1.99	1.93	1.88	1.83	1.79	1.75	1.72	1.68	1.66	1.63	1.60	1.58	1.56
2.0	3.64	2.96	2.82	2.66	2.61	2.56	2.51	2.47	2.39	2.32	2.26	2.20	2.15	2.11	2.07	2.03	2.00	1.96	1.93	1.91	1.88
2.2	4.00	3.49	3.32	3.14	3.08	3.02	2.97	2.91	2.82	2.74	2.67	2.61	2.55	2.49	2.45	2.40	2.36	2.32	2.29	2.26	2.23
2.4	4.37	4.06	3.87	3.65	3.58	3.51	3.45	3.39	3.29	3.19	3.11	3.04	2.97	2.91	2.85	2.80	2.76	2.71	2.67	2.64	2.60
2.6	4.73	4.66	4.44	4.20	4.12	4.04	3.97	3.90	3.78	3.68	3.58	3.50	3.42	3.35	3.29	3.23	3.18	3.13	3.08	3.04	3.00
2.8	5.09	5.30	5.05	4.78	4.69	4.60	4.52	4.44	4.31	4.19	4.08	3.99	3.90	3.82	3.75	3.68	3.62	3.57	3.52	3.47	3.42
3.0	5.46	5.97	5.70	5.39	5.29	5.19	5.11	5.02	4.87	4.73	4.61	4.50	4.41	4.32	4.24	4.16	4.10	4.03	3.98	3.92	3.87
3.2	5.82	6.68	6.38	6.03	5.93	5.81	5.72	5.62	5.45	5.30	5.17	5.05	4.94	4.84	4.75	4.67	4.60	4.53	4.46	4.40	4.35
3.4	6.19	7.42	7.09	6.71	6.59	6.46	6.36	6.25	6.07	5.90	5.75	5.62	5.50	5.39	5.29	5.20	5.12	5.04	4.97	4.91	4.85
3.6	6.55	8.20	7.83	7.42	7.29	7.15	7.03	6.91	6.71	6.53	6.37	6.22	6.09	5.97	5.86	5.76	5.67	5.58	5.51	5.43	5.37
3.8	6.91	9.01	8.61	8.16	8.01	7.86	7.74	7.61	7.38	7.18	7.01	6.85	6.70	6.57	6.45	6.34	6.25	6.15	6.07	5.99	5.91
4.0	7.28	9.85	9.42	8.93	8.77	8.60	8.47	8.33	8.08	7.87	7.67	7.50	7.34	7.20	7.07	6.95	6.84	6.74	6.65	6.56	6.48
4.2	7.64	10.73	10.26	9.72	9.55	9.38	9.23	9.08	8.81	8.58	8.37	8.18	8.01	7.86	7.72	7.59	7.47	7.36	7.26	7.16	7.08
4.4	8.00	11.64	11.13	10.55	10.37	10.18	10.02	9.85	9.57	9.31	9.09	8.89	8.70	8.54	8.38	8.24	8.12	8.00	7.89	7.79	7.69
4.6	8.37	12.58	12.03	11.41	11.22	11.01	10.84	10.66	10.35	10.08	9.83	9.62	9.42	9.24	9.08	8.93	8.79	8.66	8.54	8.43	8.33
4.8	8.73	13.55	12.97	12.30	12.09	11.87	11.68	11.49	11.16	10.87	10.61	10.37	10.16	9.97	9.79	9.63	9.48	9.34	9.22	9.10	8.99
5.0	9.10	14.56	13.93	13.22	12.99	12.75	12.56	12.35	12.00	11.69	11.41	11.16	10.93	10.72	10.54	10.36	10.20	10.05	9.92	9.80	9.68
5.2	9.46	15.59	14.93	14.17	13.92	13.67	13.46	13.24	12.86	12.53	12.23	11.96	11.72	11.50	11.30	11.12	10.95	10.79	10.64	10.51	10.39
5.4	9.82	16.66	15.95	15.14	14.88	14.61	14.39	14.16	13.76	13.40	13.08	12.80	12.54	12.30	12.09	11.89	11.71	11.54	11.39	11.25	11.12
5.6	10.19	17.76	17.00	16.14	15.87	15.59	15.35	15.10	14.67	14.30	13.96	13.66	13.38	13.13	12.90	12.69	12.50	12.32	12.16	12.01	11.87
5.8	10.55	18.89	18.09	17.18	16.89	16.58	16.33	16.07	15.62	15.22	14.86	14.54	14.25	13.98	13.74	13.52	13.32	13.13	12.95	12.79	12.64
6.0	10.92	20.05	19.20	18.24	17.93	17.61	17.35	17.07	16.59	16.17	15.79	15.45	15.14	14.86	14.60	14.37	14.15	13.95	13.77	13.60	13.44
6.2	11.28	21.24	20.34	19.33	19.00	18.66	18.38	18.09	17.58	17.14	16.74	16.38	16.05	15.76	15.49	15.24	15.01	14.80	14.61	14.43	14.26
6.4	11.64	22.46	21.51	20.44	20.10	19.74	19.45	19.14	18.61	18.14	17.71	17.34	16.99	16.68	16.40	16.13	15.89	15.67	15.47	15.28	15.10
6.6	12.01	23.71	22.71	21.59	21.23	20.85	20.54	20.22	19.66	19.16	18.71	18.32	17.95	17.63	17.33	17.05	16.80	16.56	16.35	16.15	15.96
6.8	12.37	24.98	23.94	22.76	22.38	21.99	21.66	21.32	20.73	20.21	19.74	19.32	18.94	18.59	18.28	17.99	17.73	17.48	17.25	17.04	16.84
7.0	12.73	26.29	25.20	23.96	23.56	23.15	22.81	22.45	21.83	21.28	20.79	20.35	19.95	19.59	19.26	18.95	18.68	18.41	18.18	17.96	17.75
7.2	13.10	27.63	26.49	25.18	24.77	24.34	23.98	23.60	22.95	22.38	21.86	21.40	20.98	20.60	20.26	19.94	19.65	19.37	19.12	18.89	18.68
7.4	13.46	29.00	27.80	26.44	26.01	25.55	25.17	24.78	24.10	23.50	22.96	22.48	22.04	21.64	21.28	20.95	20.64	20.35	20.09	19.85	19.63
7.6	13.83	30.39	29.14	27.72	27.27	26.79	26.40	25.98	25.28	24.65	24.08	23.58	23.12	22.70	22.33	21.98	21.66	21.36	21.08	20.83	20.60
7.8	14.19	31.82	30.51	29.03	28.55	28.06	27.65	27.22	26.47	25.82	25.23	24.70	24.22	23.79	23.39	23.03	22.70	22.38	22.10	21.83	21.59
8.0	14.55	33.27	31.91	30.36	29.87	29.35	28.92	28.47	27.70	27.01	26.40	25.85	25.35	24.90	24.49	24.10	23.76	23.43	23.13	22.86	22.60

Note: For systems with glycol or velocities outside this range, please visit Uponor’s online calculator available at uponor.com/calculator.

1¼" Uponor PEX (100% water)

Feet of head per 100 ft. of PEX																					
Velocity (ft/s)	GPM	40°F 4°C	45°F 7°C	50°F 10°C	55°F 13°C	60°F 16°C	65°F 18°C	70°F 21°C	80°F 27°C	90°F 32°C	100°F 38°C	110°F 43°C	120°F 49°C	130°F 54°C	140°F 60°C	150°F 66°C	160°F 71°C	170°F 77°C	180°F 82°C	190°F 88°C	200°F 93°C
1.5	4.08	1.39	1.33	1.25	1.23	1.20	1.18	1.16	1.12	1.09	1.06	1.03	1.01	0.99	0.97	0.95	0.94	0.92	0.91	0.89	0.88
1.6	4.35	1.56	1.48	1.40	1.37	1.34	1.32	1.30	1.26	1.22	1.19	1.16	1.13	1.11	1.09	1.07	1.05	1.03	1.02	1.00	0.99
1.8	4.90	1.91	1.82	1.72	1.69	1.65	1.62	1.59	1.54	1.50	1.46	1.43	1.39	1.36	1.34	1.31	1.29	1.27	1.25	1.24	1.22
2.0	5.44	2.29	2.18	2.06	2.02	1.98	1.95	1.92	1.86	1.81	1.76	1.72	1.68	1.64	1.61	1.58	1.56	1.53	1.51	1.49	1.47
2.2	5.98	2.70	2.58	2.44	2.39	2.34	2.31	2.27	2.20	2.13	2.08	2.03	1.99	1.95	1.91	1.88	1.84	1.82	1.79	1.77	1.74
2.4	6.53	3.14	3.00	2.84	2.78	2.73	2.69	2.64	2.56	2.49	2.42	2.37	2.32	2.27	2.23	2.19	2.15	2.12	2.09	2.06	2.04
2.6	7.07	3.61	3.45	3.26	3.20	3.14	3.09	3.04	2.95	2.87	2.79	2.73	2.67	2.62	2.57	2.52	2.48	2.44	2.41	2.38	2.35
2.8	7.62	4.11	3.92	3.71	3.65	3.58	3.52	3.46	3.36	3.27	3.18	3.11	3.04	2.98	2.93	2.88	2.83	2.79	2.75	2.71	2.68
3.0	8.16	4.63	4.43	4.19	4.12	4.04	3.98	3.91	3.79	3.69	3.60	3.52	3.44	3.37	3.31	3.26	3.20	3.16	3.11	3.07	3.03
3.2	8.70	5.19	4.96	4.69	4.61	4.53	4.45	4.38	4.25	4.14	4.03	3.94	3.86	3.78	3.72	3.65	3.60	3.54	3.49	3.45	3.40
3.4	9.25	5.76	5.51	5.22	5.13	5.04	4.96	4.87	4.73	4.60	4.49	4.39	4.30	4.22	4.14	4.07	4.01	3.95	3.89	3.84	3.80
3.6	9.79	6.37	6.09	5.77	5.67	5.57	5.48	5.39	5.23	5.10	4.97	4.86	4.76	4.67	4.59	4.51	4.44	4.37	4.31	4.26	4.21
3.8	10.34	7.00	6.70	6.35	6.24	6.13	6.03	5.93	5.76	5.61	5.47	5.35	5.24	5.14	5.05	4.97	4.89	4.82	4.75	4.69	4.63
4.0	10.88	7.66	7.33	6.95	6.83	6.71	6.60	6.49	6.31	6.14	6.00	5.86	5.74	5.63	5.53	5.44	5.36	5.28	5.21	5.14	5.08
4.2	11.42	8.34	7.98	7.58	7.45	7.31	7.20	7.08	6.88	6.70	6.54	6.40	6.26	6.15	6.04	5.94	5.85	5.76	5.69	5.61	5.55
4.4	11.97	9.05	8.66	8.22	8.08	7.94	7.82	7.69	7.47	7.28	7.10	6.95	6.81	6.68	6.56	6.46	6.36	6.27	6.18	6.10	6.03
4.6	12.51	9.79	9.37	8.90	8.75	8.59	8.46	8.32	8.08	7.88	7.69	7.52	7.37	7.23	7.11	6.99	6.89	6.79	6.70	6.61	6.53
4.8	13.06	10.55	10.10	9.59	9.43	9.26	9.12	8.97	8.72	8.50	8.29	8.12	7.95	7.80	7.67	7.55	7.43	7.32	7.23	7.14	7.05
5.0	13.60	11.33	10.85	10.31	10.13	9.95	9.80	9.65	9.38	9.14	8.92	8.73	8.55	8.40	8.25	8.12	8.00	7.88	7.78	7.68	7.59
5.2	14.14	12.14	11.63	11.05	10.86	10.67	10.51	10.34	10.05	9.80	9.57	9.36	9.18	9.01	8.85	8.71	8.58	8.46	8.35	8.24	8.15
5.4	14.69	12.97	12.43	11.81	11.61	11.41	11.24	11.06	10.75	10.48	10.23	10.02	9.82	9.64	9.47	9.32	9.18	9.05	8.93	8.83	8.72
5.6	15.23	13.83	13.25	12.60	12.39	12.17	11.99	11.80	11.47	11.18	10.92	10.69	10.48	10.29	10.11	9.95	9.80	9.67	9.54	9.42	9.31
5.8	15.78	14.71	14.10	13.40	13.18	12.95	12.76	12.56	12.21	11.90	11.63	11.38	11.16	10.95	10.77	10.60	10.44	10.30	10.16	10.04	9.92
6.0	16.32	15.62	14.97	14.23	14.00	13.75	13.55	13.34	12.97	12.65	12.36	12.09	11.86	11.64	11.45	11.27	11.10	10.94	10.80	10.67	10.55
6.2	16.86	16.54	15.86	15.09	14.84	14.58	14.36	14.14	13.75	13.41	13.10	12.83	12.58	12.35	12.14	11.95	11.78	11.61	11.46	11.32	11.19
6.4	17.41	17.50	16.78	15.96	15.70	15.43	15.20	14.96	14.55	14.19	13.87	13.58	13.31	13.07	12.85	12.65	12.47	12.29	12.14	11.99	11.85
6.6	17.95	18.47	17.72	16.86	16.58	16.29	16.05	15.81	15.38	14.99	14.65	14.35	14.07	13.82	13.59	13.37	13.18	13.00	12.83	12.68	12.53
6.8	18.49	19.47	18.68	17.77	17.48	17.18	16.93	16.67	16.22	15.82	15.46	15.14	14.84	14.58	14.34	14.11	13.91	13.72	13.54	13.38	13.23
7.0	19.04	20.50	19.66	18.71	18.41	18.09	17.83	17.55	17.08	16.66	16.28	15.94	15.64	15.36	15.10	14.87	14.65	14.45	14.27	14.10	13.94
7.2	19.58	21.54	20.67	19.67	19.36	19.02	18.75	18.46	17.96	17.52	17.12	16.77	16.45	16.16	15.89	15.64	15.42	15.21	15.02	14.84	14.67
7.4	20.13	22.61	21.70	20.65	20.32	19.97	19.68	19.38	18.86	18.40	17.99	17.62	17.28	16.97	16.69	16.44	16.20	15.98	15.78	15.59	15.42
7.6	20.67	23.70	22.75	21.66	21.31	20.95	20.64	20.33	19.78	19.30	18.87	18.48	18.13	17.81	17.52	17.25	17.00	16.77	16.56	16.36	16.18
7.8	21.21	24.82	23.82	22.68	22.32	21.94	21.62	21.29	20.72	20.22	19.77	19.36	18.99	18.66	18.36	18.07	17.82	17.57	17.35	17.15	16.96
8.0	21.76	25.95	24.91	23.73	23.35	22.95	22.62	22.28	21.68	21.16	20.69	20.26	19.88	19.53	19.21	18.92	18.65	18.40	18.17	17.96	17.76

Note: For systems with glycol or velocities outside this range, please visit Uponor's online calculator available at uponor.com/calculator.

1½" Uponor PEX (100% water)

Feet of head per 100 ft. of PEX																					
Velocity (ft/s)	GPM	40°F 4°C	45°F 7°C	50°F 10°C	55°F 13°C	60°F 16°C	65°F 18°C	70°F 21°C	80°F 27°C	90°F 32°C	100°F 38°C	110°F 43°C	120°F 49°C	130°F 54°C	140°F 60°C	150°F 66°C	160°F 71°C	170°F 77°C	180°F 82°C	190°F 88°C	200°F 93°C
1.5	5.68	1.13	1.08	1.01	1.00	0.98	0.96	0.94	0.91	0.89	0.86	0.84	0.82	0.81	0.79	0.78	0.76	0.75	0.74	0.73	0.72
1.6	6.06	1.26	1.20	1.14	1.11	1.09	1.07	1.05	1.02	0.99	0.97	0.94	0.92	0.90	0.89	0.87	0.86	0.84	0.83	0.82	0.81
1.8	6.82	1.55	1.48	1.39	1.37	1.34	1.32	1.30	1.26	1.22	1.19	1.16	1.14	1.11	1.09	1.07	1.05	1.04	1.02	1.01	1.00
2.0	7.58	1.86	1.77	1.68	1.64	1.61	1.59	1.56	1.51	1.47	1.43	1.40	1.37	1.34	1.32	1.29	1.27	1.25	1.23	1.22	1.20
2.2	8.34	2.19	2.09	1.98	1.94	1.91	1.88	1.84	1.79	1.74	1.69	1.66	1.62	1.59	1.56	1.53	1.51	1.48	1.46	1.44	1.42
2.4	9.09	2.55	2.44	2.31	2.26	2.22	2.18	2.15	2.08	2.03	1.98	1.93	1.89	1.85	1.82	1.79	1.76	1.73	1.71	1.68	1.66
2.6	9.85	2.93	2.80	2.65	2.61	2.56	2.52	2.47	2.40	2.33	2.28	2.23	2.18	2.14	2.10	2.06	2.03	2.00	1.97	1.94	1.92
2.8	10.61	3.34	3.19	3.02	2.97	2.91	2.87	2.82	2.74	2.66	2.60	2.54	2.48	2.44	2.39	2.35	2.32	2.28	2.25	2.22	2.19
3.0	11.37	3.76	3.60	3.41	3.35	3.29	3.24	3.18	3.09	3.01	2.93	2.87	2.81	2.76	2.71	2.66	2.62	2.58	2.54	2.51	2.48
3.2	12.12	4.21	4.03	3.82	3.75	3.68	3.63	3.57	3.46	3.37	3.29	3.22	3.15	3.09	3.04	2.99	2.94	2.90	2.86	2.82	2.79
3.4	12.88	4.68	4.48	4.25	4.18	4.10	4.04	3.97	3.86	3.76	3.67	3.58	3.51	3.44	3.38	3.33	3.28	3.23	3.18	3.14	3.11
3.6	13.64	5.18	4.95	4.70	4.62	4.54	4.47	4.39	4.27	4.16	4.06	3.97	3.89	3.81	3.75	3.69	3.63	3.58	3.53	3.48	3.44
3.8	14.40	5.69	5.45	5.17	5.08	4.99	4.92	4.84	4.70	4.58	4.47	4.37	4.28	4.20	4.13	4.06	4.00	3.94	3.89	3.84	3.79
4.0	15.16	6.23	5.96	5.66	5.57	5.47	5.38	5.30	5.15	5.01	4.90	4.79	4.69	4.60	4.52	4.45	4.38	4.32	4.26	4.21	4.16
4.2	15.91	6.79	6.50	6.17	6.07	5.96	5.87	5.78	5.61	5.47	5.34	5.22	5.12	5.02	4.94	4.86	4.78	4.72	4.65	4.60	4.54
4.4	16.67	7.36	7.05	6.70	6.59	6.47	6.37	6.27	6.10	5.94	5.80	5.68	5.56	5.46	5.37	5.28	5.20	5.13	5.06	5.00	4.94
4.6	17.43	7.96	7.63	7.25	7.13	7.00	6.90	6.79	6.60	6.43	6.28	6.15	6.02	5.91	5.81	5.72	5.63	5.55	5.48	5.41	5.35
4.8	18.19	8.58	8.22	7.82	7.69	7.55	7.44	7.32	7.12	6.94	6.78	6.63	6.50	6.38	6.27	6.17	6.08	6.00	5.92	5.85	5.78
5.0	18.94	9.22	8.84	8.40	8.26	8.12	8.00	7.87	7.66	7.46	7.29	7.14	6.99	6.87	6.75	6.64	6.55	6.45	6.37	6.29	6.22
5.2	19.70	9.88	9.47	9.01	8.86	8.70	8.58	8.44	8.21	8.00	7.82	7.65	7.50	7.37	7.24	7.13	7.02	6.93	6.84	6.75	6.68
5.4	20.46	10.56	10.13	9.63	9.47	9.31	9.17	9.03	8.78	8.56	8.37	8.19	8.03	7.88	7.75	7.63	7.52	7.41	7.32	7.23	7.15
5.6	21.22	11.26	10.80	10.27	10.11	9.93	9.78	9.63	9.37	9.14	8.93	8.74	8.57	8.42	8.28	8.15	8.03	7.92	7.81	7.72	7.63
5.8	21.98	11.98	11.49	10.93	10.76	10.57	10.42	10.25	9.98	9.73	9.51	9.31	9.13	8.96	8.82	8.68	8.55	8.43	8.33	8.23	8.13
6.0	22.73	12.72	12.20	11.61	11.42	11.23	11.06	10.89	10.60	10.34	10.10	9.89	9.70	9.53	9.37	9.22	9.09	8.96	8.85	8.75	8.65
6.2	23.49	13.48	12.93	12.31	12.11	11.90	11.73	11.55	11.24	10.96	10.71	10.49	10.29	10.11	9.94	9.79	9.64	9.51	9.39	9.28	9.18
6.4	24.25	14.26	13.68	13.02	12.81	12.59	12.41	12.22	11.89	11.60	11.34	11.11	10.89	10.70	10.52	10.36	10.21	10.07	9.95	9.83	9.72
6.6	25.01	15.05	14.45	13.76	13.54	13.30	13.11	12.91	12.57	12.26	11.98	11.74	11.51	11.31	11.12	10.95	10.80	10.65	10.52	10.39	10.27
6.8	25.76	15.87	15.23	14.51	14.27	14.03	13.83	13.62	13.26	12.93	12.64	12.38	12.15	11.93	11.74	11.56	11.39	11.24	11.10	10.97	10.85
7.0	26.52	16.70	16.04	15.27	15.03	14.78	14.56	14.34	13.96	13.62	13.32	13.05	12.80	12.57	12.37	12.18	12.01	11.84	11.70	11.56	11.43
7.2	27.28	17.56	16.86	16.06	15.81	15.54	15.32	15.08	14.68	14.33	14.01	13.72	13.46	13.23	13.01	12.82	12.63	12.46	12.31	12.16	12.03
7.4	28.04	18.43	17.70	16.86	16.60	16.32	16.08	15.84	15.42	15.05	14.72	14.42	14.15	13.90	13.67	13.47	13.28	13.10	12.93	12.78	12.64
7.6	28.79	19.32	18.56	17.68	17.40	17.11	16.87	16.61	16.18	15.79	15.44	15.13	14.84	14.58	14.35	14.13	13.93	13.74	13.57	13.42	13.27
7.8	29.55	20.24	19.43	18.52	18.23	17.92	17.67	17.40	16.95	16.54	16.18	15.85	15.55	15.28	15.04	14.81	14.60	14.41	14.23	14.06	13.91
8.0	30.31	21.16	20.33	19.38	19.07	18.75	18.49	18.21	17.73	17.31	16.93	16.59	16.28	16.00	15.74	15.50	15.29	15.08	14.90	14.73	14.56

Note: For systems with glycol or velocities outside this range, please visit Uponor’s online calculator available at uponor.com/calculator.

2" Uponor PEX (100% water)

Feet of head per 100 ft. of PEX																					
Velocity (ft/s)	GPM	40°F 4°C	45°F 7°C	50°F 10°C	55°F 13°C	60°F 16°C	65°F 18°C	70°F 21°C	80°F 27°C	90°F 32°C	100°F 38°C	110°F 43°C	120°F 49°C	130°F 54°C	140°F 60°C	150°F 66°C	160°F 71°C	170°F 77°C	180°F 82°C	190°F 88°C	200°F 93°C
1.5	9.75	0.80	0.76	0.72	0.71	0.70	0.68	0.67	0.65	0.63	0.62	0.60	0.59	0.58	0.57	0.56	0.55	0.54	0.53	0.52	0.52
1.6	10.39	0.90	0.86	0.81	0.79	0.78	0.77	0.75	0.73	0.71	0.69	0.68	0.66	0.65	0.64	0.62	0.61	0.60	0.60	0.59	0.58
1.8	11.69	1.10	1.05	0.99	0.98	0.96	0.94	0.93	0.90	0.87	0.85	0.83	0.81	0.80	0.78	0.77	0.76	0.75	0.74	0.73	0.72
2.0	12.99	1.32	1.26	1.20	1.17	1.15	1.13	1.11	1.08	1.05	1.03	1.00	0.98	0.96	0.95	0.93	0.91	0.90	0.89	0.88	0.87
2.2	14.29	1.56	1.49	1.41	1.39	1.36	1.34	1.32	1.28	1.25	1.22	1.19	1.16	1.14	1.12	1.10	1.08	1.07	1.05	1.04	1.03
2.4	15.59	1.82	1.74	1.65	1.62	1.59	1.56	1.54	1.49	1.45	1.42	1.39	1.36	1.33	1.31	1.29	1.27	1.25	1.23	1.21	1.20
2.6	16.89	2.09	2.00	1.90	1.86	1.83	1.80	1.77	1.72	1.68	1.64	1.60	1.57	1.54	1.51	1.48	1.46	1.44	1.42	1.40	1.38
2.8	18.19	2.38	2.28	2.16	2.12	2.09	2.05	2.02	1.96	1.91	1.87	1.82	1.79	1.75	1.72	1.69	1.67	1.64	1.62	1.60	1.58
3.0	19.49	2.69	2.57	2.44	2.40	2.36	2.32	2.28	2.22	2.16	2.11	2.06	2.02	1.98	1.95	1.92	1.89	1.86	1.84	1.81	1.79
3.2	20.79	3.01	2.88	2.74	2.69	2.64	2.60	2.56	2.49	2.42	2.37	2.32	2.27	2.23	2.19	2.15	2.12	2.09	2.06	2.04	2.01
3.4	22.09	3.35	3.21	3.05	2.99	2.94	2.90	2.85	2.77	2.70	2.64	2.58	2.53	2.48	2.44	2.40	2.36	2.33	2.30	2.27	2.24
3.6	23.39	3.70	3.55	3.37	3.31	3.25	3.21	3.16	3.07	2.99	2.92	2.86	2.80	2.75	2.70	2.66	2.62	2.58	2.55	2.52	2.49
3.8	24.69	4.07	3.90	3.71	3.65	3.58	3.53	3.47	3.38	3.29	3.22	3.15	3.09	3.03	2.98	2.93	2.89	2.85	2.81	2.77	2.74
4.0	25.99	4.46	4.27	4.06	3.99	3.92	3.87	3.81	3.70	3.61	3.52	3.45	3.38	3.32	3.26	3.21	3.17	3.12	3.08	3.04	3.01
4.2	27.29	4.86	4.66	4.43	4.36	4.28	4.22	4.15	4.04	3.94	3.85	3.77	3.69	3.62	3.56	3.51	3.46	3.41	3.36	3.32	3.28
4.4	28.59	5.27	5.06	4.81	4.73	4.65	4.58	4.51	4.39	4.28	4.18	4.09	4.01	3.94	3.87	3.81	3.76	3.70	3.66	3.61	3.57
4.6	29.89	5.70	5.47	5.20	5.12	5.03	4.96	4.88	4.75	4.63	4.53	4.43	4.35	4.27	4.20	4.13	4.07	4.01	3.96	3.92	3.87
4.8	31.18	6.15	5.90	5.61	5.52	5.43	5.35	5.27	5.12	5.00	4.88	4.78	4.69	4.61	4.53	4.46	4.40	4.33	4.28	4.23	4.18
5.0	32.48	6.61	6.34	6.04	5.94	5.84	5.75	5.66	5.51	5.38	5.26	5.15	5.05	4.96	4.88	4.80	4.73	4.67	4.61	4.55	4.50
5.2	33.78	7.08	6.80	6.47	6.37	6.26	6.17	6.07	5.91	5.77	5.64	5.52	5.42	5.32	5.23	5.15	5.08	5.01	4.95	4.89	4.83
5.4	35.08	7.57	7.27	6.92	6.81	6.69	6.60	6.50	6.32	6.17	6.03	5.91	5.80	5.69	5.60	5.52	5.44	5.36	5.29	5.23	5.17
5.6	36.38	8.07	7.75	7.38	7.27	7.14	7.04	6.93	6.75	6.59	6.44	6.31	6.19	6.08	5.98	5.89	5.81	5.73	5.65	5.59	5.53
5.8	37.68	8.59	8.25	7.86	7.74	7.60	7.50	7.38	7.19	7.01	6.86	6.72	6.59	6.48	6.37	6.27	6.19	6.10	6.03	5.96	5.89
6.0	38.98	9.12	8.76	8.35	8.22	8.08	7.97	7.85	7.64	7.45	7.29	7.14	7.01	6.88	6.77	6.67	6.58	6.49	6.41	6.33	6.26
6.2	40.28	9.67	9.29	8.85	8.71	8.57	8.45	8.32	8.10	7.91	7.73	7.58	7.43	7.30	7.19	7.08	6.98	6.88	6.80	6.72	6.65
6.4	41.58	10.23	9.83	9.37	9.22	9.07	8.94	8.81	8.57	8.37	8.19	8.02	7.87	7.73	7.61	7.50	7.39	7.29	7.20	7.12	7.04
6.6	42.88	10.80	10.38	9.90	9.74	9.58	9.45	9.30	9.06	8.85	8.65	8.48	8.32	8.18	8.05	7.92	7.81	7.71	7.61	7.53	7.44
6.8	44.18	11.39	10.95	10.44	10.28	10.10	9.96	9.82	9.56	9.33	9.13	8.95	8.78	8.63	8.49	8.36	8.25	8.14	8.04	7.95	7.86
7.0	45.48	11.99	11.53	10.99	10.82	10.64	10.49	10.34	10.07	9.83	9.62	9.43	9.25	9.09	8.95	8.81	8.69	8.58	8.47	8.38	8.28
7.2	46.78	12.61	12.12	11.56	11.38	11.19	11.04	10.87	10.59	10.34	10.12	9.92	9.73	9.57	9.42	9.28	9.15	9.03	8.92	8.81	8.72
7.4	48.08	13.24	12.73	12.14	11.95	11.76	11.59	11.42	11.13	10.87	10.63	10.42	10.23	10.05	9.89	9.75	9.61	9.49	9.37	9.26	9.16
7.6	49.38	13.88	13.35	12.73	12.54	12.33	12.16	11.98	11.67	11.40	11.15	10.93	10.73	10.55	10.38	10.23	10.09	9.96	9.84	9.72	9.62
7.8	50.68	14.54	13.98	13.34	13.13	12.92	12.74	12.55	12.23	11.95	11.69	11.46	11.25	11.06	10.88	10.72	10.58	10.44	10.31	10.19	10.09
8.0	51.97	15.21	14.62	13.95	13.74	13.52	13.33	13.14	12.80	12.50	12.23	11.99	11.77	11.58	11.39	11.23	11.07	10.93	10.80	10.68	10.56

Note: For systems with glycol or velocities outside this range, please visit Uponor's online calculator available at uponor.com/calculator.

2½" Uponor PEX (100% water)

Feet of head per 100 ft. of PEX																					
Velocity (ft/s)	GPM	40°F 4°C	45°F 7°C	50°F 10°C	55°F 13°C	60°F 16°C	65°F 18°C	70°F 21°C	80°F 27°C	90°F 32°C	100°F 38°C	110°F 43°C	120°F 49°C	130°F 54°C	140°F 60°C	150°F 66°C	160°F 71°C	170°F 77°C	180°F 82°C	190°F 88°C	200°F 93°C
1.5	14.85	0.61	0.59	0.56	0.55	0.53	0.53	0.52	0.50	0.49	0.48	0.47	0.46	0.45	0.44	0.43	0.42	0.42	0.41	0.41	0.40
1.6	15.84	0.69	0.66	0.62	0.61	0.60	0.59	0.58	0.56	0.55	0.53	0.52	0.51	0.50	0.49	0.48	0.48	0.47	0.46	0.46	0.45
1.8	17.82	0.84	0.81	0.76	0.75	0.74	0.73	0.71	0.69	0.67	0.66	0.64	0.63	0.62	0.61	0.60	0.59	0.58	0.57	0.56	0.55
2.0	19.80	1.01	0.97	0.92	0.90	0.89	0.87	0.86	0.83	0.81	0.79	0.77	0.76	0.74	0.73	0.72	0.71	0.70	0.69	0.68	0.67
2.2	21.78	1.20	1.15	1.09	1.07	1.05	1.03	1.02	0.99	0.96	0.94	0.92	0.90	0.88	0.87	0.85	0.84	0.83	0.82	0.81	0.80
2.4	23.76	1.40	1.34	1.27	1.25	1.22	1.21	1.19	1.15	1.12	1.10	1.07	1.05	1.03	1.01	1.00	0.98	0.97	0.95	0.94	0.93
2.6	25.74	1.61	1.54	1.46	1.44	1.41	1.39	1.37	1.33	1.29	1.26	1.24	1.21	1.19	1.17	1.15	1.13	1.12	1.10	1.09	1.07
2.8	27.72	1.83	1.75	1.67	1.64	1.61	1.59	1.56	1.52	1.48	1.44	1.41	1.38	1.36	1.33	1.31	1.29	1.27	1.26	1.24	1.23
3.0	29.70	2.07	1.98	1.88	1.85	1.82	1.79	1.76	1.71	1.67	1.63	1.60	1.57	1.54	1.51	1.49	1.46	1.44	1.42	1.41	1.39
3.2	31.68	2.32	2.22	2.11	2.08	2.04	2.01	1.98	1.92	1.87	1.83	1.79	1.76	1.72	1.70	1.67	1.64	1.62	1.60	1.58	1.56
3.4	33.66	2.58	2.47	2.35	2.31	2.27	2.24	2.20	2.14	2.09	2.04	2.00	1.96	1.92	1.89	1.86	1.83	1.81	1.78	1.76	1.74
3.6	35.64	2.85	2.73	2.60	2.56	2.51	2.48	2.44	2.37	2.31	2.26	2.21	2.17	2.13	2.09	2.06	2.03	2.00	1.98	1.95	1.93
3.8	37.62	3.14	3.01	2.86	2.82	2.77	2.73	2.69	2.61	2.55	2.49	2.44	2.39	2.35	2.31	2.27	2.24	2.21	2.18	2.15	2.13
4.0	39.60	3.43	3.29	3.14	3.09	3.03	2.99	2.94	2.86	2.79	2.73	2.67	2.62	2.57	2.53	2.49	2.46	2.42	2.39	2.36	2.34
4.2	41.58	3.74	3.59	3.42	3.37	3.31	3.26	3.21	3.12	3.05	2.98	2.92	2.86	2.81	2.76	2.72	2.68	2.65	2.61	2.58	2.55
4.4	43.57	4.06	3.90	3.72	3.66	3.59	3.54	3.49	3.40	3.31	3.24	3.17	3.11	3.06	3.01	2.96	2.92	2.88	2.84	2.81	2.78
4.6	45.55	4.40	4.22	4.02	3.96	3.89	3.84	3.78	3.68	3.59	3.51	3.44	3.37	3.31	3.26	3.21	3.16	3.12	3.08	3.04	3.01
4.8	47.53	4.74	4.55	4.34	4.27	4.20	4.14	4.08	3.97	3.87	3.79	3.71	3.64	3.57	3.52	3.46	3.41	3.37	3.33	3.29	3.25
5.0	49.51	5.10	4.90	4.67	4.59	4.51	4.45	4.38	4.27	4.17	4.07	3.99	3.92	3.85	3.79	3.73	3.67	3.63	3.58	3.54	3.50
5.2	51.49	5.46	5.25	5.00	4.93	4.84	4.77	4.70	4.58	4.47	4.37	4.28	4.20	4.13	4.06	4.00	3.94	3.89	3.84	3.80	3.76
5.4	53.47	5.84	5.61	5.35	5.27	5.18	5.11	5.03	4.90	4.78	4.68	4.58	4.50	4.42	4.35	4.28	4.22	4.17	4.12	4.07	4.02
5.6	55.45	6.23	5.99	5.71	5.62	5.53	5.45	5.37	5.23	5.11	4.99	4.89	4.80	4.72	4.64	4.57	4.51	4.45	4.40	4.35	4.30
5.8	57.43	6.63	6.38	6.08	5.99	5.89	5.80	5.72	5.57	5.44	5.32	5.21	5.12	5.03	4.95	4.87	4.81	4.74	4.68	4.63	4.58
6.0	59.41	7.05	6.77	6.46	6.36	6.25	6.17	6.08	5.92	5.78	5.65	5.54	5.44	5.35	5.26	5.18	5.11	5.04	4.98	4.92	4.87
6.2	61.39	7.47	7.18	6.85	6.74	6.63	6.54	6.45	6.28	6.13	6.00	5.88	5.77	5.67	5.58	5.50	5.42	5.35	5.29	5.23	5.17
6.4	63.37	7.90	7.60	7.25	7.14	7.02	6.92	6.82	6.65	6.49	6.35	6.23	6.11	6.01	5.91	5.83	5.75	5.67	5.60	5.54	5.48
6.6	65.35	8.35	8.03	7.66	7.54	7.42	7.32	7.21	7.03	6.86	6.71	6.58	6.46	6.35	6.25	6.16	6.07	6.00	5.92	5.86	5.79
6.8	67.33	8.80	8.47	8.08	7.96	7.83	7.72	7.61	7.41	7.24	7.09	6.95	6.82	6.70	6.60	6.50	6.41	6.33	6.25	6.18	6.12
7.0	69.31	9.27	8.92	8.51	8.38	8.24	8.13	8.01	7.81	7.63	7.47	7.32	7.19	7.07	6.95	6.85	6.76	6.67	6.59	6.52	6.45
7.2	71.29	9.75	9.37	8.95	8.81	8.67	8.55	8.43	8.22	8.03	7.85	7.70	7.56	7.43	7.32	7.21	7.11	7.02	6.94	6.86	6.79
7.4	73.27	10.23	9.85	9.40	9.26	9.11	8.99	8.86	8.63	8.43	8.25	8.09	7.95	7.81	7.69	7.58	7.48	7.38	7.29	7.21	7.13
7.6	75.25	10.73	10.33	9.86	9.71	9.56	9.43	9.29	9.06	8.85	8.66	8.49	8.34	8.20	8.07	7.96	7.85	7.75	7.65	7.57	7.49
7.8	77.23	11.24	10.82	10.33	10.17	10.01	9.88	9.73	9.49	9.27	9.08	8.90	8.74	8.59	8.46	8.34	8.23	8.12	8.03	7.94	7.85
8.0	79.21	11.76	11.32	10.81	10.65	10.48	10.34	10.19	9.93	9.70	9.50	9.32	9.15	9.00	8.86	8.73	8.61	8.50	8.40	8.31	8.22

Note: For systems with glycol or velocities outside this range, please visit Uponor’s online calculator available at uponor.com/calculator.

3" Uponor PEX (100% water)

Feet of head per 100 ft. of PEX																					
Velocity (ft/s)	GPM	40°F 4°C	45°F 7°C	50°F 10°C	55°F 13°C	60°F 16°C	65°F 18°C	70°F 21°C	80°F 27°C	90°F 32°C	100°F 38°C	110°F 43°C	120°F 49°C	130°F 54°C	140°F 60°C	150°F 66°C	160°F 71°C	170°F 77°C	180°F 82°C	190°F 88°C	200°F 93°C
1.5	21.12	0.49	0.47	0.45	0.44	0.43	0.42	0.42	0.40	0.39	0.38	0.37	0.37	0.36	0.35	0.35	0.34	0.34	0.33	0.33	0.32
1.6	22.53	0.55	0.53	0.50	0.49	0.48	0.47	0.47	0.45	0.44	0.43	0.42	0.41	0.40	0.40	0.39	0.38	0.38	0.37	0.37	0.36
1.8	25.34	0.68	0.65	0.61	0.60	0.59	0.58	0.57	0.56	0.54	0.53	0.52	0.51	0.50	0.49	0.48	0.47	0.47	0.46	0.45	0.45
2.0	28.16	0.81	0.78	0.74	0.73	0.71	0.70	0.69	0.67	0.65	0.64	0.63	0.61	0.60	0.59	0.58	0.57	0.56	0.56	0.55	0.54
2.2	30.97	0.96	0.92	0.88	0.86	0.85	0.83	0.82	0.80	0.78	0.76	0.74	0.73	0.71	0.70	0.69	0.68	0.67	0.66	0.65	0.64
2.4	33.79	1.12	1.07	1.02	1.00	0.99	0.97	0.96	0.93	0.91	0.88	0.87	0.85	0.83	0.82	0.80	0.79	0.78	0.77	0.76	0.75
2.6	36.60	1.29	1.24	1.18	1.16	1.14	1.12	1.10	1.07	1.04	1.02	1.00	0.98	0.96	0.94	0.93	0.92	0.90	0.89	0.88	0.87
2.8	39.42	1.47	1.41	1.34	1.32	1.30	1.28	1.26	1.22	1.19	1.16	1.14	1.12	1.10	1.08	1.06	1.05	1.03	1.02	1.00	0.99
3.0	42.24	1.66	1.59	1.52	1.49	1.47	1.44	1.42	1.38	1.35	1.32	1.29	1.26	1.24	1.22	1.20	1.18	1.17	1.15	1.14	1.13
3.2	45.05	1.86	1.79	1.70	1.67	1.64	1.62	1.60	1.55	1.51	1.48	1.45	1.42	1.39	1.37	1.35	1.33	1.31	1.29	1.28	1.26
3.4	47.87	2.07	1.99	1.89	1.86	1.83	1.80	1.78	1.73	1.69	1.65	1.61	1.58	1.55	1.53	1.51	1.48	1.46	1.44	1.43	1.41
3.6	50.68	2.29	2.20	2.10	2.06	2.03	2.00	1.97	1.92	1.87	1.83	1.79	1.75	1.72	1.69	1.67	1.64	1.62	1.60	1.58	1.56
3.8	53.50	2.52	2.42	2.31	2.27	2.23	2.20	2.17	2.11	2.06	2.01	1.97	1.93	1.90	1.87	1.84	1.81	1.79	1.77	1.74	1.72
4.0	56.31	2.76	2.65	2.53	2.49	2.45	2.41	2.38	2.31	2.26	2.21	2.16	2.12	2.08	2.05	2.02	1.99	1.96	1.94	1.91	1.89
4.2	59.13	3.01	2.90	2.76	2.72	2.67	2.63	2.59	2.52	2.46	2.41	2.36	2.31	2.27	2.24	2.20	2.17	2.14	2.12	2.09	2.07
4.4	61.95	3.27	3.14	3.00	2.95	2.90	2.86	2.82	2.74	2.68	2.62	2.57	2.52	2.47	2.43	2.40	2.36	2.33	2.30	2.27	2.25
4.6	64.76	3.54	3.40	3.24	3.19	3.14	3.10	3.05	2.97	2.90	2.84	2.78	2.73	2.68	2.64	2.60	2.56	2.53	2.49	2.47	2.44
4.8	67.58	3.82	3.67	3.50	3.45	3.39	3.34	3.29	3.21	3.13	3.06	3.00	2.94	2.89	2.85	2.80	2.77	2.73	2.69	2.66	2.63
5.0	70.39	4.11	3.95	3.77	3.71	3.65	3.60	3.54	3.45	3.37	3.30	3.23	3.17	3.12	3.07	3.02	2.98	2.94	2.90	2.87	2.84
5.2	73.21	4.40	4.23	4.04	3.98	3.91	3.86	3.80	3.70	3.61	3.54	3.47	3.40	3.34	3.29	3.24	3.20	3.15	3.12	3.08	3.05
5.4	76.02	4.71	4.53	4.32	4.25	4.18	4.13	4.07	3.96	3.87	3.79	3.71	3.64	3.58	3.52	3.47	3.42	3.38	3.34	3.30	3.26
5.6	78.84	5.02	4.83	4.61	4.54	4.47	4.40	4.34	4.23	4.13	4.04	3.96	3.89	3.82	3.76	3.71	3.66	3.61	3.56	3.52	3.49
5.8	81.66	5.35	5.14	4.91	4.83	4.76	4.69	4.62	4.50	4.40	4.31	4.22	4.14	4.07	4.01	3.95	3.90	3.84	3.80	3.76	3.72
6.0	84.47	5.68	5.47	5.22	5.14	5.05	4.99	4.91	4.79	4.68	4.58	4.49	4.41	4.33	4.26	4.20	4.14	4.09	4.04	3.99	3.95
6.2	87.29	6.02	5.79	5.53	5.45	5.36	5.29	5.21	5.08	4.96	4.86	4.76	4.67	4.60	4.52	4.46	4.40	4.34	4.29	4.24	4.19
6.4	90.10	6.37	6.13	5.86	5.77	5.67	5.60	5.52	5.38	5.25	5.14	5.04	4.95	4.87	4.79	4.72	4.66	4.60	4.54	4.49	4.44
6.6	92.92	6.73	6.48	6.19	6.09	6.00	5.92	5.83	5.68	5.55	5.44	5.33	5.23	5.15	5.07	4.99	4.93	4.86	4.80	4.75	4.70
6.8	95.73	7.10	6.83	6.53	6.43	6.33	6.24	6.15	6.00	5.86	5.74	5.63	5.52	5.43	5.35	5.27	5.20	5.13	5.07	5.02	4.96
7.0	98.55	7.48	7.20	6.88	6.77	6.67	6.58	6.48	6.32	6.17	6.05	5.93	5.82	5.73	5.64	5.56	5.48	5.41	5.35	5.29	5.23
7.2	101.37	7.86	7.57	7.23	7.13	7.01	6.92	6.82	6.65	6.50	6.36	6.24	6.13	6.03	5.93	5.85	5.77	5.70	5.63	5.57	5.51
7.4	104.18	8.26	7.95	7.60	7.48	7.37	7.27	7.16	6.99	6.83	6.68	6.56	6.44	6.33	6.24	6.15	6.06	5.99	5.92	5.85	5.79
7.6	107.00	8.66	8.34	7.97	7.85	7.73	7.62	7.52	7.33	7.16	7.01	6.88	6.76	6.65	6.55	6.45	6.37	6.28	6.21	6.14	6.08
7.8	109.81	9.07	8.74	8.35	8.23	8.10	7.99	7.88	7.68	7.51	7.35	7.21	7.08	6.97	6.86	6.76	6.67	6.59	6.51	6.44	6.37
8.0	112.63	9.49	9.14	8.74	8.61	8.47	8.36	8.24	8.04	7.86	7.70	7.55	7.42	7.29	7.18	7.08	6.99	6.90	6.82	6.74	6.68

Note: For systems with glycol or velocities outside this range, please visit Uponor's online calculator available at uponor.com/calculator.

4" Uponor PEX (100% water)

Feet of head per 100 ft. of PEX																					
Velocity (ft/s)	GPM	40°F 4°C	45°F 7°C	50°F 10°C	55°F 13°C	60°F 16°C	65°F 18°C	70°F 21°C	80°F 27°C	90°F 32°C	100°F 38°C	110°F 43°C	120°F 49°C	130°F 54°C	140°F 60°C	150°F 66°C	160°F 71°C	170°F 77°C	180°F 82°C	190°F 88°C	200°F 93°C
1.5	36.88	0.35	0.33	0.32	0.31	0.30	0.30	0.29	0.29	0.28	0.27	0.27	0.26	0.26	0.25	0.25	0.24	0.24	0.24	0.23	0.23
1.6	39.34	0.39	0.37	0.35	0.35	0.34	0.34	0.33	0.32	0.31	0.31	0.30	0.29	0.29	0.28	0.28	0.27	0.27	0.27	0.26	0.26
1.8	44.26	0.48	0.46	0.44	0.43	0.42	0.41	0.41	0.40	0.39	0.38	0.37	0.36	0.35	0.35	0.34	0.34	0.33	0.33	0.32	0.32
2.0	49.17	0.58	0.55	0.52	0.52	0.51	0.50	0.49	0.48	0.47	0.45	0.45	0.44	0.43	0.42	0.41	0.41	0.40	0.40	0.39	0.39
2.2	54.09	0.68	0.65	0.62	0.61	0.60	0.59	0.58	0.57	0.55	0.54	0.53	0.52	0.51	0.50	0.49	0.48	0.48	0.47	0.47	0.46
2.4	59.01	0.79	0.76	0.73	0.71	0.70	0.69	0.68	0.66	0.65	0.63	0.62	0.61	0.59	0.58	0.57	0.57	0.56	0.55	0.54	0.54
2.6	63.93	0.92	0.88	0.84	0.82	0.81	0.80	0.78	0.76	0.74	0.73	0.71	0.70	0.69	0.67	0.66	0.65	0.65	0.64	0.63	0.62
2.8	68.84	1.04	1.00	0.95	0.94	0.92	0.91	0.90	0.87	0.85	0.83	0.81	0.80	0.78	0.77	0.76	0.75	0.74	0.73	0.72	0.71
3.0	73.76	1.18	1.13	1.08	1.06	1.04	1.03	1.01	0.99	0.96	0.94	0.92	0.90	0.89	0.87	0.86	0.85	0.84	0.82	0.82	0.81
3.2	78.68	1.32	1.27	1.21	1.19	1.17	1.15	1.14	1.11	1.08	1.06	1.03	1.01	1.00	0.98	0.97	0.95	0.94	0.93	0.92	0.91
3.4	83.60	1.47	1.41	1.35	1.33	1.30	1.29	1.27	1.23	1.20	1.18	1.15	1.13	1.11	1.09	1.08	1.06	1.05	1.03	1.02	1.01
3.6	88.51	1.63	1.57	1.49	1.47	1.44	1.42	1.40	1.37	1.33	1.30	1.28	1.25	1.23	1.21	1.19	1.18	1.16	1.15	1.13	1.12
3.8	93.43	1.79	1.72	1.64	1.62	1.59	1.57	1.55	1.51	1.47	1.44	1.41	1.38	1.36	1.34	1.32	1.30	1.28	1.27	1.25	1.24
4.0	98.35	1.96	1.89	1.80	1.77	1.74	1.72	1.69	1.65	1.61	1.58	1.55	1.52	1.49	1.47	1.45	1.42	1.41	1.39	1.37	1.36
4.2	103.27	2.14	2.06	1.97	1.94	1.90	1.88	1.85	1.80	1.76	1.72	1.69	1.66	1.63	1.60	1.58	1.56	1.54	1.52	1.50	1.48
4.4	108.18	2.33	2.24	2.14	2.10	2.07	2.04	2.01	1.96	1.91	1.87	1.84	1.80	1.77	1.74	1.72	1.69	1.67	1.65	1.63	1.61
4.6	113.10	2.52	2.42	2.31	2.28	2.24	2.21	2.18	2.12	2.07	2.03	1.99	1.95	1.92	1.89	1.86	1.84	1.81	1.79	1.77	1.75
4.8	118.02	2.72	2.61	2.50	2.46	2.42	2.39	2.35	2.29	2.24	2.19	2.15	2.11	2.07	2.04	2.01	1.98	1.96	1.93	1.91	1.89
5.0	122.94	2.92	2.81	2.69	2.64	2.60	2.57	2.53	2.47	2.41	2.36	2.31	2.27	2.23	2.20	2.16	2.14	2.11	2.08	2.06	2.04
5.2	127.85	3.13	3.02	2.88	2.84	2.79	2.75	2.71	2.65	2.59	2.53	2.48	2.44	2.40	2.36	2.32	2.29	2.26	2.24	2.21	2.19
5.4	132.77	3.35	3.23	3.08	3.04	2.99	2.95	2.91	2.83	2.77	2.71	2.66	2.61	2.57	2.53	2.49	2.46	2.42	2.40	2.37	2.34
5.6	137.69	3.58	3.44	3.29	3.24	3.19	3.15	3.10	3.02	2.96	2.89	2.84	2.79	2.74	2.70	2.66	2.62	2.59	2.56	2.53	2.50
5.8	142.60	3.81	3.67	3.50	3.45	3.40	3.35	3.30	3.22	3.15	3.08	3.02	2.97	2.92	2.88	2.83	2.80	2.76	2.73	2.70	2.67
6.0	147.52	4.05	3.90	3.72	3.67	3.61	3.56	3.51	3.42	3.35	3.28	3.21	3.16	3.11	3.06	3.01	2.97	2.94	2.90	2.87	2.84
6.2	152.44	4.29	4.13	3.95	3.89	3.83	3.78	3.73	3.63	3.55	3.48	3.41	3.35	3.30	3.25	3.20	3.16	3.12	3.08	3.05	3.01
6.4	157.36	4.54	4.37	4.18	4.12	4.06	4.00	3.95	3.85	3.76	3.68	3.61	3.55	3.49	3.44	3.39	3.34	3.30	3.26	3.23	3.19
6.6	162.27	4.80	4.62	4.42	4.35	4.29	4.23	4.17	4.07	3.98	3.89	3.82	3.75	3.69	3.64	3.58	3.54	3.49	3.45	3.41	3.38
6.8	167.19	5.06	4.88	4.66	4.59	4.52	4.46	4.40	4.29	4.20	4.11	4.03	3.96	3.90	3.84	3.78	3.73	3.69	3.65	3.61	3.57
7.0	172.11	5.33	5.14	4.91	4.84	4.77	4.70	4.64	4.52	4.42	4.33	4.25	4.18	4.11	4.05	3.99	3.94	3.89	3.84	3.80	3.76
7.2	177.03	5.61	5.40	5.17	5.09	5.01	4.95	4.88	4.76	4.65	4.56	4.47	4.40	4.32	4.26	4.20	4.14	4.09	4.05	4.00	3.96
7.4	181.94	5.89	5.67	5.43	5.35	5.27	5.20	5.13	5.00	4.89	4.79	4.70	4.62	4.55	4.48	4.41	4.36	4.30	4.25	4.21	4.16
7.6	186.86	6.18	5.95	5.70	5.61	5.53	5.45	5.38	5.25	5.13	5.03	4.93	4.85	4.77	4.70	4.63	4.57	4.52	4.47	4.42	4.37
7.8	191.78	6.47	6.24	5.97	5.88	5.79	5.72	5.64	5.50	5.38	5.27	5.17	5.08	5.00	4.93	4.86	4.80	4.74	4.68	4.63	4.58
8.0	196.70	6.77	6.53	6.25	6.16	6.06	5.98	5.90	5.76	5.63	5.52	5.42	5.32	5.24	5.16	5.09	5.02	4.96	4.90	4.85	4.80

Note: For systems with glycol or velocities outside this range, please visit Uponor's online calculator available at uponor.com/calculator.

Appendix C

Fitting Equivalent Length and C_v

Equivalent length of fittings

This section provides the equivalent length of piping pressure loss for several ProPEX fittings as well as C_v where applicable. The equivalent length is used to approximate the impact the fittings have on pressure loss across the piping length. The equivalent length for each fitting is shown in the tables below. Add the equivalent length to the total piping length for each fitting installed along the piping run. The total pressure loss is then computed from the adjusted total piping length. Equivalent lengths are commonly utilized

to calculate the Total Developed Length (TDL) along a critical piping path. All Uponor values represent pressure loss at 8 ft./sec.

Many methods exist for calculating the coefficient of velocity (C_v) across valves and fittings. The proceeding set of Uponor data was derived from empirical testing performed by NSF International and tested to ISA-S75.02 *Pressure Drop Measurement and C_v Calculations* at a measured and verified flow rate. In order to calculate equivalent length in feet, a quadratic equation is utilized to determine pressure drop versus flow data at precisely 8 ft./sec.

Other common methods for calculating C_v include UL 1821 *Thermoplastic Sprinkler Pipe and Fittings for Fire Protection* and the use of flow modeling software. Through extensive testing and validation by NSF International, Uponor has built a complete and accurate data set for our PEX piping systems. When comparing equivalent length data across PEX fitting manufacturers, values may differ due to different testing methods and reported values at specific flow velocities other than 8 ft./sec.

For comparison purposes, NSF International tested commonly available ASTM

F1807 *Brass Insert Fittings Utilizing Copper Crimp Ring for PEX Tubing Fittings* and ASTM F2159 *Plastic Insert Fittings Utilizing Copper Crimp Rings for PEX Tubing Fittings* to the ISA-S75.02 test method using the same quadratic equation as the Uponor ProPEX fittings to determine pressure drop versus flow data at precisely 8 ft./sec. Reference **Table C-1** for equivalent length comparisons.

Fittings	Nominal size (in.)	ASTM F1960	ASTM F1807	ASTM F2159	F1960 vs. F1807	F1960 vs. F2159
		Uponor ProPEX eq. length	Brass crimp ring eq. length	Plastic crimp ring eq. length		
Tee run	½	1	3.19	6.03	219.00%	503.00%
	¾	1.5	2.57	6.12	71.33%	308.00%
	1	1.3	2.49	6.26	91.54%	381.54%
Tee branch	½	6.3	9.05	15.34	43.65%	143.49%
	¾	15.6	10.16	17.04	-34.87%	9.23%
	1	12.7	11.87	20.17	-6.54%	58.82%
Elbow	½	10.4	9.11	13.53	-12.40%	30.10%
	¾	10.8	10.47	16.21	-3.06%	50.09%
	1	11.5	10.14	17.05	-11.83%	48.26%
Coupling	½	0.8	2.03	6.55	153.75%	718.75%
	¾	0.9	2.18	5.64	142.22%	526.67%
	1	0.9	1.49	4.97	65.56%	452.22%

Table C-1: Equivalent length comparison of various PEX fitting types



Fitting equivalent length and C_v data

EP tees	Flow/port	Avg. C_v	Eq. length (ft)
$\frac{1}{2} \times \frac{1}{2} \times \frac{1}{2}$	Through	7.7	1.0
	Branch	3.4	6.3
$\frac{3}{4} \times \frac{3}{4} \times \frac{3}{4}$	Through	15.7	1.5
	Branch	5.4	15.6
1 x 1 x 1	Through	30.5	1.3
	Branch	11.3	12.7
$1\frac{1}{4} \times 1\frac{1}{4} \times 1\frac{1}{4}$	Through	34.0	3.8
	Branch	23.9	8.6
$1\frac{1}{2} \times 1\frac{1}{2} \times 1\frac{1}{2}$	Through	63.7	1.8
	Branch	31.0	10.6
2 x 2 x 2	Through	150.7	0.8
	Branch	52.5	15.5
$2\frac{1}{2} \times 2\frac{1}{2} \times 2\frac{1}{2}$	Through	197.2	2.7
	Branch	81.5	22.3
3 x 3 x 3	Through	286.6	2.8
	Branch	122.8	23.9

EP reducing tees	Flow/port	Avg. C_v	Eq. length (ft)
$\frac{1}{2} \times \frac{1}{2} \times \frac{3}{4}$	Branch	3.8	4.1
	Through	4.6	3.5
$\frac{3}{4} \times \frac{1}{2} \times \frac{1}{2}$	Branch	3.4	6.4
	Through	5.4	2.3
$\frac{3}{4} \times \frac{1}{2} \times \frac{3}{4}$	Branch	5.4	16.1
	Through	14.2	2.0
$\frac{3}{4} \times \frac{3}{4} \times \frac{1}{2}$	Branch	3.1	7.6
	Through	8.7	5.7
1 x $\frac{3}{4}$ x $\frac{3}{4}$	Branch	12.8	2.4
	Through	5.3	16.7
1 x $\frac{3}{4}$ x 1	Branch	12.9	2.4
	Through	10.5	15.1
1 x 1 x $\frac{1}{2}$	Branch	32.2	1.2
	Through	3.4	6.5
1 x 1 x $\frac{3}{4}$	Branch	27.8	1.7
	Through	8.2	6.4
1 x $\frac{3}{4}$ x $1\frac{1}{4}$	Branch	14.7	2.74
	Through	12.0	19.48
1 x 1 x $1\frac{1}{4}$	Branch	15.0	6.52
	Through	28.0	5.37
$1\frac{1}{4} \times \frac{3}{4} \times \frac{3}{4}$	Branch	7.3	2.74
	Through	12.0	7.41

EP reducing tees	Flow/port	Avg. C_v	Eq. length (ft)
$1\frac{1}{4} \times \frac{3}{4} \times 1$	Branch	13.9	2.70
	Through	12.1	7.59
$1\frac{1}{4} \times \frac{3}{4} \times 1\frac{1}{4}$	Branch	18.8	2.74
	Through	12.0	11.91
$1\frac{1}{4} \times 1 \times \frac{3}{4}$	Branch	21.0	3.4
	Through	9.3	5.2
$1\frac{1}{4} \times 1 \times 1$	Branch	11.7	11.0
	Through	8.4	23.0
$1\frac{1}{4} \times 1\frac{1}{4} \times \frac{1}{2}$	Branch	45.2	1.9
	Through	4.1	3.9
$1\frac{1}{4} \times 1\frac{1}{4} \times \frac{3}{4}$	Branch	43.4	2.3
	Through	8.9	5.7
$1\frac{1}{4} \times 1\frac{1}{4} \times 1$	Branch	33.0	4.2
	Through	15.8	6.3
$1\frac{1}{2} \times \frac{3}{4} \times \frac{3}{4}$	Branch	7.3	2.88
	Through	11.7	7.41
$1\frac{1}{2} \times \frac{3}{4} \times 1\frac{1}{2}$	Branch	22.9	2.74
	Through	12.0	19.10
$1\frac{1}{2} \times 1 \times \frac{3}{4}$	Branch	19.5	4.0
	Through	9.3	5.1
$1\frac{1}{2} \times 1 \times 1$	Branch	18.9	4.3
	Through	15.6	6.5
$1\frac{1}{2} \times 1 \times 1\frac{1}{2}$	Branch	19.1	4.2
	Through	26.5	14.9
$1\frac{1}{2} \times 1\frac{1}{4} \times \frac{3}{4}$	Branch	33.1	4.2
	Through	6.3	11.3
$1\frac{1}{2} \times 1\frac{1}{4} \times 1$	Branch	36.4	3.1
	Through	11.2	13.1
$1\frac{1}{2} \times 1\frac{1}{4} \times 1\frac{1}{4}$	Branch	45.4	2.0
	Through	17.0	17.7
$1\frac{1}{2} \times 1\frac{1}{2} \times \frac{1}{2}$	Branch	60.5	2.4
	Through	3.4	6.3
$1\frac{1}{2} \times 1\frac{1}{2} \times \frac{3}{4}$	Branch	56.0	2.9
	Through	9.0	5.4
$1\frac{1}{2} \times 1\frac{1}{2} \times 1$	Branch	53.8	3.1
	Through	15.3	6.9
$1\frac{1}{2} \times 1\frac{1}{2} \times 1\frac{1}{4}$	Branch	54.3	3.2
	Through	33.7	4.1
2 x $1\frac{1}{2}$ x $\frac{3}{4}$	Branch	43.5	4.9
	Through	8.4	6.2

EP reducing tees
(continued)



EP reducing tees	Flow path	Avg. C_v	Eq. length (ft)
2 x 1½ x 1	Through	42.4	5.5
	Branch	13.9	8.4
2 x 1½ x 1¼	Through	41.8	5.6
	Branch	22.0	10.3
2 x 1½ x 1½	Through	42.1	5.4
	Branch	28.5	13.0
2 x 1½ x 2	Through	38.6	6.6
	Branch	51.8	16.1
2 x 2 x ½	Through	111.1	2.7
	Branch	4.3	4.0
2 x 2 x ¾	Through	115.0	2.7
	Branch	8.2	6.8
2 x 2 x 1	Through	119.7	2.4
	Branch	13.8	8.5
2 x 2 x 1¼	Through	107.0	3.1
	Branch	23.6	8.8
2 x 2 x 1½	Through	115.8	2.5
	Branch	29.9	11.7
2½ x 2 x 1½	Through	80.4	5.9
	Branch	30.2	11.2
2½ x 2 x 2	Through	79.5	5.7
	Branch	51.8	16.0
2½ x 2½ x ¾	Through	209.6	2.0
	Branch	8.5	6.0
2½ x 2½ x 1	Through	202.0	2.4
	Branch	17.5	5.0
2½ x 2½ x 1¼	Through	198.8	2.5
	Branch	22.4	9.7
2½ x 2½ x 1½	Through	200.0	2.5
	Branch	29.8	11.5
2½ x 2½ x 2	Through	193.2	2.7
	Branch	53.6	14.7
3 x 2 x 2	Through	69.9	8.1
	Branch	52.8	15.3
3 x 2½ x 1½	Through	132.5	7.5
	Branch	29.2	12.0
3 x 2½ x 2	Through	133.2	7.4
	Branch	51.7	16.4
3 x 3 x ¾	Through	294.9	2.7
	Branch	8.5	6.0
3 x 3 x 1	Through	291.4	2.8
	Branch	14.8	7.3
3 x 3 x 1¼	Through	290.4	3.0
	Branch	22.8	9.3

EP reducing tees (continued)



EP reducing tees	Flow path	Avg. C_v	Eq. length (ft)
3 x 3 x 1½	Through	290.5	2.9
	Branch	29.9	11.3
3 x 3 x 2	Through	287.6	3.0
	Branch	53.8	14.6
3 x 3 x 2½	Through	288.3	3.0
	Branch	82.2	22.2

EP coupling





Nominal size (in)	Flow path	Avg. C_v	Eq. length (ft)
½ x ½	Through	8.3	0.8
¾ x ½	Through	5.2	2.6
¾ x ¾	Through	19.0	0.9
1 x ¾	Through	12.5	2.7
1 x 1	Through	33.8	0.9
1¼ x ¾	Through	10.9	3.6
1¼ x 1	Through	22.3	2.6
1¼ x 1¼	Through	53.3	1.1
1½ x ¾	Through	10.8	3.5
1½ x 1	Through	19.0	4.3
1½ x 1¼	Through	33.9	3.7
1½ x 1½	Through	69.5	1.4
2 x 1½	Through	45.2	4.6
2 x 2	Through	107.8	2.7
2½ x 1¼	Through	29.3	5.4
2½ x 1½	Through	35.9	7.5
2½ x 2	Through	82.6	5.4
2½ x 2½	Through	219.1	1.7
3 x 2	Through	73.4	7.2
3 x 2½	Through	136.2	7.1
3 x 3	Through	320.6	1.9


45° elbow



Nominal size (in)	Flow path	Avg. C_v	Eq. length (ft)
1½ x 1½	Through	33.1	9.3
2 x 2	Through	68.9	8.8
2½ x 2½	Through	136.8	6.9
3 x 3	Through	195.5	8.3

90° elbow 	Nominal size (in)	Flow path	Avg. C _v	Eq. length (ft)
	½ x ½	Through	2.6	10.4
	¾ x ¾	Through	6.7	10.8
	1 x 1	Through	11.9	11.5
	1¼ x 1¼	Through	22.2	10.0
	1½ x 1½	Through	29.7	11.5
	2 x 2	Through	50.2	17.1
	2½ x 2½	Through	86.0	20.0
	3 x 3	Through	125.0	23.2

Elbows 	EP multiport elbows	Flow/port	Avg. C _v	Eq. length (ft)
	EP flow-through multiport elbow, 3 outlets, ¾" x ¾" ProPEX	Through	7.1	8.8
		#2	3.4	6.3
	EP flow-through multiport elbow, 4 outlets, ¾" x ¾" ProPEX	Through	7.1	8.9
		#3	3.4	6.4
1" EP branch multiport elbow, 10 outlets with mounting clips	#5	3.0	7.9	

Flow-through 	EP flow-through multiport tees	Flow/port	Avg. C _v	Eq. length (ft)
	EP flow-through multiport tee, 2 outlets, ¾" x ¾" ProPEX	Through	15.3	1.6
		#2	3.4	6.4
	EP flow-through multiport tee, 3 (1") outlets, 2" x 2" ProPEX	Through	99.0	3.9
		#2	13.4	9.0
	EP flow-through multiport tee, 3 outlets, 1" x ¾" PEX	Through	11.6	3.2
		#2	3.7	5.4
	EP flow-through multiport tee, 3 outlets, ¾" x ¾" ProPEX	Through	7.1	8.8
		#2	3.4	6.3
	EP flow-through multiport tee, 3 (¾") outlets, 1¼" x 1¼" PEX	Through	45.9	7.9
		#2	1.8	7.1
	EP flow-through multiport tee, 4 outlets, ¾" x ¾" ProPEX	Through	7.1	8.9
		#3	3.4	6.4
	EP flow-through multiport tee, 4 outlets, 1" x 1" PEX	Through	29.3	1.5
		#3	3.2	7.5
EP flow-through multiport tee, 4 outlets, 1" x ¾" ProPEX	Through	11.7	3.0	
	#3	4.0	4.5	
EP flow-through multiport tee, 6 outlets, 1" x ¾" ProPEX	Through	11.8	3.1	
	#3	3.5	5.8	
EP flow-through multiport tee, 6 outlets, ¾" x ¾" ProPEX	Through	13.2	3.8	
	#3	3.7	5.3	
EP flow-through multiport tee, 6 outlets, 1" x 1" ProPEX	Through	25.1	2.5	
	#3	3.1	7.6	

Vertical



EP Flow-through multiport vertical tee	Flow/port	Avg. C _v	Eq. length (ft)
EP flow-through multiport vertical tee, 3 outlets, ¾" x ¾" x ¾" ProPEX	Tee to tee	13.6	2.3
	Tee to side	7.4	8.2
	Tee to #2	3.1	7.8
	Side to tee	6.9	9.5
	Side to #2	3.6	4.9

Branch



EP branch multiport tees	Flow/port	Avg. C _v	Eq. length (ft)
¾" EP branch multiport tee, 3 outlets	#2	3.4	6.0
1¼" EP branch multiport tee, 3 (¾") outlets	#2	7.9	7.1
1" EP branch multiport tee, 4 outlets	#3	4.2	3.9
¾" EP branch multiport tee, 4 outlets	#3	3.3	6.7
1" EP branch multiport tee, 6 outlets	#3	3.6	5.4
¾" EP branch multiport tee, 6 outlets	#3	4.1	3.8
¾" EP branch multiport tee, 7 outlets with mounting clips	#4	2.6	10.6
1" EP branch multiport tee, 7 outlets with mounting clips	#4	2.6	10.7
¾" EP branch multiport tee, 8 outlets with mounting clips	#4	2.6	10.9
1" EP branch multiport tee, 8 outlets with mounting clips	#4	3.2	6.1

Opposing



EP opposing-port multiport tees	Flow/port	Avg. C _v	Eq. length (ft)
¾" EP branch opposing-port multiport tee, 3 outlets	#2	3.3	6.5
EP flow-through opposing-port multiport tee, 3 outlets, ¾" x ¾" ProPEX	Through	15.9	1.6
	#3	3.4	6.4
¾" EP branch opposing-port multiport tee, 4 outlets	#3	3.5	6.0
EP flow-through opposing-port multiport tee, 4 outlets, ¾" x ¾" ProPEX	Through	16.9	1.3
	#3	3.4	6.3
EP flow-through opposing-port multiport tee, 6 outlets, ¾" x ¾" ProPEX	Through	16.4	1.3
	#3	3.4	6.2
¾" EP branch opposing-port multiport tee, 8 outlets	#4	3.4	6.0

Opposing-port tees



EP opposing-port tees	Flow	Avg. C _v	Eq. length (ft)
EP opposing-port tee, 1" x 1" x ¾" x ¾"	Through	34.1	1.4
	Branch	8.9	5.7
EP opposing-port tee, 1¼" x 1¼" x ¾" x ¾"	Through	57.1	1.5
	Branch	9.1	5.4
EP opposing-port tee, 1½" x 1½" x ¾" x ¾"	Through	69.3	2.4
	Branch	9.0	5.5
EP opposing-port tee, 2" x 2" x ¾" x ¾"	Through	130.0	2.7
	Branch	9.1	5.4

Sweat adapters



Nominal size (in)	Flow path	Avg. C _v	Eq. length (ft)
½ PEX x ½ copper	Through	5.7	2.0
½ PEX x ¾ copper	Through	5.1	2.7
¾ PEX x ½ copper	Through	8.8	1.4
¾ PEX x ¾ copper	Through	13.4	2.1
¾ PEX x 1 copper	Through	10.9	3.7
1 PEX x 1 copper	Through	22.1	2.4
1¼ PEX x 1¼ copper	Through	34.0	3.9
1½ PEX x 1½ copper	Through	45.5	4.3
2 PEX x 2 copper	Through	83.6	5.3
2½ PEX x 2½ copper	Through	136.2	6.9
3 PEX x 3 copper	Through	189.1	8.8

Fitting sweat adapters



Nominal size (in)	Flow path	Avg. C _v	Eq. length (ft)
½ PEX x ½ copper	Through	7.7	1.0
½ PEX x ¾ copper	Cu to PEX	5.6	2.2
¾ PEX x ½ copper	PEX to Cu	8.8	1.5
¾ PEX x ¾ copper	Through	15.7	1.5
¾ PEX x 1 copper	Cu to PEX	11.4	3.1
1 PEX x 1 copper	Through	30.5	1.3
1¼ PEX x 1¼ copper	Through	34.0	3.8
1½ PEX x 1½ copper	Through	63.7	1.8
2 PEX x 2 copper	Through	150.7	0.8

LF brass copper press adapters



Nominal size (in)	Avg. C _v	Eq. length (ft)
LF brass copper press adapter, ½" PEX x ½" copper	5.7	2.0
LF brass copper press adapter, ¾" PEX x ¾" copper	13.4	2.1
LF brass copper press adapter, 1" PEX x 1" copper	22.1	2.4
LF brass copper press adapter, 1¼" PEX x 1¼" copper	34.0	3.9
LF brass copper press adapter, 1½" PEX x 1½" copper	45.5	4.3
LF brass copper press adapter, 2" PEX x 2" copper	83.6	5.3
LF brass copper press adapter, 2½" PEX x 2½" copper	136.2	6.9
LF brass copper press adapter, 3" PEX x 3" copper	189.1	8.8

LF brass copper press fitting adapters



Nominal size (in)	Avg. C _v	Eq. length (ft)
LF brass copper press fitting adapter, ½" PEX x ½" copper	5.6	2.1
LF brass copper press fitting adapter, ¾" PEX x ¾" copper	12.8	2.4
LF brass copper press fitting adapter, 1" PEX x 1" copper	21.4	3.1
LF brass copper press fitting adapter, 1¼" PEX x 1¼" copper	31.5	4.7
LF brass copper press fitting adapter, 1½" PEX x 1½" copper	43.5	4.8
LF brass copper press fitting adapter, 2" PEX x 2" copper	81.5	5.6
LF brass copper press fitting adapter, 2½" PEX x 2½" copper	137.0	6.9
LF brass copper press fitting adapter, 3" PEX x 3" copper	187.1	9.4

Male adapters



Nominal size (in)	Flow path	Avg. C _v	Eq. length (ft)
½ PEX x ½ MNPT	Through	5.0	2.3
½ PEX x ¾ MNPT	NPT to PEX	6.2	1.8
¾ PEX x ¾ MNPT	Through	11.3	2.7
¾ PEX x 1 MNPT	NPT to PEX	10.9	3.4
1 PEX x ¾ MNPT	PEX to NPT	17.8	1.2
1 PEX x 1 MNPT	Through	19.9	3.2
1¼ PEX x 1¼ MNPT	Through	32.4	4.2
1½ PEX x 1½ MNPT	Through	39.3	5.5
2 PEX x 2 MNPT	Through	78.6	5.6
2½ PEX x 2½ MNPT	Through	227.3	1.5
3 PEX x 3 MNPT	Through	187.5	9.1

Female adapters



Nominal size (in)	Flow path	Avg. C _v	Eq. length (ft)
½ PEX x ½ FNPT	Through	4.8	2.5
½ PEX x ¾ FNPT	NPT to PEX	5.1	2.7
¾ PEX x ¾ FNPT	Through	12.0	2.3
¾ PEX x 1 FNPT	NPT to PEX	10.8	3.6
1 PEX x 1 FNPT	Through	19.7	3.8
1¼ PEX x 1¼ FNPT	Through	30.8	4.8
1½ PEX x 1½ FNPT	Through	40.9	5.1
2 PEX x 2 FNPT	Through	77.7	5.7

CPVC adapters



Nominal size (in)	Flow path	Avg. C _v	Eq. length (ft)
1¼ PEX x 1¼ CPVC spigot	CVPC to PEX	42.6	2.1
1¼ PEX x 1¼ CPVC socket	CVPC to PEX	43.3	2.0
1½ PEX x 1½ CPVC spigot	CVPC to PEX	55.7	2.6
1½ PEX x 1½ CPVC socket	CVPC to PEX	54.1	2.8
2 PEX x 2 CPVC spigot	CVPC to PEX	110.2	2.5
2 PEX x 2 CPVC socket	CVPC to PEX	112.6	2.4

Groove adapters



Nominal size (in)	Avg. C _v ¹	Eq. Length (ft) ¹	Avg. C _v ²	Eq. Length (ft) ²
2 PEX x 2 CTS groove	86.1	4.9	141.4	1.0
2 PEX x 2 IPS groove	79.7	5.9	114.5	2.3
2 PEX x 2½ CTS groove	73.2	7.3	128.3	1.6
2 PEX x 2½ IPS groove	71.6	7.6	124.0	1.7
2½ PEX x 2 IPS groove	195.6	2.3	239.5	1.2
2½ PEX x 2½ CTS groove	138.7	6.5	222.7	1.5
2½ PEX x 2½ IPS groove	130.2	7.6	202.0	2.4
2½ PEX x 3 IPS groove	114.9	10.2	199.8	2.4
3 PEX x 2½ IPS groove	250.7	4.2	334.4	1.4
3 PEX x 3 CTS groove	192.3	8.3	338.3	1.6
3 PEX x 3 IPS groove	177.4	10.0	282.4	2.8

¹Copper-to-PEX flow
²PEX-to-copper flow

Flange adapters



Nominal size (in)	Flow path	Avg. C _v	Eq. length (ft)
2½ PEX x flange	Through	131.5	7.6
3 PEX x flange	Through	310.7	2.2

LF brass commercial ball valve (full port)



Nominal size (in)	Avg. C _v	Equivalent length (ft)
½ PEX x ½ PEX	7.0	2.8
¾ PEX x ¾ PEX	18.7	3.3
1 PEX x 1 PEX	29.0	4.3
1¼ PEX x 1¼ PEX	54.7	4.8
1½ PEX x 1½ PEX	68.2	5.7
2 PEX x 2 PEX	132.2	7.1

Brass commercial ball valve (full port)



Nominal size (in)	Avg. C _v	Equivalent length (ft)
½" PEX x ½" PEX	7.0	2.8
¾" PEX x ¾" PEX	18.7	3.3
1" PEX x 1" PEX	29.0	4.3
1¼" PEX x 1¼" PEX	54.7	4.8
1½" PEX x 1½" PEX	68.2	5.7
2" PEX x 2" PEX	132.2	7.1

Appendix D

Pipe Heat Loss and Surface Temperature

**½" Uponor PEX heat loss
at 50°F/10°C ambient**

Water temp (°F)	Heat loss (btu/hr-ft)				
	No insulation	½" insulation	1" insulation	1½" insulation	2" insulation
30	-3.2	-2.0	-1.6	-1.4	-1.2
40	-1.6	-1.0	-0.8	-0.7	-0.6
50	0.0	0.0	0.0	0.0	0.0
60	1.6	1.0	0.8	0.7	0.6
70	3.2	2.0	1.6	1.4	1.2
80	4.7	3.0	2.4	2.0	1.8
90	6.3	4.1	3.2	2.7	2.4
100	7.9	5.1	4.0	3.4	3.1
110	9.5	6.1	4.7	4.1	3.7
120	11.1	7.1	5.5	4.8	4.3
130	12.6	8.1	6.3	5.4	4.9
140	14.2	9.1	7.1	6.1	5.5
150	15.8	10.1	7.9	6.8	6.1
160	17.4	11.1	8.7	7.5	6.7
170	18.9	12.2	9.5	8.2	7.3
180	20.5	13.2	10.3	8.8	8.0
190	22.1	14.2	11.1	9.5	8.6
200	23.7	15.2	11.9	10.2	9.2

**½" Uponor PEX surface
temperature at 50°F/10°C ambient**

Water temp (°F)	Heat loss (btu/hr-ft)				
	No insulation	½" insulation	1" insulation	1½" insulation	2" insulation
30	30.7	45.2	47.7	48.6	49.0
40	40.4	47.6	48.8	49.3	49.5
50	50.0	50.0	50.0	50.0	50.0
60	59.6	52.4	51.2	50.7	50.5
70	69.3	54.8	52.3	51.4	51.0
80	78.9	57.1	53.5	52.1	51.5
90	88.6	59.5	54.6	52.9	52.0
100	98.2	61.9	55.8	53.6	52.5
110	107.9	64.3	56.9	54.3	53.0
120	117.5	66.7	58.1	55.0	53.5
130	127.2	69.0	59.2	55.7	54.0
140	136.8	71.4	60.4	56.4	54.5
150	146.5	73.8	61.5	57.2	55.1
160	156.1	76.2	62.7	57.9	55.6
170	165.8	78.6	63.8	58.6	56.1
180	175.4	81.0	65.0	59.3	56.6
190	185.1	83.3	66.1	60.0	57.1
200	194.7	85.7	67.3	60.7	57.6

1. All calculations based on cylindrical thermal resistance methodology (ASHRAE).
2. Based on fluid velocity of 8 ft./sec. at 160°F/71.1°C (maximizing heat transfer from 100% water).
3. Pipe convection set to be 1.00 Btu/hr·ft²·°F (based on standard value for free convection of air).
4. This heat loss comparison uses 0.25 Btu·in/(hr·ft²·°F) as the insulation thermal conductivity. This is a standard value for fiberglass pipe insulation at a 100°F/37.8°C mean temperature.

**3/8" Uponor PEX heat loss
at 50°F/10°C ambient**

Water temp (°F)	Heat loss (btu/hr-ft)				
	No insulation	1/2" insulation	1" insulation	1 1/2" insulation	2" insulation
30	-3.8	-2.3	-1.7	-1.5	-1.3
40	-1.9	-1.1	-0.9	-0.7	-0.7
50	0.0	0.0	0.0	0.0	0.0
60	1.9	1.1	0.9	0.7	0.7
70	3.8	2.3	1.7	1.5	1.3
80	5.7	3.4	2.6	2.2	2.0
90	7.5	4.5	3.5	3.0	2.6
100	9.4	5.6	4.3	3.7	3.3
110	11.3	6.8	5.2	4.4	4.0
120	13.2	7.9	6.1	5.2	4.6
130	15.1	9.0	6.9	5.9	5.3
140	17.0	10.2	7.8	6.7	6.0
150	18.9	11.3	8.7	7.4	6.6
160	20.7	12.4	9.5	8.1	7.3
170	22.6	13.5	10.4	8.9	7.9
180	24.5	14.7	11.3	9.6	8.6
190	26.4	15.8	12.1	10.4	9.3
200	28.3	16.9	13.0	11.1	9.9

**3/8" Uponor PEX surface
temperature at 50°F/10°C ambient**

Water temp (°F)	Surface temperature (°F)				
	No insulation	1/2" insulation	1" insulation	1 1/2" insulation	2" insulation
30	30.8	45.1	47.6	48.5	48.9
40	40.4	47.5	48.8	49.2	49.5
50	50.0	50.0	50.0	50.0	50.0
60	59.6	52.5	51.2	50.8	50.5
70	69.2	54.9	52.4	51.5	51.1
80	78.8	57.4	53.6	52.3	51.6
90	88.4	59.8	54.8	53.0	52.1
100	98.0	62.3	56.0	53.8	52.7
110	107.6	64.8	57.2	54.5	53.2
120	117.2	67.2	58.4	55.3	53.7
130	126.8	69.7	59.6	56.0	54.3
140	136.4	72.2	60.8	56.8	54.8
150	146.0	74.6	62.1	57.5	55.3
160	155.6	77.1	63.3	58.3	55.9
170	165.2	79.5	64.5	59.0	56.4
180	174.8	82.0	65.7	59.8	56.9
190	184.4	84.5	66.9	60.5	57.4
200	194.0	86.9	68.1	61.3	58.0

1. All calculations based on cylindrical thermal resistance methodology (ASHRAE).
2. Based on fluid velocity of 8 ft./sec. at 160°F (maximizing heat transfer from 100% water).
3. Pipe convection set to be 1.00 Btu/hr·ft²·°F (based on standard value for free convection of air).
4. This heat loss comparison uses 0.25 Btu·in/(hr·ft²·°F) as the insulation thermal conductivity. This is a standard value for fiberglass pipe insulation at a 100°F mean temperature.

**¾" Uponor PEX heat loss
at 50°F/10°C ambient**

Water temp (°F)	Heat loss (btu/hr-ft)				
	No insulation	½" insulation	1" insulation	1½" insulation	2" insulation
30	-4.4	-2.5	-1.9	-1.6	-1.4
40	-2.2	-1.2	-0.9	-0.8	-0.7
50	0.0	0.0	0.0	0.0	0.0
60	2.2	1.2	0.9	0.8	0.7
70	4.4	2.5	1.9	1.6	1.4
80	6.6	3.7	2.8	2.4	2.1
90	8.7	5.0	3.8	3.2	2.8
100	10.9	6.2	4.7	4.0	3.5
110	13.1	7.4	5.6	4.8	4.3
120	15.3	8.7	6.6	5.6	5.0
130	17.5	9.9	7.5	6.4	5.7
140	19.7	11.2	8.5	7.2	6.4
150	21.9	12.4	9.4	8.0	7.1
160	24.0	13.6	10.4	8.8	7.8
170	26.2	14.9	11.3	9.6	8.5
180	28.4	16.1	12.2	10.3	9.2
190	30.6	17.4	13.2	11.1	9.9
200	32.8	18.6	14.1	11.9	10.6

**¾" Uponor PEX surface
temperature at 50°F/10°C ambient**

Water temp (°F)	Surface temperature (°F)				
	No insulation	½" insulation	1" insulation	1½" insulation	2" insulation
30	30.9	45.0	47.5	48.4	48.9
40	40.5	47.5	48.7	49.2	49.4
50	50.0	50.0	50.0	50.0	50.0
60	59.5	52.5	51.3	50.8	50.6
70	69.1	55.0	52.5	51.6	51.1
80	78.6	57.6	53.8	52.4	51.7
90	88.2	60.1	55.0	53.1	52.2
100	97.7	62.6	56.3	53.9	52.8
110	107.3	65.1	57.5	54.7	53.3
120	116.8	67.7	58.8	55.5	53.9
130	126.3	70.2	60.0	56.3	54.4
140	135.9	72.7	61.3	57.1	55.0
150	145.4	75.2	62.5	57.8	55.6
160	155.0	77.8	63.8	58.6	56.1
170	164.5	80.3	65.0	59.4	56.7
180	174.1	82.8	66.3	60.2	57.2
190	183.6	85.3	67.5	61.0	57.8
200	193.1	87.9	68.8	61.8	58.3

1. All calculations based on cylindrical thermal resistance methodology (ASHRAE).
2. Based on fluid velocity of 8 ft./sec. at 160°F/71.1°C (maximizing heat transfer from 100% water).
3. Pipe convection set to be 1.00 Btu/hr·ft²·°F (based on standard value for free convection of air).
4. This heat loss comparison uses 0.25 Btu·in/(hr·ft²·°F) as the insulation thermal conductivity. This is a standard value for fiberglass pipe insulation at a 100°F/37.8°C mean temperature.

1" Uponor PEX heat loss at 50°F/10°C ambient

Water temp (°F)	Heat loss (btu/hr-ft)				
	No insulation	½" insulation	1" insulation	1½" insulation	2" insulation
30	-5.5	-2.9	-2.2	-1.8	-1.6
40	-2.8	-1.5	-1.1	-0.9	-0.8
50	0.0	0.0	0.0	0.0	0.0
60	2.8	1.5	1.1	0.9	0.8
70	5.5	2.9	2.2	1.8	1.6
80	8.3	4.4	3.2	2.7	2.4
90	11.1	5.8	4.3	3.6	3.2
100	13.9	7.3	5.4	4.5	4.0
110	16.6	8.7	6.5	5.4	4.8
120	19.4	10.2	7.6	6.3	5.6
130	22.2	11.7	8.7	7.2	6.4
140	25.0	13.1	9.7	8.1	7.2
150	27.7	14.6	10.8	9.0	8.0
160	30.5	16.0	11.9	9.9	8.8
170	33.3	17.5	13.0	10.8	9.6
180	36.1	18.9	14.1	11.8	10.4
190	38.8	20.4	15.2	12.7	11.2
200	41.6	21.8	16.2	13.6	12.0

1" Uponor PEX surface temperature at 50°F/10°C ambient

Water temp (°F)	Surface temperature (°F)				
	No insulation	½" insulation	1" insulation	1½" insulation	2" insulation
30	31.2	44.8	47.4	48.3	48.8
40	40.6	47.4	48.7	49.2	49.4
50	50.0	50.0	50.0	50.0	50.0
60	59.4	52.6	51.3	50.8	50.6
70	68.8	55.2	52.6	51.7	51.2
80	78.3	57.9	54.0	52.5	51.8
90	87.7	60.5	55.3	53.3	52.4
100	97.1	63.1	56.6	54.2	53.0
110	106.5	65.7	57.9	55.0	53.6
120	115.9	68.3	59.3	55.9	54.2
130	125.3	70.9	60.6	56.7	54.8
140	134.8	73.6	61.9	57.5	55.3
150	144.2	76.2	63.2	58.4	55.9
160	153.6	78.8	64.6	59.2	56.5
170	163.0	81.4	65.9	60.0	57.1
180	172.4	84.0	67.2	60.9	57.7
190	181.9	86.7	68.5	61.7	58.3
200	191.3	89.3	69.8	62.6	58.9

1. All calculations based on cylindrical thermal resistance methodology (ASHRAE).
2. Based on fluid velocity of 8 ft./sec. at 160°F/71.1°C (maximizing heat transfer from 100% water).
3. Pipe convection set to be 1.00 Btu/hr·ft²·°F (based on standard value for free convection of air).
4. This heat loss comparison uses 0.25 Btu·in/(hr·ft²·°F) as the insulation thermal conductivity. This is a standard value for fiberglass pipe insulation at a 100°F/37.8°C mean temperature.

**1¼" Uponor PEX heat loss
at 50°F/10°C ambient**

Water temp (°F)	Heat loss (btu/hr-ft)				
	No insulation	½" insulation	1" insulation	1½" insulation	2" insulation
30	-6.7	-3.3	-2.4	-2.0	-1.8
40	-3.3	-1.7	-1.2	-1.0	-0.9
50	0.0	0.0	0.0	0.0	0.0
60	3.3	1.7	1.2	1.0	0.9
70	6.7	3.3	2.4	2.0	1.8
80	10.0	5.0	3.7	3.0	2.6
90	13.4	6.7	4.9	4.0	3.5
100	16.7	8.3	6.1	5.0	4.4
110	20.1	10.0	7.3	6.0	5.3
120	23.4	11.7	8.5	7.1	6.2
130	26.8	13.3	9.8	8.1	7.1
140	30.1	15.0	11.0	9.1	7.9
150	33.5	16.7	12.2	10.1	8.8
160	36.8	18.4	13.4	11.1	9.7
170	40.2	20.0	14.6	12.1	10.6
180	43.5	21.7	15.9	13.1	11.5
190	46.9	23.4	17.1	14.1	12.4
200	50.2	25.0	18.3	15.1	13.2

**1¼" Uponor PEX surface
temperature at 50°F/10°C ambient**

Water temp (°F)	Surface temperature (°F)				
	No insulation	½" insulation	1" insulation	1½" insulation	2" insulation
30	31.4	44.6	47.2	48.2	48.7
40	40.7	47.3	48.6	49.1	49.4
50	50.0	50.0	50.0	50.0	50.0
60	59.3	52.7	51.4	50.9	50.6
70	68.6	55.4	52.8	51.8	51.3
80	77.9	58.1	54.1	52.6	51.9
90	87.2	60.7	55.5	53.5	52.5
100	96.5	63.4	56.9	54.4	53.1
110	105.8	66.1	58.3	55.3	53.8
120	115.1	68.8	59.7	56.2	54.4
130	124.4	71.5	61.0	57.0	55.0
140	133.7	74.2	62.4	57.9	55.6
150	143.0	76.8	63.8	58.8	56.3
160	152.3	79.5	65.2	59.7	56.9
170	161.6	82.2	66.6	60.6	57.5
180	170.9	84.9	67.9	61.4	58.2
190	180.2	87.6	69.3	62.3	58.8
200	189.5	90.3	70.7	63.2	59.4

1. All calculations based on cylindrical thermal resistance methodology (ASHRAE).
2. Based on fluid velocity of 8 ft./sec. at 160°F/71.1°C (maximizing heat transfer from 100% water).
3. Pipe convection set to be 1.00 Btu/hr·ft²·°F (based on standard value for free convection of air).
4. This heat loss comparison uses 0.25 Btu·in/(hr·ft²·°F) as the insulation thermal conductivity. This is a standard value for fiberglass pipe insulation at a 100°F/37.8°C mean temperature.

**1½" Uponor PEX heat loss
at 50°F/10°C ambient**

Water temp (°F)	Heat loss (btu/hr-ft)				
	No insulation	½" insulation	1" insulation	1½" insulation	2" insulation
30	-7.8	-3.8	-2.7	-2.2	-1.9
40	-3.9	-1.9	-1.4	-1.1	-1.0
50	0.0	0.0	0.0	0.0	0.0
60	3.9	1.9	1.4	1.1	1.0
70	7.8	3.8	2.7	2.2	1.9
80	11.7	5.6	4.1	3.3	2.9
90	15.6	7.5	5.4	4.4	3.9
100	19.5	9.4	6.8	5.5	4.8
110	23.4	11.3	8.1	6.6	5.8
120	27.3	13.1	9.5	7.8	6.7
130	31.2	15.0	10.8	8.9	7.7
140	35.1	16.9	12.2	10.0	8.7
150	39.0	18.8	13.5	11.1	9.6
160	43.0	20.6	14.9	12.2	10.6
170	46.9	22.5	16.2	13.3	11.6
180	50.8	24.4	17.6	14.4	12.5
190	54.7	26.3	18.9	15.5	13.5
200	58.6	28.1	20.3	16.6	14.5

**1½" Uponor PEX surface
temperature at 50°F/10°C ambient**

Water temp (°F)	Surface temperature (°F)				
	No insulation	½" insulation	1" insulation	1½" insulation	2" insulation
30	31.6	44.5	47.1	48.2	48.7
40	40.8	47.3	48.6	49.1	49.3
50	50.0	50.0	50.0	50.0	50.0
60	59.2	52.7	51.4	50.9	50.7
70	68.4	55.5	52.9	51.8	51.3
80	77.5	58.2	54.3	52.7	52.0
90	86.7	60.9	55.7	53.7	52.6
100	95.9	63.7	57.1	54.6	53.3
110	105.1	66.4	58.6	55.5	53.9
120	114.2	69.1	60.0	56.4	54.6
130	123.4	71.8	61.4	57.3	55.2
140	132.6	74.6	62.8	58.2	55.9
150	141.8	77.3	64.3	59.1	56.5
160	151.0	80.0	65.7	60.1	57.2
170	160.1	82.8	67.1	61.0	57.9
180	169.3	85.5	68.5	61.9	58.5
190	178.5	88.2	70.0	62.8	59.2
200	187.7	91.0	71.4	63.7	59.8

1. All calculations based on cylindrical thermal resistance methodology (ASHRAE).
2. Based on fluid velocity of 8 ft./sec. at 160°F/71.1°C (maximizing heat transfer from 100% water).
3. Pipe convection set to be 1.00 Btu/hr·ft²·°F (based on standard value for free convection of air).
4. This heat loss comparison uses 0.25 Btu·in/(hr·ft²·°F) as the insulation thermal conductivity. This is a standard value for fiberglass pipe insulation at a 100°F/37.8°C mean temperature.

**2" Uponor PEX heat loss
at 50°F/10°C ambient**

Water temp (°F)	Heat loss (btu/hr-ft)				
	No insulation	½" insulation	1" insulation	1½" insulation	2" insulation
30	-10.0	-4.6	-3.2	-2.6	-2.2
40	-5.0	-2.3	-1.6	-1.3	-1.1
50	0.0	0.0	0.0	0.0	0.0
60	5.0	2.3	1.6	1.3	1.1
70	10.0	4.6	3.2	2.6	2.2
80	14.9	6.9	4.8	3.9	3.4
90	19.9	9.1	6.4	5.2	4.5
100	24.9	11.4	8.1	6.5	5.6
110	29.9	13.7	9.7	7.8	6.7
120	34.9	16.0	11.3	9.1	7.8
130	39.9	18.3	12.9	10.4	9.0
140	44.8	20.6	14.5	11.7	10.1
150	49.8	22.8	16.1	13.0	11.2
160	54.8	25.1	17.7	14.3	12.3
170	59.8	27.4	19.3	15.6	13.5
180	64.8	29.7	21.0	16.9	14.6
190	69.8	32.0	22.6	18.2	15.7
200	74.7	34.3	24.2	19.5	16.8

**2" Uponor PEX surface
temperature at 50°F/10°C ambient**

Water temp (°F)	Surface temperature (°F)				
	No insulation	½" insulation	1" insulation	1½" insulation	2" insulation
30	32.1	44.4	47.0	48.1	48.6
40	41.0	47.2	48.5	49.0	49.3
50	50.0	50.0	50.0	50.0	50.0
60	59.0	52.8	51.5	51.0	50.7
70	67.9	55.6	53.0	51.9	51.4
80	76.9	58.4	54.5	52.9	52.1
90	85.8	61.2	56.0	53.9	52.8
100	94.8	64.0	57.5	54.9	53.5
110	103.7	66.8	59.0	55.8	54.2
120	112.7	69.5	60.5	56.8	54.9
130	121.7	72.3	61.9	57.8	55.6
140	130.6	75.1	63.4	58.7	56.3
150	139.6	77.9	64.9	59.7	57.0
160	148.5	80.7	66.4	60.7	57.7
170	157.5	83.5	67.9	61.6	58.4
180	166.4	86.3	69.4	62.6	59.1
190	175.4	89.1	70.9	63.6	59.8
200	184.3	91.9	72.4	64.6	60.5

1. All calculations based on cylindrical thermal resistance methodology (ASHRAE).
2. Based on fluid velocity of 8 ft./sec. at 160°F/71.1°C (maximizing heat transfer from 100% water).
3. Pipe convection set to be 1.00 Btu/hr·ft²·°F (based on standard value for free convection of air).
4. This heat loss comparison uses 0.25 Btu·in/(hr·ft²·°F) as the insulation thermal conductivity. This is a standard value for fiberglass pipe insulation at a 100°F/37.8°C mean temperature.

**2½" Uponor PEX heat loss
at 50°F/10°C Ambient**

Water temp (°F)	Heat loss (btu/hr-ft)				
	No insulation	½" insulation	1" insulation	1½" insulation	2" insulation
30	-12.0	-5.4	-3.7	-3.0	-2.5
40	-6.0	-2.7	-1.9	-1.5	-1.3
50	0.0	0.0	0.0	0.0	0.0
60	6.0	2.7	1.9	1.5	1.3
70	12.0	5.4	3.7	3.0	2.5
80	18.0	8.0	5.6	4.5	3.8
90	24.0	10.7	7.5	6.0	5.1
100	30.0	13.4	9.3	7.5	6.4
110	36.0	16.1	11.2	8.9	7.6
120	42.0	18.8	13.1	10.4	8.9
130	48.0	21.5	14.9	11.9	10.2
140	54.1	24.1	16.8	13.4	11.5
150	60.1	26.8	18.6	14.9	12.7
160	66.1	29.5	20.5	16.4	14.0
170	72.1	32.2	22.4	17.9	15.3
180	78.1	34.9	24.2	19.4	16.5
190	84.1	37.5	26.1	20.9	17.8
200	90.1	40.2	28.0	22.4	19.1

**2½" Uponor PEX surface
temperature at 50°F/10°C ambient**

Water temp (°F)	Surface temperature (°F)				
	No insulation	½" insulation	1" insulation	1½" insulation	2" insulation
30	32.5	44.3	46.9	48.0	48.5
40	41.3	47.2	48.5	49.0	49.3
50	50.0	50.0	50.0	50.0	50.0
60	58.7	52.8	51.5	51.0	50.7
70	67.5	55.7	53.1	52.0	51.5
80	76.2	58.5	54.6	53.0	52.2
90	85.0	61.3	56.2	54.0	52.9
100	93.7	64.1	57.7	55.1	53.7
110	102.4	67.0	59.2	56.1	54.4
120	111.2	69.8	60.8	57.1	55.1
130	119.9	72.6	62.3	58.1	55.9
140	128.7	75.4	63.9	59.1	56.6
150	137.4	78.3	65.4	60.1	57.3
160	146.1	81.1	66.9	61.1	58.1
170	154.9	83.9	68.5	62.1	58.8
180	163.6	86.7	70.0	63.2	59.5
190	172.3	89.6	71.6	64.2	60.3
200	181.1	92.4	73.1	65.2	61.0

1. All calculations based on cylindrical thermal resistance methodology (ASHRAE).
2. Based on fluid velocity of 8 ft./sec. at 160°F/71.1°C (maximizing heat transfer from 100% water).
3. Pipe convection set to be 1.00 Btu/hr·ft²·°F (based on standard value for free convection of air).
4. This heat loss comparison uses 0.25 Btu·in/(hr·ft²·°F) as the insulation thermal conductivity. This is a standard value for fiberglass pipe insulation at a 100°F/37.8°C mean temperature.

**3" Uponor PEX heat loss
at 50°F/10°C ambient**

Water temp (°F)	Heat loss (btu/hr-ft)				
	No insulation	½" insulation	1" insulation	1½" insulation	2" insulation
30	-14.0	-6.1	-4.2	-3.3	-2.8
40	-7.0	-3.1	-2.1	-1.7	-1.4
50	0.0	0.0	0.0	0.0	0.0
60	7.0	3.1	2.1	1.7	1.4
70	14.0	6.1	4.2	3.3	2.8
80	21.0	9.2	6.3	5.0	4.3
90	28.0	12.3	8.5	6.7	5.7
100	34.9	15.4	10.6	8.4	7.1
110	41.9	18.4	12.7	10.0	8.5
120	48.9	21.5	14.8	11.7	9.9
130	55.9	24.6	16.9	13.4	11.4
140	62.9	27.6	19.0	15.1	12.8
150	69.9	30.7	21.1	16.7	14.2
160	76.9	33.8	23.2	18.4	15.6
170	83.9	36.9	25.4	20.1	17.0
180	90.8	39.9	27.5	21.8	18.5
190	97.8	43.0	29.6	23.4	19.9
200	104.8	46.1	31.7	25.1	21.3

**3" Uponor PEX surface
temperature at 50°F/10°C ambient**

Water temp (°F)	Surface temperature (°F)				
	No insulation	½" insulation	1" insulation	1½" insulation	2" insulation
30	32.9	44.3	46.9	47.9	48.5
40	41.5	47.2	48.4	49.0	49.2
50	50.0	50.0	50.0	50.0	50.0
60	58.5	52.8	51.6	51.0	50.8
70	67.1	55.7	53.1	52.1	51.5
80	75.6	58.5	54.7	53.1	52.3
90	84.2	61.4	56.3	54.2	53.0
100	92.7	64.2	57.9	55.2	53.8
110	101.3	67.1	59.4	56.3	54.6
120	109.8	69.9	61.0	57.3	55.3
130	118.3	72.8	62.6	58.4	56.1
140	126.9	75.6	64.2	59.4	56.9
150	135.4	78.4	65.7	60.4	57.6
160	144.0	81.3	67.3	61.5	58.4
170	152.5	84.1	68.9	62.5	59.1
180	161.0	87.0	70.5	63.6	59.9
190	169.6	89.8	72.0	64.6	60.7
200	178.1	92.7	73.6	65.7	61.4

1. All calculations based on cylindrical thermal resistance methodology (ASHRAE).
2. Based on fluid velocity of 8 ft./sec. at 160°F/71.1°C (maximizing heat transfer from 100% water).
3. Pipe convection set to be 1.00 Btu/hr·ft²·°F (based on standard value for free convection of air).
4. This heat loss comparison uses 0.25 Btu·in/(hr·ft²·°F) as the insulation thermal conductivity. This is a standard value for fiberglass pipe insulation at a 100°F/37.8°C mean temperature.

4" Uponor PEX heat loss at 50°F ambient

Water temp (°F)	Heat loss (btu/hr-ft)				
	No insulation	½" insulation	1" insulation	1½" insulation	2" insulation
30	-17.6	-7.7	-5.2	-4.1	-3.4
40	-8.8	-3.8	-2.6	-2.0	-1.7
50	0.0	0.0	0.0	0.0	0.0
60	8.8	3.8	2.6	2.0	1.7
70	17.6	7.7	5.2	4.1	3.4
80	26.5	11.5	7.8	6.1	5.1
90	35.3	15.3	10.4	8.1	6.8
100	44.1	19.1	13.0	10.2	8.5
110	52.9	23.0	15.6	12.2	10.2
120	61.7	26.8	18.2	14.2	12.0
130	70.6	30.6	20.8	16.3	13.7
140	79.4	34.5	23.4	18.3	15.4
150	88.2	38.3	26.0	20.3	17.1
160	97.0	42.1	28.6	22.4	18.8
170	105.8	46.0	31.2	24.4	20.5
180	114.7	49.8	33.8	26.4	22.2
190	123.5	53.6	36.4	28.5	23.9
200	132.3	57.4	38.9	30.5	25.6

4" Uponor PEX surface temperature at 50°F ambient

Water temp (°F)	Surface temperature (°F)				
	No insulation	½" insulation	1" insulation	1½" insulation	2" insulation
30	33.7	44.3	46.8	47.8	48.4
40	41.8	47.1	48.4	48.9	49.2
50	50.0	50.0	50.0	50.0	50.0
60	58.2	52.9	51.6	51.1	50.8
70	66.3	55.7	53.2	52.2	51.6
80	74.5	58.6	54.9	53.3	52.4
90	82.7	61.4	56.5	54.4	53.2
100	90.8	64.3	58.1	55.4	54.0
110	99.0	67.1	59.7	56.5	54.8
120	107.2	70.0	61.3	57.6	55.6
130	115.3	72.8	63.0	58.7	56.4
140	123.5	75.7	64.6	59.8	57.2
150	131.7	78.5	66.2	60.9	58.0
160	139.8	81.4	67.8	62.0	58.8
170	148.0	84.3	69.4	63.1	59.6
180	156.2	87.1	71.1	64.2	60.4
190	164.3	90.0	72.7	65.3	61.2
200	172.5	92.8	74.3	66.3	62.0

1. All calculations based on cylindrical thermal resistance methodology (ASHRAE).
2. Based on fluid velocity of 8 ft./sec. at 160°F (maximizing heat transfer from 100% water).
3. Pipe convection set to be 1.00 Btu/hr·ft²·°F (based on standard value for free convection of air).
4. This heat loss comparison uses 0.25 Btu·in/(hr·ft²·°F) as the insulation thermal conductivity. This is a standard value for fiberglass pipe insulation at a 100°F mean temperature.

**½" Uponor PEX heat loss
at 70°F/21.1°C ambient**

Water temp (°F)	Heat loss (btu/hr-ft)				
	No insulation	½" insulation	1" insulation	1½" insulation	2" insulation
30	-6.3	-4.1	-3.2	-2.7	-2.4
40	-4.7	-3.0	-2.4	-2.0	-1.8
50	-3.2	-2.0	-1.6	-1.4	-1.2
60	-1.6	-1.0	-0.8	-0.7	-0.6
70	0.0	0.0	0.0	0.0	0.0
80	1.6	1.0	0.8	0.7	0.6
90	3.2	2.0	1.6	1.4	1.2
100	4.7	3.0	2.4	2.0	1.8
110	6.3	4.1	3.2	2.7	2.4
120	7.9	5.1	4.0	3.4	3.1
130	9.5	6.1	4.7	4.1	3.7
140	11.1	7.1	5.5	4.8	4.3
150	12.6	8.1	6.3	5.4	4.9
160	14.2	9.1	7.1	6.1	5.5
170	15.8	10.1	7.9	6.8	6.1
180	17.4	11.1	8.7	7.5	6.7
190	18.9	12.2	9.5	8.2	7.3
200	20.5	13.2	10.3	8.8	8.0

**½" Uponor PEX surface
temperature at 70°F/21.1°C ambient**

Water temp (°F)	Surface temperature (°F)				
	No insulation	½" insulation	1" insulation	1½" insulation	2" insulation
30	31.4	60.5	65.4	67.1	68.0
40	41.1	62.9	66.5	67.9	68.5
50	50.7	65.2	67.7	68.6	69.0
60	60.4	67.6	68.8	69.3	69.5
70	70.0	70.0	70.0	70.0	70.0
80	79.6	72.4	71.2	70.7	70.5
90	89.3	74.8	72.3	71.4	71.0
100	98.9	77.1	73.5	72.1	71.5
110	108.6	79.5	74.6	72.9	72.0
120	118.2	81.9	75.8	73.6	72.5
130	127.9	84.3	76.9	74.3	73.0
140	137.5	86.7	78.1	75.0	73.5
150	147.2	89.0	79.2	75.7	74.0
160	156.8	91.4	80.4	76.4	74.5
170	166.5	93.8	81.5	77.2	75.1
180	176.1	96.2	82.7	77.9	75.6
190	185.8	98.6	83.8	78.6	76.1
200	195.4	101.0	85.0	79.3	76.6

1. All calculations based on cylindrical thermal resistance methodology (ASHRAE).
2. Based on fluid velocity of 8 ft./sec. at 160°F/71.1°C (maximizing heat transfer from 100% water).
3. Pipe convection set to be 1.00 Btu/hr·ft²·°F (based on standard value for free convection of air).
4. This heat loss comparison uses 0.25 Btu·in/(hr·ft²·°F) as the insulation thermal conductivity. This is a standard value for fiberglass pipe insulation at a 100°F/37.8°C mean temperature.

5/8" Uponor PEX heat loss at 70°F ambient

Water temp (°F)	Heat loss (btu/hr-ft)				
	No insulation	1/2" insulation	1" insulation	1 1/2" insulation	2" insulation
30	-7.5	-4.5	-3.5	-3.0	-2.6
40	-5.7	-3.4	-2.6	-2.2	-2.0
50	-3.8	-2.3	-1.7	-1.5	-1.3
60	-1.9	-1.1	-0.9	-0.7	-0.7
70	0.0	0.0	0.0	0.0	0.0
80	1.9	1.1	0.9	0.7	0.7
90	3.8	2.3	1.7	1.5	1.3
100	5.7	3.4	2.6	2.2	2.0
110	7.5	4.5	3.5	3.0	2.6
120	9.4	5.6	4.3	3.7	3.3
130	11.3	6.8	5.2	4.4	4.0
140	13.2	7.9	6.1	5.2	4.6
150	15.1	9.0	6.9	5.9	5.3
160	17.0	10.2	7.8	6.7	6.0
170	18.9	11.3	8.7	7.4	6.6
180	20.7	12.4	9.5	8.1	7.3
190	22.6	13.5	10.4	8.9	7.9
200	24.5	14.7	11.3	9.6	8.6

5/8" Uponor PEX surface temperature at 70°F ambient

Water temp (°F)	Surface temperature (°F)				
	No insulation	1/2" insulation	1" insulation	1 1/2" insulation	2" insulation
30	31.6	60.2	65.2	67.0	67.9
40	41.2	62.6	66.4	67.7	68.4
50	50.8	65.1	67.6	68.5	68.9
60	60.4	67.5	68.8	69.2	69.5
70	70.0	70.0	70.0	70.0	70.0
80	79.6	72.5	71.2	70.8	70.5
90	89.2	74.9	72.4	71.5	71.1
100	98.8	77.4	73.6	72.3	71.6
110	108.4	79.8	74.8	73.0	72.1
120	118.0	82.3	76.0	73.8	72.7
130	127.6	84.8	77.2	74.5	73.2
140	137.2	87.2	78.4	75.3	73.7
150	146.8	89.7	79.6	76.0	74.3
160	156.4	92.2	80.8	76.8	74.8
170	166.0	94.6	82.1	77.5	75.3
180	175.6	97.1	83.3	78.3	75.9
190	185.2	99.5	84.5	79.0	76.4
200	194.8	102.0	85.7	79.8	76.9

1. All calculations based on cylindrical thermal resistance methodology (ASHRAE).
2. Based on fluid velocity of 8 ft./sec. at 160°F (maximizing heat transfer from 100% water).
3. Pipe convection set to be 1.00 Btu/hr·ft²·°F (based on standard value for free convection of air).
4. This heat loss comparison uses 0.25 Btu·in/(hr·ft²·°F) as the insulation thermal conductivity. This is a standard value for fiberglass pipe insulation at a 100°F mean temperature.

**¾" Uponor PEX heat loss
at 70°F/21.1°C ambient**

Water temp (°F)	Heat loss (btu/hr-ft)				
	No insulation	½" insulation	1" insulation	1½" insulation	2" insulation
30	-8.7	-5.0	-3.8	-3.2	-2.8
40	-6.6	-3.7	-2.8	-2.4	-2.1
50	-4.4	-2.5	-1.9	-1.6	-1.4
60	-2.2	-1.2	-0.9	-0.8	-0.7
70	0.0	0.0	0.0	0.0	0.0
80	2.2	1.2	0.9	0.8	0.7
90	4.4	2.5	1.9	1.6	1.4
100	6.6	3.7	2.8	2.4	2.1
110	8.7	5.0	3.8	3.2	2.8
120	10.9	6.2	4.7	4.0	3.5
130	13.1	7.4	5.6	4.8	4.3
140	15.3	8.7	6.6	5.6	5.0
150	17.5	9.9	7.5	6.4	5.7
160	19.7	11.2	8.5	7.2	6.4
170	21.9	12.4	9.4	8.0	7.1
180	24.0	13.6	10.4	8.8	7.8
190	26.2	14.9	11.3	9.6	8.5
200	28.4	16.1	12.2	10.3	9.2

**¾" Uponor PEX surface
temperature at 70°F/21.1°C ambient**

Water temp (°F)	Surface temperature (°F)				
	No insulation	½" insulation	1" insulation	1½" insulation	2" insulation
30	31.8	59.9	65.0	66.9	67.8
40	41.4	62.4	66.2	67.6	68.3
50	50.9	65.0	67.5	68.4	68.9
60	60.5	67.5	68.7	69.2	69.4
70	70.0	70.0	70.0	70.0	70.0
80	79.5	72.5	71.3	70.8	70.6
90	89.1	75.0	72.5	71.6	71.1
100	98.6	77.6	73.8	72.4	71.7
110	108.2	80.1	75.0	73.1	72.2
120	117.7	82.6	76.3	73.9	72.8
130	127.3	85.1	77.5	74.7	73.3
140	136.8	87.7	78.8	75.5	73.9
150	146.3	90.2	80.0	76.3	74.4
160	155.9	92.7	81.3	77.1	75.0
170	165.4	95.2	82.5	77.8	75.6
180	175.0	97.8	83.8	78.6	76.1
190	184.5	100.3	85.0	79.4	76.7
200	194.1	102.8	86.3	80.2	77.2

1. All calculations based on cylindrical thermal resistance methodology (ASHRAE).
2. Based on fluid velocity of 8 ft./sec. at 160°F/71.1°C (maximizing heat transfer from 100% water).
3. Pipe convection set to be 1.00 Btu/hr·ft²·°F (based on standard value for free convection of air).
4. This heat loss comparison uses 0.25 Btu·in/(hr·ft²·°F) as the insulation thermal conductivity. This is a standard value for fiberglass pipe insulation at a 100°F/37.8°C mean temperature.

1" Uponor PEX heat loss at 70°F/21.1°C ambient

Water temp (°F)	Heat loss (btu/hr-ft)				
	No insulation	½" insulation	1" insulation	1½" insulation	2" insulation
30	-11.1	-5.8	-4.3	-3.6	-3.2
40	-8.3	-4.4	-3.2	-2.7	-2.4
50	-5.5	-2.9	-2.2	-1.8	-1.6
60	-2.8	-1.5	-1.1	-0.9	-0.8
70	0.0	0.0	0.0	0.0	0.0
80	2.8	1.5	1.1	0.9	0.8
90	5.5	2.9	2.2	1.8	1.6
100	8.3	4.4	3.2	2.7	2.4
110	11.1	5.8	4.3	3.6	3.2
120	13.9	7.3	5.4	4.5	4.0
130	16.6	8.7	6.5	5.4	4.8
140	19.4	10.2	7.6	6.3	5.6
150	22.2	11.7	8.7	7.2	6.4
160	25.0	13.1	9.7	8.1	7.2
170	27.7	14.6	10.8	9.0	8.0
180	30.5	16.0	11.9	9.9	8.8
190	33.3	17.5	13.0	10.8	9.6
200	36.1	18.9	14.1	11.8	10.4

1" Uponor PEX surface temperature at 70°F/21.1°C ambient

Water temp (°F)	Surface temperature (°F)				
	No insulation	½" insulation	1" insulation	1½" insulation	2" insulation
30	32.3	59.5	64.7	66.7	67.6
40	41.7	62.1	66.0	67.5	68.2
50	51.2	64.8	67.4	68.3	68.8
60	60.6	67.4	68.7	69.2	69.4
70	70.0	70.0	70.0	70.0	70.0
80	79.4	72.6	71.3	70.8	70.6
90	88.8	75.2	72.6	71.7	71.2
100	98.3	77.9	74.0	72.5	71.8
110	107.7	80.5	75.3	73.3	72.4
120	117.1	83.1	76.6	74.2	73.0
130	126.5	85.7	77.9	75.0	73.6
140	135.9	88.3	79.3	75.9	74.2
150	145.3	90.9	80.6	76.7	74.8
160	154.8	93.6	81.9	77.5	75.3
170	164.2	96.2	83.2	78.4	75.9
180	173.6	98.8	84.6	79.2	76.5
190	183.0	101.4	85.9	80.0	77.1
200	192.4	104.0	87.2	80.9	77.7

1. All calculations based on cylindrical thermal resistance methodology (ASHRAE).
2. Based on fluid velocity of 8 ft./sec. at 160°F/71.1°C (maximizing heat transfer from 100% water).
3. Pipe convection set to be 1.00 Btu/hr·ft²·°F (based on standard value for free convection of air).
4. This heat loss comparison uses 0.25 Btu·in/(hr·ft²·°F) as the insulation thermal conductivity. This is a standard value for fiberglass pipe insulation at a 100°F/37.8°C mean temperature.

**1¼" Uponor PEX heat loss
at 70°F/21.1°C ambient**

Water temp (°F)	Heat loss (btu/hr-ft)				
	No insulation	½" insulation	1" insulation	1½" insulation	2" insulation
30	-13.4	-6.7	-4.9	-4.0	-3.5
40	-10.0	-5.0	-3.7	-3.0	-2.6
50	-6.7	-3.3	-2.4	-2.0	-1.8
60	-3.3	-1.7	-1.2	-1.0	-0.9
70	0.0	0.0	0.0	0.0	0.0
80	3.3	1.7	1.2	1.0	0.9
90	6.7	3.3	2.4	2.0	1.8
100	10.0	5.0	3.7	3.0	2.6
110	13.4	6.7	4.9	4.0	3.5
120	16.7	8.3	6.1	5.0	4.4
130	20.1	10.0	7.3	6.0	5.3
140	23.4	11.7	8.5	7.1	6.2
150	26.8	13.3	9.8	8.1	7.1
160	30.1	15.0	11.0	9.1	7.9
170	33.5	16.7	12.2	10.1	8.8
180	36.8	18.4	13.4	11.1	9.7
190	40.2	20.0	14.6	12.1	10.6
200	43.5	21.7	15.9	13.1	11.5

**1¼" Uponor PEX surface
temperature at 70°F/21.1°C ambient**

Water temp (°F)	Surface temperature (°F)				
	No insulation	½" insulation	1" insulation	1½" insulation	2" insulation
30	32.8	59.3	64.5	66.5	67.5
40	42.1	61.9	65.9	67.4	68.1
50	51.4	64.6	67.2	68.2	68.7
60	60.7	67.3	68.6	69.1	69.4
70	70.0	70.0	70.0	70.0	70.0
80	79.3	72.7	71.4	70.9	70.6
90	88.6	75.4	72.8	71.8	71.3
100	97.9	78.1	74.1	72.6	71.9
110	107.2	80.7	75.5	73.5	72.5
120	116.5	83.4	76.9	74.4	73.1
130	125.8	86.1	78.3	75.3	73.8
140	135.1	88.8	79.7	76.2	74.4
150	144.4	91.5	81.0	77.0	75.0
160	153.7	94.2	82.4	77.9	75.6
170	163.0	96.8	83.8	78.8	76.3
180	172.3	99.5	85.2	79.7	76.9
190	181.6	102.2	86.6	80.6	77.5
200	190.9	104.9	87.9	81.4	78.2

1. All calculations based on cylindrical thermal resistance methodology (ASHRAE).
2. Based on fluid velocity of 8 ft./sec. at 160°F/71.1°C (maximizing heat transfer from 100% water).
3. Pipe convection set to be 1.00 Btu/hr·ft²·°F (based on standard value for free convection of air).
4. This heat loss comparison uses 0.25 Btu·in/(hr·ft²·°F) as the insulation thermal conductivity. This is a standard value for fiberglass pipe insulation at a 100°F/37.8°C mean temperature.

**1½" Uponor PEX heat loss
at 70°F/21.1°C ambient**

Water temp (°F)	Heat loss (btu/hr-ft)				
	No insulation	½" insulation	1" insulation	1½" insulation	2" insulation
30	-15.6	-7.5	-5.4	-4.4	-3.9
40	-11.7	-5.6	-4.1	-3.3	-2.9
50	-7.8	-3.8	-2.7	-2.2	-1.9
60	-3.9	-1.9	-1.4	-1.1	-1.0
70	0.0	0.0	0.0	0.0	0.0
80	3.9	1.9	1.4	1.1	1.0
90	7.8	3.8	2.7	2.2	1.9
100	11.7	5.6	4.1	3.3	2.9
110	15.6	7.5	5.4	4.4	3.9
120	19.5	9.4	6.8	5.5	4.8
130	23.4	11.3	8.1	6.6	5.8
140	27.3	13.1	9.5	7.8	6.7
150	31.2	15.0	10.8	8.9	7.7
160	35.1	16.9	12.2	10.0	8.7
170	39.0	18.8	13.5	11.1	9.6
180	43.0	20.6	14.9	12.2	10.6
190	46.9	22.5	16.2	13.3	11.6
200	50.8	24.4	17.6	14.4	12.5

**1½" Uponor PEX surface
temperature at 70°F/21.1°C ambient**

Water temp (°F)	Surface temperature (°F)				
	No insulation	½" insulation	1" insulation	1½" insulation	2" insulation
30	33.3	59.1	64.3	66.3	67.4
40	42.5	61.8	65.7	67.3	68.0
50	51.6	64.5	67.1	68.2	68.7
60	60.8	67.3	68.6	69.1	69.3
70	70.0	70.0	70.0	70.0	70.0
80	79.2	72.7	71.4	70.9	70.7
90	88.4	75.5	72.9	71.8	71.3
100	97.5	78.2	74.3	72.7	72.0
110	106.7	80.9	75.7	73.7	72.6
120	115.9	83.7	77.1	74.6	73.3
130	125.1	86.4	78.6	75.5	73.9
140	134.2	89.1	80.0	76.4	74.6
150	143.4	91.8	81.4	77.3	75.2
160	152.6	94.6	82.8	78.2	75.9
170	161.8	97.3	84.3	79.1	76.5
180	171.0	100.0	85.7	80.1	77.2
190	180.1	102.8	87.1	81.0	77.9
200	189.3	105.5	88.5	81.9	78.5

1. All calculations based on cylindrical thermal resistance methodology (ASHRAE).
2. Based on fluid velocity of 8 ft./sec. at 160°F/71.1°C (maximizing heat transfer from 100% water).
3. Pipe convection set to be 1.00 Btu/hr·ft²·°F (based on standard value for free convection of air).
4. This heat loss comparison uses 0.25 Btu·in/(hr·ft²·°F) as the insulation thermal conductivity. This is a standard value for fiberglass pipe insulation at a 100°F/37.8°C mean temperature.

**2" Uponor PEX heat loss
at 70°F/21.1°C ambient**

Water temp (°F)	Heat loss (btu/hr-ft)				
	No insulation	½" insulation	1" insulation	1½" insulation	2" insulation
30	-19.9	-9.1	-6.4	-5.2	-4.5
40	-14.9	-6.9	-4.8	-3.9	-3.4
50	-10.0	-4.6	-3.2	-2.6	-2.2
60	-5.0	-2.3	-1.6	-1.3	-1.1
70	0.0	0.0	0.0	0.0	0.0
80	5.0	2.3	1.6	1.3	1.1
90	10.0	4.6	3.2	2.6	2.2
100	14.9	6.9	4.8	3.9	3.4
110	19.9	9.1	6.4	5.2	4.5
120	24.9	11.4	8.1	6.5	5.6
130	29.9	13.7	9.7	7.8	6.7
140	34.9	16.0	11.3	9.1	7.8
150	39.9	18.3	12.9	10.4	9.0
160	44.8	20.6	14.5	11.7	10.1
170	49.8	22.8	16.1	13.0	11.2
180	54.8	25.1	17.7	14.3	12.3
190	59.8	27.4	19.3	15.6	13.5
200	64.8	29.7	21.0	16.9	14.6

**2" Uponor PEX surface
temperature at 70°F/21.1°C ambient**

Water temp (°F)	Surface temperature (°F)				
	No insulation	½" insulation	1" insulation	1½" insulation	2" insulation
30	34.2	58.8	64.0	66.1	67.2
40	43.1	61.6	65.5	67.1	67.9
50	52.1	64.4	67.0	68.1	68.6
60	61.0	67.2	68.5	69.0	69.3
70	70.0	70.0	70.0	70.0	70.0
80	79.0	72.8	71.5	71.0	70.7
90	87.9	75.6	73.0	71.9	71.4
100	96.9	78.4	74.5	72.9	72.1
110	105.8	81.2	76.0	73.9	72.8
120	114.8	84.0	77.5	74.9	73.5
130	123.7	86.8	79.0	75.8	74.2
140	132.7	89.5	80.5	76.8	74.9
150	141.7	92.3	81.9	77.8	75.6
160	150.6	95.1	83.4	78.7	76.3
170	159.6	97.9	84.9	79.7	77.0
180	168.5	100.7	86.4	80.7	77.7
190	177.5	103.5	87.9	81.6	78.4
200	186.4	106.3	89.4	82.6	79.1

1. All calculations based on cylindrical thermal resistance methodology (ASHRAE).
2. Based on fluid velocity of 8 ft./sec. at 160°F/71.1°C (maximizing heat transfer from 100% water).
3. Pipe convection set to be 1.00 Btu/hr·ft²·°F (based on standard value for free convection of air).
4. This heat loss comparison uses 0.25 Btu·in/(hr·ft²·°F) as the insulation thermal conductivity. This is a standard value for fiberglass pipe insulation at a 100°F/37.8°C mean temperature.

**2½" Uponor PEX heat loss
at 70°F/21.1°C ambient**

Water temp (°F)	Heat loss (btu/hr-ft)				
	No insulation	½" insulation	1" insulation	1½" insulation	2" insulation
30	-24.0	-10.7	-7.5	-6.0	-5.1
40	-18.0	-8.0	-5.6	-4.5	-3.8
50	-12.0	-5.4	-3.7	-3.0	-2.5
60	-6.0	-2.7	-1.9	-1.5	-1.3
70	0.0	0.0	0.0	0.0	0.0
80	6.0	2.7	1.9	1.5	1.3
90	12.0	5.4	3.7	3.0	2.5
100	18.0	8.0	5.6	4.5	3.8
110	24.0	10.7	7.5	6.0	5.1
120	30.0	13.4	9.3	7.5	6.4
130	36.0	16.1	11.2	8.9	7.6
140	42.0	18.8	13.1	10.4	8.9
150	48.0	21.5	14.9	11.9	10.2
160	54.1	24.1	16.8	13.4	11.5
170	60.1	26.8	18.6	14.9	12.7
180	66.1	29.5	20.5	16.4	14.0
190	72.1	32.2	22.4	17.9	15.3
200	78.1	34.9	24.2	19.4	16.5

**2½" Uponor PEX surface
temperature at 70°F/21.1°C ambient**

Water temp (°F)	Surface temperature (°F)				
	No insulation	½" insulation	1" insulation	1½" insulation	2" insulation
30	35.0	58.7	63.8	66.0	67.1
40	43.8	61.5	65.4	67.0	67.8
50	52.5	64.3	66.9	68.0	68.5
60	61.3	67.2	68.5	69.0	69.3
70	70.0	70.0	70.0	70.0	70.0
80	78.7	72.8	71.5	71.0	70.7
90	87.5	75.7	73.1	72.0	71.5
100	96.2	78.5	74.6	73.0	72.2
110	105.0	81.3	76.2	74.0	72.9
120	113.7	84.1	77.7	75.1	73.7
130	122.4	87.0	79.2	76.1	74.4
140	131.2	89.8	80.8	77.1	75.1
150	139.9	92.6	82.3	78.1	75.9
160	148.7	95.4	83.9	79.1	76.6
170	157.4	98.3	85.4	80.1	77.3
180	166.1	101.1	86.9	81.1	78.1
190	174.9	103.9	88.5	82.1	78.8
200	183.6	106.7	90.0	83.2	79.5

1. All calculations based on cylindrical thermal resistance methodology (ASHRAE).
2. Based on fluid velocity of 8 ft./sec. at 160°F/71.1°C (maximizing heat transfer from 100% water).
3. Pipe convection set to be 1.00 Btu/hr·ft²·°F (based on standard value for free convection of air).
4. This heat loss comparison uses 0.25 Btu·in/(hr·ft²·°F) as the insulation thermal conductivity. This is a standard value for fiberglass pipe insulation at a 100°F/37.8°C mean temperature.

**3" Uponor PEX heat loss
at 70°F/21.1°C ambient**

Water temp (°F)	Heat loss (btu/hr-ft)				
	No insulation	½" insulation	1" insulation	1½" insulation	2" insulation
30	-28.0	-12.3	-8.5	-6.7	-5.7
40	-21.0	-9.2	-6.3	-5.0	-4.3
50	-14.0	-6.1	-4.2	-3.3	-2.8
60	-7.0	-3.1	-2.1	-1.7	-1.4
70	0.0	0.0	0.0	0.0	0.0
80	7.0	3.1	2.1	1.7	1.4
90	14.0	6.1	4.2	3.3	2.8
100	21.0	9.2	6.3	5.0	4.3
110	28.0	12.3	8.5	6.7	5.7
120	34.9	15.4	10.6	8.4	7.1
130	41.9	18.4	12.7	10.0	8.5
140	48.9	21.5	14.8	11.7	9.9
150	55.9	24.6	16.9	13.4	11.4
160	62.9	27.6	19.0	15.1	12.8
170	69.9	30.7	21.1	16.7	14.2
180	76.9	33.8	23.2	18.4	15.6
190	83.9	36.9	25.4	20.1	17.0
200	90.8	39.9	27.5	21.8	18.5

**3" Uponor PEX surface
temperature at 70°F/21.1°C ambient**

Water temp (°F)	Surface temperature (°F)				
	No insulation	½" insulation	1" insulation	1½" insulation	2" insulation
30	35.8	58.6	63.7	65.8	67.0
40	44.4	61.5	65.3	66.9	67.7
50	52.9	64.3	66.9	67.9	68.5
60	61.5	67.2	68.4	69.0	69.2
70	70.0	70.0	70.0	70.0	70.0
80	78.5	72.8	71.6	71.0	70.8
90	87.1	75.7	73.1	72.1	71.5
100	95.6	78.5	74.7	73.1	72.3
110	104.2	81.4	76.3	74.2	73.0
120	112.7	84.2	77.9	75.2	73.8
130	121.3	87.1	79.4	76.3	74.6
140	129.8	89.9	81.0	77.3	75.3
150	138.3	92.8	82.6	78.4	76.1
160	146.9	95.6	84.2	79.4	76.9
170	155.4	98.4	85.7	80.4	77.6
180	164.0	101.3	87.3	81.5	78.4
190	172.5	104.1	88.9	82.5	79.1
200	181.0	107.0	90.5	83.6	79.9

1. All calculations based on cylindrical thermal resistance methodology (ASHRAE).
2. Based on fluid velocity of 8 ft./sec. at 160°F/71.1°C (maximizing heat transfer from 100% water).
3. Pipe convection set to be 1.00 Btu/hr·ft²·°F (based on standard value for free convection of air).
4. This heat loss comparison uses 0.25 Btu·in/(hr·ft²·°F) as the insulation thermal conductivity. This is a standard value for fiberglass pipe insulation at a 100°F/37.8°C mean temperature.

4" Uponor PEX heat loss at 70°F ambient

Water temp (°F)	Heat loss (btu/hr-ft)				
	No insulation	½" insulation	1" insulation	1½" insulation	2" insulation
30	-35.3	-15.3	-10.4	-8.1	-6.8
40	-26.5	-11.5	-7.8	-6.1	-5.1
50	-17.6	-7.7	-5.2	-4.1	-3.4
60	-8.8	-3.8	-2.6	-2.0	-1.7
70	0.0	0.0	0.0	0.0	0.0
80	8.8	3.8	2.6	2.0	1.7
90	17.6	7.7	5.2	4.1	3.4
100	26.5	11.5	7.8	6.1	5.1
110	35.3	15.3	10.4	8.1	6.8
120	44.1	19.1	13.0	10.2	8.5
130	52.9	23.0	15.6	12.2	10.2
140	61.7	26.8	18.2	14.2	12.0
150	70.6	30.6	20.8	16.3	13.7
160	79.4	34.5	23.4	18.3	15.4
170	88.2	38.3	26.0	20.3	17.1
180	97.0	42.1	28.6	22.4	18.8
190	105.8	46.0	31.2	24.4	20.5
200	114.7	49.8	33.8	26.4	22.2

4" Uponor PEX surface temperature at 70°F ambient

Water temp (°F)	Surface temperature (°F)				
	No insulation	½" insulation	1" insulation	1½" insulation	2" insulation
30	37.3	58.6	63.5	65.6	66.8
40	45.5	61.4	65.1	66.7	67.6
50	53.7	64.3	66.8	67.8	68.4
60	61.8	67.1	68.4	68.9	69.2
70	70.0	70.0	70.0	70.0	70.0
80	78.2	72.9	71.6	71.1	70.8
90	86.3	75.7	73.2	72.2	71.6
100	94.5	78.6	74.9	73.3	72.4
110	102.7	81.4	76.5	74.4	73.2
120	110.8	84.3	78.1	75.4	74.0
130	119.0	87.1	79.7	76.5	74.8
140	127.2	90.0	81.3	77.6	75.6
150	135.3	92.8	83.0	78.7	76.4
160	143.5	95.7	84.6	79.8	77.2
170	151.7	98.5	86.2	80.9	78.0
180	159.8	101.4	87.8	82.0	78.8
190	168.0	104.3	89.4	83.1	79.6
200	176.2	107.1	91.1	84.2	80.4

1. All calculations based on cylindrical thermal resistance methodology (ASHRAE).
2. Based on fluid velocity of 8 ft./sec. at 160°F (maximizing heat transfer from 100% water).
3. Pipe convection set to be 1.00 Btu/hr·ft²·°F (based on standard value for free convection of air).
4. This heat loss comparison uses 0.25 Btu·in/(hr·ft²·°F) as the insulation thermal conductivity. This is a standard value for fiberglass pipe insulation at a 100°F mean temperature.

**½" Uponor PEX heat loss
at 90°F/32.2°C ambient**

Water temp (°F)	Heat loss (btu/hr-ft)				
	No insulation	½" insulation	1" insulation	1½" insulation	2" insulation
30	-9.5	-6.1	-4.7	-4.1	-3.7
40	-7.9	-5.1	-4.0	-3.4	-3.1
50	-6.3	-4.1	-3.2	-2.7	-2.4
60	-4.7	-3.0	-2.4	-2.0	-1.8
70	-3.2	-2.0	-1.6	-1.4	-1.2
80	-1.6	-1.0	-0.8	-0.7	-0.6
90	0.0	0.0	0.0	0.0	0.0
100	1.6	1.0	0.8	0.7	0.6
110	3.2	2.0	1.6	1.4	1.2
120	4.7	3.0	2.4	2.0	1.8
130	6.3	4.1	3.2	2.7	2.4
140	7.9	5.1	4.0	3.4	3.1
150	9.5	6.1	4.7	4.1	3.7
160	11.1	7.1	5.5	4.8	4.3
170	12.6	8.1	6.3	5.4	4.9
180	14.2	9.1	7.1	6.1	5.5
190	15.8	10.1	7.9	6.8	6.1
200	17.4	11.1	8.7	7.5	6.7

**½" Uponor PEX surface
temperature at 90°F/32.2°C ambient**

Water temp (°F)	Surface temperature (°F)				
	No insulation	½" insulation	1" insulation	1½" insulation	2" insulation
30	32.1	75.7	83.1	85.7	87.0
40	41.8	78.1	84.2	86.4	87.5
50	51.4	80.5	85.4	87.1	88.0
60	61.1	82.9	86.5	87.9	88.5
70	70.7	85.2	87.7	88.6	89.0
80	80.4	87.6	88.8	89.3	89.5
90	90.0	90.0	90.0	90.0	90.0
100	99.6	92.4	91.2	90.7	90.5
110	109.3	94.8	92.3	91.4	91.0
120	118.9	97.1	93.5	92.1	91.5
130	128.6	99.5	94.6	92.9	92.0
140	138.2	101.9	95.8	93.6	92.5
150	147.9	104.3	96.9	94.3	93.0
160	157.5	106.7	98.1	95.0	93.5
170	167.2	109.0	99.2	95.7	94.0
180	176.8	111.4	100.4	96.4	94.5
190	186.5	113.8	101.5	97.2	95.1
200	196.1	116.2	102.7	97.9	95.6

1. All calculations based on cylindrical thermal resistance methodology (ASHRAE).
2. Based on fluid velocity of 8 ft./sec. at 160°F/71.1°C (maximizing heat transfer from 100% water).
3. Pipe convection set to be 1.00 Btu/hr·ft²·°F (based on standard value for free convection of air).
4. This heat loss comparison uses 0.25 Btu·in/(hr·ft²·°F) as the insulation thermal conductivity. This is a standard value for fiberglass pipe insulation at a 100°F/37.8°C mean temperature.

5/8" Uponor PEX heat loss at 90°F ambient

Water temp (°F)	Heat loss (btu/hr-ft)				
	No insulation	1/2" insulation	1" insulation	1 1/2" insulation	2" insulation
30	-11.3	-6.8	-5.2	-4.4	-4.0
40	-9.4	-5.6	-4.3	-3.7	-3.3
50	-7.5	-4.5	-3.5	-3.0	-2.6
60	-5.7	-3.4	-2.6	-2.2	-2.0
70	-3.8	-2.3	-1.7	-1.5	-1.3
80	-1.9	-1.1	-0.9	-0.7	-0.7
90	0.0	0.0	0.0	0.0	0.0
100	1.9	1.1	0.9	0.7	0.7
110	3.8	2.3	1.7	1.5	1.3
120	5.7	3.4	2.6	2.2	2.0
130	7.5	4.5	3.5	3.0	2.6
140	9.4	5.6	4.3	3.7	3.3
150	11.3	6.8	5.2	4.4	4.0
160	13.2	7.9	6.1	5.2	4.6
170	15.1	9.0	6.9	5.9	5.3
180	17.0	10.2	7.8	6.7	6.0
190	18.9	11.3	8.7	7.4	6.6
200	20.7	12.4	9.5	8.1	7.3

5/8" Uponor PEX surface temperature at 90°F ambient

Water temp (°F)	Surface temperature (°F)				
	No insulation	1/2" insulation	1" insulation	1 1/2" insulation	2" insulation
30	32.4	75.2	82.8	85.5	86.8
40	42.0	77.7	84.0	86.2	87.3
50	51.6	80.2	85.2	87.0	87.9
60	61.2	82.6	86.4	87.7	88.4
70	70.8	85.1	87.6	88.5	88.9
80	80.4	87.5	88.8	89.2	89.5
90	90.0	90.0	90.0	90.0	90.0
100	99.6	92.5	91.2	90.8	90.5
110	109.2	94.9	92.4	91.5	91.1
120	118.8	97.4	93.6	92.3	91.6
130	128.4	99.8	94.8	93.0	92.1
140	138.0	102.3	96.0	93.8	92.7
150	147.6	104.8	97.2	94.5	93.2
160	157.2	107.2	98.4	95.3	93.7
170	166.8	109.7	99.6	96.0	94.3
180	176.4	112.2	100.8	96.8	94.8
190	186.0	114.6	102.1	97.5	95.3
200	195.6	117.1	103.3	98.3	95.9

1. All calculations based on cylindrical thermal resistance methodology (ASHRAE).
2. Based on fluid velocity of 8 ft./sec. at 160°F (maximizing heat transfer from 100% water).
3. Pipe convection set to be 1.00 Btu/hr·ft²·°F (based on standard value for free convection of air).
4. This heat loss comparison uses 0.25 Btu·in/(hr·ft²·°F) as the insulation thermal conductivity. This is a standard value for fiberglass pipe insulation at a 100°F mean temperature.

**¾" Uponor PEX heat loss
at 90°F/32.2°C ambient**

Water temp (°F)	Heat loss (btu/hr-ft)				
	No insulation	½" insulation	1" insulation	1½" insulation	2" insulation
30	-13.1	-7.4	-5.6	-4.8	-4.3
40	-10.9	-6.2	-4.7	-4.0	-3.5
50	-8.7	-5.0	-3.8	-3.2	-2.8
60	-6.6	-3.7	-2.8	-2.4	-2.1
70	-4.4	-2.5	-1.9	-1.6	-1.4
80	-2.2	-1.2	-0.9	-0.8	-0.7
90	0.0	0.0	0.0	0.0	0.0
100	2.2	1.2	0.9	0.8	0.7
110	4.4	2.5	1.9	1.6	1.4
120	6.6	3.7	2.8	2.4	2.1
130	8.7	5.0	3.8	3.2	2.8
140	10.9	6.2	4.7	4.0	3.5
150	13.1	7.4	5.6	4.8	4.3
160	15.3	8.7	6.6	5.6	5.0
170	17.5	9.9	7.5	6.4	5.7
180	19.7	11.2	8.5	7.2	6.4
190	21.9	12.4	9.4	8.0	7.1
200	24.0	13.6	10.4	8.8	7.8

**¾" Uponor PEX surface
temperature at 90°F/32.2°C ambient**

Water temp (°F)	Surface temperature (°F)				
	No insulation	½" insulation	1" insulation	1½" insulation	2" insulation
30	32.7	74.9	82.5	85.3	86.7
40	42.3	77.4	83.7	86.1	87.2
50	51.8	79.9	85.0	86.9	87.8
60	61.4	82.4	86.2	87.6	88.3
70	70.9	85.0	87.5	88.4	88.9
80	80.5	87.5	88.7	89.2	89.4
90	90.0	90.0	90.0	90.0	90.0
100	99.5	92.5	91.3	90.8	90.6
110	109.1	95.0	92.5	91.6	91.1
120	118.6	97.6	93.8	92.4	91.7
130	128.2	100.1	95.0	93.1	92.2
140	137.7	102.6	96.3	93.9	92.8
150	147.3	105.1	97.5	94.7	93.3
160	156.8	107.7	98.8	95.5	93.9
170	166.3	110.2	100.0	96.3	94.4
180	175.9	112.7	101.3	97.1	95.0
190	185.4	115.2	102.5	97.8	95.6
200	195.0	117.8	103.8	98.6	96.1

1. All calculations based on cylindrical thermal resistance methodology (ASHRAE).
2. Based on fluid velocity of 8 ft./sec. at 160°F/71.1°C (maximizing heat transfer from 100% water).
3. Pipe convection set to be 1.00 Btu/hr·ft²·°F (based on standard value for free convection of air).
4. This heat loss comparison uses 0.25 Btu·in/(hr·ft²·°F) as the insulation thermal conductivity. This is a standard value for fiberglass pipe insulation at a 100°F/37.8°C mean temperature.

**1" Uponor PEX heat loss
at 90°F/32.2°C ambient**

Water temp (°F)	Heat loss (btu/hr-ft)				
	No insulation	½" insulation	1" insulation	1½" insulation	2" insulation
30	-16.6	-8.7	-6.5	-5.4	-4.8
40	-13.9	-7.3	-5.4	-4.5	-4.0
50	-11.1	-5.8	-4.3	-3.6	-3.2
60	-8.3	-4.4	-3.2	-2.7	-2.4
70	-5.5	-2.9	-2.2	-1.8	-1.6
80	-2.8	-1.5	-1.1	-0.9	-0.8
90	0.0	0.0	0.0	0.0	0.0
100	2.8	1.5	1.1	0.9	0.8
110	5.5	2.9	2.2	1.8	1.6
120	8.3	4.4	3.2	2.7	2.4
130	11.1	5.8	4.3	3.6	3.2
140	13.9	7.3	5.4	4.5	4.0
150	16.6	8.7	6.5	5.4	4.8
160	19.4	10.2	7.6	6.3	5.6
170	22.2	11.7	8.7	7.2	6.4
180	25.0	13.1	9.7	8.1	7.2
190	27.7	14.6	10.8	9.0	8.0
200	30.5	16.0	11.9	9.9	8.8

**1" Uponor PEX surface
temperature at 90°F/32.2°C ambient**

Water temp (°F)	Surface temperature (°F)				
	No insulation	½" insulation	1" insulation	1½" insulation	2" insulation
30	33.5	74.3	82.1	85.0	86.4
40	42.9	76.9	83.4	85.8	87.0
50	52.3	79.5	84.7	86.7	87.6
60	61.7	82.1	86.0	87.5	88.2
70	71.2	84.8	87.4	88.3	88.8
80	80.6	87.4	88.7	89.2	89.4
90	90.0	90.0	90.0	90.0	90.0
100	99.4	92.6	91.3	90.8	90.6
110	108.8	95.2	92.6	91.7	91.2
120	118.3	97.9	94.0	92.5	91.8
130	127.7	100.5	95.3	93.3	92.4
140	137.1	103.1	96.6	94.2	93.0
150	146.5	105.7	97.9	95.0	93.6
160	155.9	108.3	99.3	95.9	94.2
170	165.3	110.9	100.6	96.7	94.8
180	174.8	113.6	101.9	97.5	95.3
190	184.2	116.2	103.2	98.4	95.9
200	193.6	118.8	104.6	99.2	96.5

1. All calculations based on cylindrical thermal resistance methodology (ASHRAE).
2. Based on fluid velocity of 8 ft./sec. at 160°F/71.1°C (maximizing heat transfer from 100% water).
3. Pipe convection set to be 1.00 Btu/hr·ft²·°F (based on standard value for free convection of air).
4. This heat loss comparison uses 0.25 Btu·in/(hr·ft²·°F) as the insulation thermal conductivity. This is a standard value for fiberglass pipe insulation at a 100°F/37.8°C mean temperature.

**1¼" Uponor PEX heat loss
at 90°F/32.2°C ambient**

Water temp (°F)	Heat loss (btu/hr-ft)				
	No insulation	½" insulation	1" insulation	1½" insulation	2" insulation
30	-20.1	-10.0	-7.3	-6.0	-5.3
40	-16.7	-8.3	-6.1	-5.0	-4.4
50	-13.4	-6.7	-4.9	-4.0	-3.5
60	-10.0	-5.0	-3.7	-3.0	-2.6
70	-6.7	-3.3	-2.4	-2.0	-1.8
80	-3.3	-1.7	-1.2	-1.0	-0.9
90	0.0	0.0	0.0	0.0	0.0
100	3.3	1.7	1.2	1.0	0.9
110	6.7	3.3	2.4	2.0	1.8
120	10.0	5.0	3.7	3.0	2.6
130	13.4	6.7	4.9	4.0	3.5
140	16.7	8.3	6.1	5.0	4.4
150	20.1	10.0	7.3	6.0	5.3
160	23.4	11.7	8.5	7.1	6.2
170	26.8	13.3	9.8	8.1	7.1
180	30.1	15.0	11.0	9.1	7.9
190	33.5	16.7	12.2	10.1	8.8
200	36.8	18.4	13.4	11.1	9.7

**1¼" Uponor PEX surface
temperature at 90°F/32.2°C ambient**

Water temp (°F)	Surface temperature (°F)				
	No insulation	½" insulation	1" insulation	1½" insulation	2" insulation
30	34.2	73.9	81.7	84.7	86.2
40	43.5	76.6	83.1	85.6	86.9
50	52.8	79.3	84.5	86.5	87.5
60	62.1	81.9	85.9	87.4	88.1
70	71.4	84.6	87.2	88.2	88.7
80	80.7	87.3	88.6	89.1	89.4
90	90.0	90.0	90.0	90.0	90.0
100	99.3	92.7	91.4	90.9	90.6
110	108.6	95.4	92.8	91.8	91.3
120	117.9	98.1	94.1	92.6	91.9
130	127.2	100.7	95.5	93.5	92.5
140	136.5	103.4	96.9	94.4	93.1
150	145.8	106.1	98.3	95.3	93.8
160	155.1	108.8	99.7	96.2	94.4
170	164.4	111.5	101.0	97.0	95.0
180	173.7	114.2	102.4	97.9	95.6
190	183.0	116.8	103.8	98.8	96.3
200	192.3	119.5	105.2	99.7	96.9

1. All calculations based on cylindrical thermal resistance methodology (ASHRAE).
2. Based on fluid velocity of 8 ft./sec. at 160°F/71.1°C (maximizing heat transfer from 100% water).
3. Pipe convection set to be 1.00 Btu/hr·ft²·°F (based on standard value for free convection of air).
4. This heat loss comparison uses 0.25 Btu·in/(hr·ft²·°F) as the insulation thermal conductivity. This is a standard value for fiberglass pipe insulation at a 100°F/37.8°C mean temperature.

**1½" Uponor PEX heat loss
at 90°F/32.2°C ambient**

Water temp (°F)	Heat loss (btu/hr-ft)				
	No insulation	½" insulation	1" insulation	1½" insulation	2" insulation
30	-23.4	-11.3	-8.1	-6.6	-5.8
40	-19.5	-9.4	-6.8	-5.5	-4.8
50	-15.6	-7.5	-5.4	-4.4	-3.9
60	-11.7	-5.6	-4.1	-3.3	-2.9
70	-7.8	-3.8	-2.7	-2.2	-1.9
80	-3.9	-1.9	-1.4	-1.1	-1.0
90	0.0	0.0	0.0	0.0	0.0
100	3.9	1.9	1.4	1.1	1.0
110	7.8	3.8	2.7	2.2	1.9
120	11.7	5.6	4.1	3.3	2.9
130	15.6	7.5	5.4	4.4	3.9
140	19.5	9.4	6.8	5.5	4.8
150	23.4	11.3	8.1	6.6	5.8
160	27.3	13.1	9.5	7.8	6.7
170	31.2	15.0	10.8	8.9	7.7
180	35.1	16.9	12.2	10.0	8.7
190	39.0	18.8	13.5	11.1	9.6
200	43.0	20.6	14.9	12.2	10.6

**1½" Uponor PEX surface
temperature at 90°F/32.2°C ambient**

Water temp (°F)	Surface temperature (°F)				
	No insulation	½" insulation	1" insulation	1½" insulation	2" insulation
30	34.9	73.6	81.4	84.5	86.1
40	44.1	76.3	82.9	85.4	86.7
50	53.3	79.1	84.3	86.3	87.4
60	62.5	81.8	85.7	87.3	88.0
70	71.6	84.5	87.1	88.2	88.7
80	80.8	87.3	88.6	89.1	89.3
90	90.0	90.0	90.0	90.0	90.0
100	99.2	92.7	91.4	90.9	90.7
110	108.4	95.5	92.9	91.8	91.3
120	117.5	98.2	94.3	92.7	92.0
130	126.7	100.9	95.7	93.7	92.6
140	135.9	103.7	97.1	94.6	93.3
150	145.1	106.4	98.6	95.5	93.9
160	154.2	109.1	100.0	96.4	94.6
170	163.4	111.8	101.4	97.3	95.2
180	172.6	114.6	102.8	98.2	95.9
190	181.8	117.3	104.3	99.1	96.5
200	191.0	120.0	105.7	100.1	97.2

1. All calculations based on cylindrical thermal resistance methodology (ASHRAE).
2. Based on fluid velocity of 8 ft./sec. at 160°F/71.1°C (maximizing heat transfer from 100% water).
3. Pipe convection set to be 1.00 Btu/hr·ft²·°F (based on standard value for free convection of air).
4. This heat loss comparison uses 0.25 Btu·in/(hr·ft²·°F) as the insulation thermal conductivity. This is a standard value for fiberglass pipe insulation at a 100°F/37.8°C mean temperature.

**2" Uponor PEX heat loss
at 90°F/32.2°C ambient**

Water temp (°F)	Heat loss (btu/hr-ft)				
	No insulation	½" insulation	1" insulation	1½" insulation	2" insulation
30	-29.9	-13.7	-9.7	-7.8	-6.7
40	-24.9	-11.4	-8.1	-6.5	-5.6
50	-19.9	-9.1	-6.4	-5.2	-4.5
60	-14.9	-6.9	-4.8	-3.9	-3.4
70	-10.0	-4.6	-3.2	-2.6	-2.2
80	-5.0	-2.3	-1.6	-1.3	-1.1
90	0.0	0.0	0.0	0.0	0.0
100	5.0	2.3	1.6	1.3	1.1
110	10.0	4.6	3.2	2.6	2.2
120	14.9	6.9	4.8	3.9	3.4
130	19.9	9.1	6.4	5.2	4.5
140	24.9	11.4	8.1	6.5	5.6
150	29.9	13.7	9.7	7.8	6.7
160	34.9	16.0	11.3	9.1	7.8
170	39.9	18.3	12.9	10.4	9.0
180	44.8	20.6	14.5	11.7	10.1
190	49.8	22.8	16.1	13.0	11.2
200	54.8	25.1	17.7	14.3	12.3

**2" Uponor PEX surface
temperature at 90°F/32.2°C ambient**

Water temp (°F)	Surface temperature (°F)				
	No insulation	½" insulation	1" insulation	1½" insulation	2" insulation
30	36.3	73.2	81.0	84.2	85.8
40	45.2	76.0	82.5	85.1	86.5
50	54.2	78.8	84.0	86.1	87.2
60	63.1	81.6	85.5	87.1	87.9
70	72.1	84.4	87.0	88.1	88.6
80	81.0	87.2	88.5	89.0	89.3
90	90.0	90.0	90.0	90.0	90.0
100	99.0	92.8	91.5	91.0	90.7
110	107.9	95.6	93.0	91.9	91.4
120	116.9	98.4	94.5	92.9	92.1
130	125.8	101.2	96.0	93.9	92.8
140	134.8	104.0	97.5	94.9	93.5
150	143.7	106.8	99.0	95.8	94.2
160	152.7	109.5	100.5	96.8	94.9
170	161.7	112.3	101.9	97.8	95.6
180	170.6	115.1	103.4	98.7	96.3
190	179.6	117.9	104.9	99.7	97.0
200	188.5	120.7	106.4	100.7	97.7

1. All calculations based on cylindrical thermal resistance methodology (ASHRAE).
2. Based on fluid velocity of 8 ft./sec. at 160°F/71.1°C (maximizing heat transfer from 100% water).
3. Pipe convection set to be 1.00 Btu/hr·ft²·°F (based on standard value for free convection of air).
4. This heat loss comparison uses 0.25 Btu·in/(hr·ft²·°F) as the insulation thermal conductivity. This is a standard value for fiberglass pipe insulation at a 100°F/37.8°C mean temperature.

**2½" Uponor PEX heat loss
at 90°F/32.2°C ambient**

Water temp (°F)	Heat loss (btu/hr-ft)				
	No insulation	½" insulation	1" insulation	1½" insulation	2" insulation
30	-36.0	-16.1	-11.2	-8.9	-7.6
40	-30.0	-13.4	-9.3	-7.5	-6.4
50	-24.0	-10.7	-7.5	-6.0	-5.1
60	-18.0	-8.0	-5.6	-4.5	-3.8
70	-12.0	-5.4	-3.7	-3.0	-2.5
80	-6.0	-2.7	-1.9	-1.5	-1.3
90	0.0	0.0	0.0	0.0	0.0
100	6.0	2.7	1.9	1.5	1.3
110	12.0	5.4	3.7	3.0	2.5
120	18.0	8.0	5.6	4.5	3.8
130	24.0	10.7	7.5	6.0	5.1
140	30.0	13.4	9.3	7.5	6.4
150	36.0	16.1	11.2	8.9	7.6
160	42.0	18.8	13.1	10.4	8.9
170	48.0	21.5	14.9	11.9	10.2
180	54.1	24.1	16.8	13.4	11.5
190	60.1	26.8	18.6	14.9	12.7
200	66.1	29.5	20.5	16.4	14.0

**2½" Uponor PEX surface
temperature at 90°F/32.2°C ambient**

Water temp (°F)	Surface temperature (°F)				
	No insulation	½" insulation	1" insulation	1½" insulation	2" insulation
30	37.6	73.0	80.8	83.9	85.6
40	46.3	75.9	82.3	84.9	86.3
50	55.0	78.7	83.8	86.0	87.1
60	63.8	81.5	85.4	87.0	87.8
70	72.5	84.3	86.9	88.0	88.5
80	81.3	87.2	88.5	89.0	89.3
90	90.0	90.0	90.0	90.0	90.0
100	98.7	92.8	91.5	91.0	90.7
110	107.5	95.7	93.1	92.0	91.5
120	116.2	98.5	94.6	93.0	92.2
130	125.0	101.3	96.2	94.0	92.9
140	133.7	104.1	97.7	95.1	93.7
150	142.4	107.0	99.2	96.1	94.4
160	151.2	109.8	100.8	97.1	95.1
170	159.9	112.6	102.3	98.1	95.9
180	168.7	115.4	103.9	99.1	96.6
190	177.4	118.3	105.4	100.1	97.3
200	186.1	121.1	106.9	101.1	98.1

1. All calculations based on cylindrical thermal resistance methodology (ASHRAE).
2. Based on fluid velocity of 8 ft./sec. at 160°F/71.1°C (maximizing heat transfer from 100% water).
3. Pipe convection set to be 1.00 Btu/hr·ft²·°F (based on standard value for free convection of air).
4. This heat loss comparison uses 0.25 Btu·in/(hr·ft²·°F) as the insulation thermal conductivity. This is a standard value for fiberglass pipe insulation at a 100°F/37.8°C mean temperature.

**3" Uponor PEX—a heat loss
at 90°F/32.2°C ambient**

Water temp (°F)	Heat loss (btu/hr-ft)				
	No insulation	½" insulation	1" insulation	1½" insulation	2" insulation
30	-41.9	-18.4	-12.7	-10.0	-8.5
40	-34.9	-15.4	-10.6	-8.4	-7.1
50	-28.0	-12.3	-8.5	-6.7	-5.7
60	-21.0	-9.2	-6.3	-5.0	-4.3
70	-14.0	-6.1	-4.2	-3.3	-2.8
80	-7.0	-3.1	-2.1	-1.7	-1.4
90	0.0	0.0	0.0	0.0	0.0
100	7.0	3.1	2.1	1.7	1.4
110	14.0	6.1	4.2	3.3	2.8
120	21.0	9.2	6.3	5.0	4.3
130	28.0	12.3	8.5	6.7	5.7
140	34.9	15.4	10.6	8.4	7.1
150	41.9	18.4	12.7	10.0	8.5
160	48.9	21.5	14.8	11.7	9.9
170	55.9	24.6	16.9	13.4	11.4
180	62.9	27.6	19.0	15.1	12.8
190	69.9	30.7	21.1	16.7	14.2
200	76.9	33.8	23.2	18.4	15.6

**3" Uponor PEX surface
temperature at 90°F/32.2°C ambient**

Water temp (°F)	Surface temperature (°F)				
	No insulation	½" insulation	1" insulation	1½" insulation	2" insulation
30	38.7	72.9	80.6	83.7	85.4
40	47.3	75.8	82.1	84.8	86.2
50	55.8	78.6	83.7	85.8	87.0
60	64.4	81.5	85.3	86.9	87.7
70	72.9	84.3	86.9	87.9	88.5
80	81.5	87.2	88.4	89.0	89.2
90	90.0	90.0	90.0	90.0	90.0
100	98.5	92.8	91.6	91.0	90.8
110	107.1	95.7	93.1	92.1	91.5
120	115.6	98.5	94.7	93.1	92.3
130	124.2	101.4	96.3	94.2	93.0
140	132.7	104.2	97.9	95.2	93.8
150	141.3	107.1	99.4	96.3	94.6
160	149.8	109.9	101.0	97.3	95.3
170	158.3	112.8	102.6	98.4	96.1
180	166.9	115.6	104.2	99.4	96.9
190	175.4	118.4	105.7	100.4	97.6
200	184.0	121.3	107.3	101.5	98.4

1. All calculations based on cylindrical thermal resistance methodology (ASHRAE).
2. Based on fluid velocity of 8 ft./sec. at 160°F/71.1°C (maximizing heat transfer from 100% water).
3. Pipe convection set to be 1.00 Btu/hr·ft²·°F (based on standard value for free convection of air).
4. This heat loss comparison uses 0.25 Btu·in/(hr·ft²·°F) as the insulation thermal conductivity. This is a standard value for fiberglass pipe insulation at a 100°F/37.8°C mean temperature.

4" Uponor PEX heat loss at 90°F ambient

Water temp (°F)	Heat loss (btu/hr-ft)				
	No insulation	½" insulation	1" insulation	1½" insulation	2" insulation
30	-52.9	-23.0	-15.6	-12.2	-10.2
40	-44.1	-19.1	-13.0	-10.2	-8.5
50	-35.3	-15.3	-10.4	-8.1	-6.8
60	-26.5	-11.5	-7.8	-6.1	-5.1
70	-17.6	-7.7	-5.2	-4.1	-3.4
80	-8.8	-3.8	-2.6	-2.0	-1.7
90	0.0	0.0	0.0	0.0	0.0
100	8.8	3.8	2.6	2.0	1.7
110	17.6	7.7	5.2	4.1	3.4
120	26.5	11.5	7.8	6.1	5.1
130	35.3	15.3	10.4	8.1	6.8
140	44.1	19.1	13.0	10.2	8.5
150	52.9	23.0	15.6	12.2	10.2
160	61.7	26.8	18.2	14.2	12.0
170	70.6	30.6	20.8	16.3	13.7
180	79.4	34.5	23.4	18.3	15.4
190	88.2	38.3	26.0	20.3	17.1
200	97.0	42.1	28.6	22.4	18.8

4" Uponor PEX surface temperature at 90°F ambient

Water temp (°F)	Surface temperature (°F)				
	No insulation	½" insulation	1" insulation	1½" insulation	2" insulation
30	41.0	72.9	80.3	83.5	85.2
40	49.2	75.7	81.9	84.6	86.0
50	57.3	78.6	83.5	85.6	86.8
60	65.5	81.4	85.1	86.7	87.6
70	73.7	84.3	86.8	87.8	88.4
80	81.8	87.1	88.4	88.9	89.2
90	90.0	90.0	90.0	90.0	90.0
100	98.2	92.9	91.6	91.1	90.8
110	106.3	95.7	93.2	92.2	91.6
120	114.5	98.6	94.9	93.3	92.4
130	122.7	101.4	96.5	94.4	93.2
140	130.8	104.3	98.1	95.4	94.0
150	139.0	107.1	99.7	96.5	94.8
160	147.2	110.0	101.3	97.6	95.6
170	155.3	112.8	103.0	98.7	96.4
180	163.5	115.7	104.6	99.8	97.2
190	171.7	118.5	106.2	100.9	98.0
200	179.8	121.4	107.8	102.0	98.8

1. All calculations based on cylindrical thermal resistance methodology (ASHRAE).
2. Based on fluid velocity of 8 ft./sec. at 160°F (maximizing heat transfer from 100% water).
3. Pipe convection set to be 1.00 Btu/hr·ft²·°F (based on standard value for free convection of air).
4. This heat loss comparison uses 0.25 Btu·in/(hr·ft²·°F) as the insulation thermal conductivity. This is a standard value for fiberglass pipe insulation at a 100°F mean temperature.

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