uponor

PLUMBING SYSTEMS

PLUMBING DESIGN ASSISTANCE MANUAL (PDAM)

Uponor Plumbing Design Assistance Manual (PDAM)

Uponor Plumbing Design Assistance Manual (PDAM)
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5925 148th Street West
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Phone: (800) 321-4739
Fax: (952) 891-2008
www.uponor-usa.com

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Foreword

This design assistance manual is published for architects, building officials, engineers and mechanical contractors interested in Uponor Professional Plumbing Systems. It describes general installation recommendations that use Wirsbo AQUAPEX® tubing 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® Network or Uponor AQUASAFE® Looped Fire Safety Installation Guides 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 toll-free (800) 321-4739 (United States) or (888) 994-7726 (Canada).

Register personal contact information in the "For Professionals" section at www.uponor-usa.com or www.uponor.ca to receive updates to this manual or request additional copies.

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Section 1 —

Wirsbo AQUAPEX® Tubing

Properties of PEX

PEX is an acronym for crosslinked polyethylene. The PE refers to the raw material — polyethylene — used to make PEX. 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.

Several methods exist to crosslink polyethylene. These methods create products with very different properties. Particularly, a distinction should be made between PEX produced above the crystal-melting temperature (hot crosslinking) and PEX produced below the crystal-melting temperature (cold crosslinking).

Uponor manufactures PEX tubing using the Engel method, a hot crosslinking process. The actual crosslinking takes place during the extrusion process when the base polyethylene is above its crystal-melting temperatures. Classified within the industry as PEX-a tubing, Engel-method PEX is superior to other types of PEX produced below the crystal-melting temperature, which crosslinks after the manufacturing process. Because Uponor PEX tubing incorporates crosslinking during the manufacturing process, the crosslinking is essentially built in. This results in consistent, uniform and evenly crosslinked PEX, with no weak links within its molecular chains.

PEX Stress Resistance

Tubing installed in plumbing applications must be capable of withstanding the extreme stresses that result from a variety of installation methodologies, (i.e., within a concrete slab, overhead, riser application or trenched).

Typical stresses include:

- Expansion and contraction that result from repeated heating and subsequent cooling of the internal fluid.
  - Linear Expansion Rate — the unrestrained linear expansion (thermal) rate for Wirsbo AQUAPEX tubing is approximately 1.1 inches per 10ºF/12.2ºC temperature change per 100 feet of tubing.
- Mechanical abrasion, shearing and stretching that occurs as a result of installation, normal structural movement and heating and cooling from seasonal weather changes.

Wirsbo AQUAPEX® tubing, which provides the durability and reliability that is needed for these applications, currently holds the unofficial world record for long-term testing at elevated temperature and pressure. Since 1973, the tubing has been subjected to ongoing testing at 203ºF/95ºC at 175 psi by Studvik in Sweden and BASF in Germany. The resulting data indicates a life expectancy of well over 100 years.

Wirsbo AQUAPEX Tubing Technical Data

Table 1-1 and **Table 1-2** on **page 13** contain temperature and pressure ratings, and various material properties, respectively, for Wirsbo AQUAPEX tubing. This data can be used by engineers, architects and designers when designing an Uponor plumbing system.

PEX Chemical Resistance

Crosslinked polyethylene has greatly enhanced resistance to chemical-dissolving agents. The unique molecular structure is stable and inert and is unaffected by chemicals (organic or inorganic) commonly found in plumbing systems.

PEX Volume Capacities

Wirsbo AQUAPEX tubing volume capacities are listed below:

- ¼" nominal inside diameter (contains 0.24 gallons/100 feet of tubing)
- ⅜" nominal inside diameter (contains 0.50 gallons/100 feet of tubing)
- ½" nominal inside diameter (contains 0.92 gallons/100 feet of tubing)
- ¾" nominal inside diameter (contains 1.84 gallons/100 feet of tubing)
- 1" nominal inside diameter (contains 3.03 gallons/100 feet of tubing)
- 1¼" nominal inside diameter (contains 4.53 gallons/100 feet of tubing)
- 1½" nominal inside diameter (contains 6.32 gallons/100 feet of tubing)
- 2" nominal inside diameter (contains 10.83 gallons/100 feet of tubing)

Temperature and Pressure Ratings			
Temperature (°F/°C)	Plastics Pipe Institute-recommended HDB* (psi)	HDS** (psi)	Resultant-pressure Rating (RPR)*** (psi)
73.4/23	1,250	630	160
180/82.2	800	400	100
200/93.3	630	315	80

* Hydrostatic Design Basis (HDB) — refers to the categorized long-term strength in the circumferential direction for a given set of end-use conditions as established by ASTM Standard D 2837

** Hydrostatic Design Stress (HDS) — HDS = 0.5 * HDB, where 0.5 Design Factor = Safety Factor of two times

*** Resultant-pressure Rating (RPR) — RPR = 2*(HDS)/(SDR-1), where the SDR = 9 for Wirsbo AQUAPEX tubing

Table 1-1: Temperature and Pressure Ratings of Wirsbo AQUAPEX Tubing

Wirsbo AQUAPEX Tubing or Wirsbo AQUAPEX plus Tubing

Wirsbo AQUAPEX tubing and Wirsbo AQUAPEX plus tubing are registered trade names for Uponor's hot- and cold-potable water PEX tubing. Uponor PEX tubing is outside-diameter controlled to copper-tube size (CTS) and has a standard dimension ratio (SDR9) wall thickness.

Application

Wirsbo AQUAPEX tubing is suitable in all plumbing-distribution and water-service systems operating within the temperature and pressure ratings of the tubing.

Standards, Listings and Ratings

Wirsbo AQUAPEX tubing is manufactured to meet these requirements:

1. Standards

ASTM International

- 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 Firestops

Material Properties		
Property	**English Units**	**SI Units**
Approximate Modulus of Elasticity (secant at 1% & 73°F/22.8°C)	91,350 psi	630 N/mm^2
Tubing 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
Recommended Working-temperature Limits	-284°F to 200°F	-140°C to 93°C
Short-term Maximum Temperature	210°F	99°C
Coefficient of Linear Expansion at 135°F/57°C	Average = $9.2*10^{-5}$ in/in-°F	Average = $1.7*10^{-4}$ 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-ft/Hr –ft^2-°F	0.38 W/m-°C
Degree of Crosslinking	70 to 89%	
Minimum Bend Radius	Six times the outside diameter	

Table 1-2: Material Properties for Wirsbo AQUAPEX Tubing

- ASTM F876 Standard Specification for Crosslinked Polyethylene (PEX) Tubing
- ASTM F877 Standard Specification for Crosslinked Polyethylene (PEX) Plastic hot- and cold-water Distribution Systems
- ASTM F1960 Standard Specification for Cold-expansion Fittings with PEX-reinforcing Rings for use With Crosslinked Polyethylene (PEX) Tubing
- ASTM F2023 Standard Test Method for Evaluating the Oxidative Resistance of Crosslinked Polyethylene (PEX) Tubing and Systems to hot Chlorinated Water

NSF International

- ANSI/NSF Standard 14 Plastics Piping System Components and Related Materials
- ANSI/NSF Standard 61 Drinking Water System Components — Health Effects

Note: Obtain listings at www.nsf.org.

American Water Works Association (AWWA)

- AWWA C904 Crosslinked Polyethylene (PEX) Pressure Pipe, half inch through three inch for Water Service

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 (½" - 1" Wirsbo AQUAPEX tubing only)

Underwriters Laboratories, Canada (ULC)

- Comply with CAN/CSA B137.5. Crosslinked Polyethylene (PEX) Tubing Systems for Pressure Applications
- CAN/ULC-S101. Standard Methods of Fire-endurance Tests of Building Construction and Materials
- CAN/ULC-S102.2. Standard Method of Test for Surface-burning Characteristics of Flooring, Floor Covering and Miscellaneous Materials and Assemblies

- CAN/ULC-S115. Standard Method of Fire Tests of Firestop Systems

Plastics Pipe Institute (PPI)

- PPI Technical Report TR-4

2. Listings and Regulatory Approvals

- Comply with ANSI/NSF Standard 14
- ASTM F876
- ASTM F877
- ASTM F1960
- Comply with ANSI/NSF Standard 61
- Comply with ASTM E119 and ANSI/UL 263.
  - UL Design No. L557 — one-hour wood frame floor/ ceiling assemblies
  - UL Design No. K913 — two-hour concrete floor/ ceiling assemblies
  - UL Design No. U372 — one-hour load-bearing wood-stud/gypsum wallboard wall assemblies
  - UL Design No. V444 — one-hour non-load bearing steel-stud/gypsum wallboard wall assemblies

Note: Obtain listings at www.ul.com.

- Comply with CAN/ULC-S101.
  - Warnock Hersey (WH) Design No. UW/FCA 60-01 — one-hour wood-frame floor/ ceiling assemblies
  - WH Design No. UW/FCA 120-01 — two-hour concrete floor/ceiling assemblies
  - WH Design No. UW/FCA 120-02 — two-hour concrete floor/ceiling assemblies
  - WH Design No. UW/WA 60-02 — one-hour load-bearing wood-stud/gypsum wallboard wall assemblies
  - WH Design No. UW/WA 60-01 — one-hour non-load-bearing steel-stud/gypsum wallboard wall assemblies
- Certification of flamespread/ smoke-developed rating of 25/50 in accordance with ASTM E84 for the PEX tubing sizes up to ¾-inch tubing is to be installed no closer than 18 inches apart.
- Certification of flamespread/ smoke-developed rating of 25/50 in accordance with CAN/ULC-S102.2 for PEX tubing sizes up to one inch. Tubing is to be installed no closer than 18 inches apart.
- Certification of flamespread/ smoke-developed rating of 25/50 in accordance with ASTM E84 and CAN/ULC S102.2 for up to two-inch tubing with minimum ½ -inch fiberglass insulation.

Note: Obtain listings at www.intertek-etlsemko.com.

Building Materials With Surface-burning Characteristics

Wirsbo AQUAPEX tubing, manufactured with a maximum outside diameter two-inch nominal tubing size, is encased in fiberglass tubing insulation. Insulated tubing runs shall be located at zero-inch minimum spacing for a maximum of three adjacent tubes with an additional 18-inch spacing to the next tubing run. There shall be no exposed tubing. Ratings apply when tubing is field-insulated with fiberglass insulation conforming to:

- Wall thickness: ½ to one inch
- Nominal density: 4.0 to 4.5 pcf
- Flamespread/Smoke-developed rating of insulation:
  20 FS/30 SD maximum.
- Insulation shall be listed for flamespread rating to the applicable test methods shown in **Table 1-3**.

Tubing Identification

Stamped bearing the test standard, rating and Warnock Hersey certification mark.

Model Plumbing Code Listings

International Code Council (ICC)
- International Plumbing Code (IPC)
- ICC Evaluation Service (ES) Evaluation Report No. ESR 1099

Building Officials and Code Administrators International (BOCA)
- 1993 BOCA National Plumbing Code

International Association of Plumbing Officials (IAPMO)
- Uniform Plumbing Code (UPC)
- IAPMO Files 3558, 3946 and 3960

National Association of Plumbing, Heating and Cooling Contractors (NAPHCC)
- National Standard Plumbing Code (NSPC)

Classified as to Surface-burning Characteristics		
ASTM-E84 Nominal ½" to ¾" size	**Flamespread** 25 or less	**Smoke developed** 50 or less
CAN/ULC-S102.2 Nominal ½" to 1" size	**Flamespread** 25 or less	**Smoke developed** 50 or less

Classified as to Surface-burning Characteristics		
ASTM-E84 Nominal 2" O.D.; Min. ½" FG Insulation	**Flamespread** 25 or less	**Smoke developed** 50 or less
CAN/ULC-S102.2 Nominal 2" O.D.; Min. ½" FG Insulation	**Flamespread** 25 or less	**Smoke developed** 50 or less

Table 1-3: Surface-burning Characteristics of Wirsbo AQUAPEX Tubing

U.S. Department of Housing and Urban Development (HUD)

- HUD Material Release No. 1269

National Research Council Canada (NRC-CNRC)

- National Plumbing Code of Canada.

3. Ratings

Wirsbo AQUAPEX tubing has standard-grade hydrostatic design stress and pressure ratings in accordance with PPI TR-3 and listed in PPI TR-4. The standard-grade hydrostatic design ratings are:

- 73.4ºF/23ºC at 160 psi
- 180ºF/82.2ºC at 100 psi
- 200ºF/93.3ºC at 80 psi

The Hydrostatic Design Stress Board of PPI issues these pressure and temperature ratings. These values listed are ratings, not limitations. The designer should stay within these parameters during the design phase.

Storing and Handling PEX

Caution:

- Do not store PEX tubing outdoors.
- Keep PEX tubing in the original packaging until time of installation.
- Ensure that exposure to sunlight during installation does not exceed the maximum recommended ultraviolet-ray exposure time of 30 days.

Uncoiling PEX

Uponor recommends an Uponor Uncoiler for convenient uncoiling.

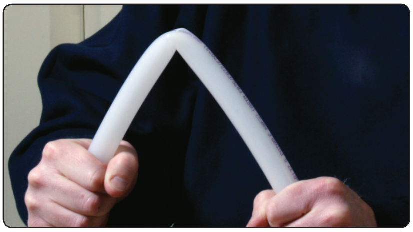
Bending PEX

The minimum bend radius of Wirsbo AQUAPEX tubing is six times the outside diameter. Bend supports are available for ³⁄₈- ¹⁄₂- ³⁄₄- and one-inch tubing and may be used to facilitate 90-degree rigid bends.

Reforming Kinked Tubing

If the tubing is kinked and hinders flow, repairs can be made easily:

1. Make sure the system is not pressurized.
2. Straighten the kinked portion of the tubing.
3. Heat the kinked area to approximately 265ºF/129.4ºC with an electric heat gun (approximately 450 watts of power). Apply the heat evenly until the tubing returns to its original size and shape. Do not use an open flame.
4. Let the repaired Wirsbo AQUAPEX tubing cool undisturbed to room temperature. When the tubing returns to its opaque appearance, the repair is complete.



Caution: Temperature of the tubing surface must not exceed 338ºF/170ºC. Do not apply direct flame to Wirsbo AQUAPEX tubing.

Wirsbo AQUAPEX tubing repaired according to these recommendations will return to its original shape and strength. If the tubing is sliced, punctured or otherwise damaged beyond the capacity of the crosslinked memory, install a ProPEX coupling. Wirsbo AQUAPEX tubing cannot be welded or repaired with adhesives.

Thawing Frozen Tubing

Wirsbo AQUAPEX tubing can withstand extreme freeze-thaw cycles better than other tubing or pipe. The crosslinking of the tubing allows it to expand and absorb much of the expansion energy from the freezing process. No tubing product is freeze-proof, but Wirsbo AQUAPEX tubing is extremely resistant to freeze damage.

If freezing occurs, the contractor should advise the end user to correct the lack of insulation or heat to eliminate the problem from reoccurring. Should Wirsbo AQUAPEX tubing experience an ice blockage, thaw the tubing using these methods:

1. Pour hot water over the tubing's affected area.
2. Wrap hot towels around the tubing's affected area.
3. Place a small portable heating unit in the area to heat the space and thaw the ice blockage from the tubing.
4. Slowly heat the affected area with a heat gun. Rub a hand over the area while heating to ensure the tubing does not get too hot.

Handling Guidelines for PEX Tubing

Although not comprehensive, the following highlights the most common guidelines when handling Wirsbo AQUAPEX tubing:

- Install Uponor systems according to the installation instructions. Failure to follow the instructions and installation guidelines in the Uponor Professional Plumbing Installation Guide can result in the failure of Uponor systems.
- Do not use Wirsbo AQUAPEX tubing where temperatures and pressures exceed ratings.
- Do not use or store Wirsbo AQUAPEX tubing where it will be exposed to direct sunlight for more than 30 days.
- Do not weld, glue or use adhesives or adhesive tape with Wirsbo AQUAPEX tubing.[1]
- Do not apply open flame to Wirsbo AQUAPEX tubing.
- Do not install Wirsbo AQUAPEX tubing within six inches of any gas appliance vents, with the exception of double-wall B-vents, which have a minimum clearance of one inch.
- Do not install Wirsbo AQUAPEX tubing within 12 inches (over or under) of any recessed light fixture unless the PEX tubing line is protected with suitable insulation.
- Do not install Wirsbo AQUAPEX tubing directly below fluorescent light fixtures, unless the tubing line is protected with suitable insulation.
- Do not use Wirsbo AQUAPEX tubing to convey natural gas.

[1] You may temporarily affix adhesive tape to Wirsbo AQUAPEX tubing during installation. However, to protect the integrity of the system, the tape should not be permanent. Remove the tape and residual adhesive after completing the installation.

- Do not solder within 18 inches of any Wirsbo AQUAPEX tubing in the same water line. Sweat connections must be made prior to making the ProPEX connection.
- Do not install Wirsbo AQUAPEX tubing between the tub/shower valve and tub spout.
- Do not use Wirsbo AQUAPEX tubing for an electrical ground.
- Do not spray on or allow organic chemicals, pesticides, strong acids or strong bases to come into contact with Wirsbo AQUAPEX tubing.
- Do not use petroleum or solvent-based paints, greases or sealants on Wirsbo AQUAPEX tubing.
- Use only approved and appropriate firestop materials with Wirsbo AQUAPEX tubing.
- Do not allow rodents, insects or other pests to come into contact with Wirsbo AQUAPEX tubing.
- Do not subject Wirsbo AQUAPEX tubing to blunt impact.
- During remodeling or ceiling repair, implement appropriate precautions to protect the tubing from damage.
- Do not install Wirsbo AQUAPEX tubing 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 tubing. Where such conditions are suspected, perform a chemical analysis of the soil or groundwater to ascertain the acceptability of Wirsbo AQUAPEX tubing for the specific installation. Check local codes for additional requirements.

Termiticide/Pesticide Application Guidelines for Wirsbo AQUAPEX Tubing

This section recommends the correct installation of Wirsbo AQUAPEX tubing for service-line applications as well as hot- and cold-water distribution use concerning termiticides and pesticides. These recommendations are based on Uponor's extensive history of use and available research and are intended to help prevent misapplication of liquid termiticides/pesticides around PEX tubing. Adhere to the instructions from the termiticides/pesticides manufacturer. As in all cases, follow all local codes and standards.

Background and Research

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 tubing 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 tubing.

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,"[1] 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 that "this indicates that the concentrations 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,

[1] Crosslinked polyethylene (PEX) tubing is assumed to behave similarly to polyethylene water tubing.

a PEX tubing wall thickness of 5 mm and a typical diffusion coefficient for organic compound migration of 1.0 x 10^{-12} cm^2/s, the time to permeate through the walls, would be 2.5 x 10^{11} seconds or approximately 8,000 years. If the wall thickness was reduced to 2 mm, then the time to permeate completely through the pipe wall would be reduced to 1,300 years.

Available data indicate that the solvents used in liquid termiticides/pesticides will soak into the ground and/or evaporate before they can pass through the wall of polyethylene tubing. The data also indicate that these solvents are prevented from passing through the wall of polyethylene tubing because of the large size of the water- or organic-solvent molecules, relative to the size of the molecules in the tubing itself. Once liquid solvents have dissipated or evaporated, the solids that remain behind can not permeate through the walls of polyethylene or PEX tubing 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 tubing. Instances of water-based termiticides/pesticides permeating through polyethylene or PEX tubing are not known. Pesticides have not been found to be corrosive or have polymer degradation.

Although all research data and anecdotal evidence strongly suggest that there is no permeation issues with water-based termiticides/pesticides and PEX, caution is required to ensure safe installation of PEX tubing and to prevent misapplication of the liquid termiticides/pesticides, especially to prevent pooling or puddling of these chemicals around PEX tubing.

Installation Recommendations

PEX tubing for hot- and cold-water distribution is approved for installation directly within or below concrete slabs where soil termiticide/pesticide treatment is required. This is especially useful in slab-on-grade construction. It is not required that PEX tubing, which are installed within or below concrete slabs, be sleeved. It is recommended to use either flexible polyethylene protection sleeve or rigid polyvinyl chloride (PVC) bend guides at all slab penetrations to protect PEX tubing from abrasion where they pass through the concrete slab. These products are described as slab-penetration protection devices.

When using pre-sleeved Wirsbo AQUAPEX tubing or a protection sleeve, an annular gap between these protection devices and the PEX tubing will exist. In such installations, the annular gap between the protection device and the PEX tubing at the exposed ends must be filled to help prevent pathways for pests and the mistaken application of harmful chemicals into the space between the PEX tubing and the protection device. Use only sealants that are compatible with PEX tubing.

Note: The following products can be used when sealing PEX tubing and slab-penetration protection devices:

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

The misapplication of these products could result in pooling or puddling of the products around the PEX tubing, a practice that is prohibited.

Caution:

1. If termiticides/pesticides are applied while the installed PEX tubing still has exposed open ends that are not yet connected to plumbing fixtures, the ends of the tubing must be capped, plugged or closed to prevent these chemicals from entering the tubing.

2. Do not allow organic (petroleum-based) chemicals, petroleum distillates, termiticides or pesticides to come into direct contact with PEX tubing.

3. The annular gap between PEX tubing and slab-penetration protection devices (sleeving or PVC bend guides) at the ends of the tubing must be filled to help prevent pathways for pests and the mistaken application of harmful chemicals into the space between the PEX tubing and the protection device. Use only sealants that are compatible with PEX tubing.

4. When PEX tubing is continuously sleeved below or above a slab (such as when using ½" pre-sleeved Wirsbo AQUAPEX tubing), the space between the PEX tubing and the sleeving must never be filled with any liquid chemical, including pesticides or termiticides. Prevent pooling or puddling of these liquids around PEX tubing.

5. When it is necessary to retreat soil near PEX tubing, prevent the puddling or pooling of the termiticide/pesticide.

Section 2 —

Making the ProPEX® Fitting

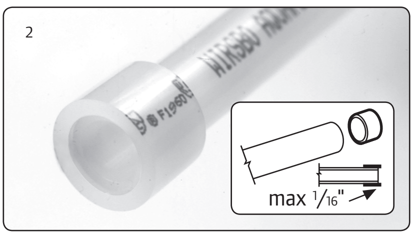
Uponor ProPEX® fittings, manufactured to ASTM F1960, are designed for use with Wirsbo AQUAPEX tubing. Make connections by sliding a ProPEX Ring over the tubing and expanding them simultaneously. The ProPEX fitting is then inserted into the expanded tubing and ProPEX Ring. The connection is made as the PEX tubing shrinks over the fitting because of the unique shape memory of Wirsbo AQUAPEX tubing.

Uponor offers ProPEX fittings made of engineered plastic (EP) or brass. Both are NSF-61 certified.

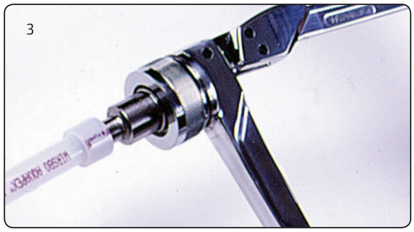
Making ProPEX Connections

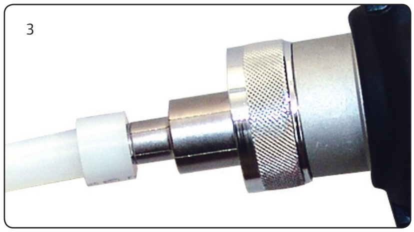
Make strong, reliable connections using one of Uponor's expander tools (battery, air or manual). The steps are virtually the same for all three tools — with a slight variation in **Step 3** on **page 24**.

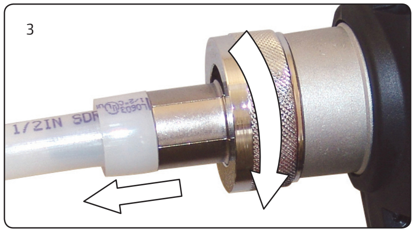
1. Square-cut the PEX tubing perpendicular to the length of the tubing. Remove all excess material or burrs that might affect the fitting connection.
2. Slide the ProPEX Ring over the end of the tubing. Make sure the end of the ring extends over the end of the tubing no more than 1⁄16 inch.



3. When using the ProPEX Manual Expander Tool, brace the free handle of the tool against your hip, or place one hand on each handle. Fully separate the handles and slide the expander head into the tubing until it stops. Full expansions are necessary to make a proper connection. Bring the handles together to expand. Separate the handles, remove the head slightly from the tubing and rotate it one-eighth turn. Slide the tool head into the tubing until it stops in the newly rotated position and expand again.

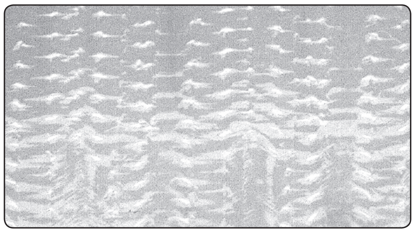


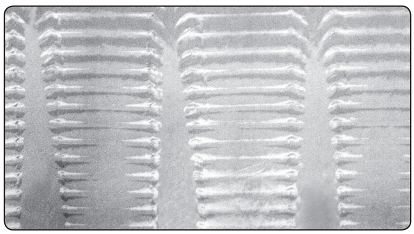




When using the ProPEX Air or Battery Expander tools, slide the expander head into the tubing until it stops. Full expansions are necessary to make a proper connection. Press the trigger to expand. Release the trigger, remove the head slightly from the tubing and rotate it one-eighth turn after each expansion. Slide the tool head into the tubing until it stops in the newly rotated position and expand again.

Important: Rotate the tool one-eighth turn in either direction after **each** expansion to provide smooth and even expansion of the tubing. If the head is not repositioned after each expansion, the segments on the tool head may cause deep grooves in the tubing. These grooves can result in potential leak paths. The photos to the right show enlarged views inside expanded tubing. Refer to **pages 26-27** for information about the ProPEX Auto Rotation Adapter, which eliminates the need to manually rotate the tubing after each expansion.


Expansion with proper rotation


Expansion without proper rotation

Note: It is not necessary to rotate the tool in only one direction. Alternating the turning direction will ease expansion in confined spaces.

4. Repeat the expansion process until the tubing and ring are snug against the shoulder on the expander head. See **Table 2-1** for the recommended number of expansions for each tubing size.

Note: The "H" in the table refers to the H-series expander heads, which are only used with the ProPEX Battery Expander Tool. Only use the two-inch H-series Expander Head on the ProPEX 200 Battery Expander Tool.

5. Immediately remove the ProPEX Expander Tool. As you slide the tubing over the fitting, you should feel some resistance. If the tubing reaches the shoulder of the fitting without any resistance, the tubing may be over-expanded and require additional time to fully shrink over the fitting. The tubing and ProPEX Ring should seat against the shoulder of the fitting for a proper connection.

Important Tips for a Proper ProPEX Connection

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

Note: Avoid over-expanding the tubing. Do not hold the tubing in the expanded position.

The number of expansions in **Table 2-1** lists 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 tubing and the shoulder of the fitting to fit snugly together.

Good connections result when the ProPEX ring rests snugly against the stop of the ProPEX fitting shoulder. If there is more than 1/16 inch between the ring and the shoulder of the fitting, square-cut the tubing two inches away from the fitting, and make another connection using a new ProPEX Ring.

Tubing Size	Ring Marking	Head Marking			Number of Expansions		
		Manual	Air Exp.	Bat. Exp.	Manual	Air Exp.	Bat. Exp.
3/8"	3/8"	3/8"	3/8"	—	4-5	4-5	6-7
1/2"	1/2"	1/2"	1/2"	1/2"	3-4	3-4	3-4
3/4"	3/4"	3/4"	3/4"	3/4"H	7-9	7-9	6-7H
1"	1"	1"	1"	1"H	12-14	12-14	6-7H
1 1/4"	1 1/4"	—	—	1 1/4"H	—	—	6-7H
1 1/2"	1 1/2"	—	—	1 1/2"H	—	—	6-7H
2"	2"	—	—	2" H	—	—	4-5H

Table 2-1: Recommended Number of Expansions

Making 3⁄8" ProPEX Connections

The 3⁄8" ProPEX Ring is smaller and thicker than the ProPEX Rings used for other tubing sizes. The 3⁄8" ProPEX Ring must be expanded once on each side to properly fit over the tubing. Expansion of the ProPEX ring is only necessary for 3⁄8" Wirsbo AQUAPEX tubing.

1. Square-cut the 3⁄8" Wirsbo AQUAPEX tubing perpendicular to the length of the tubing.
2. Expand each side of 3⁄8" ProPEX Ring with the ProPEX Expander Tool once.
3. Slide the expanded 3⁄8" ProPEX ring over the end of the tubing. Make sure the end of the ring extends over the end of the tubing no more than 1⁄16 inch. Once the 3⁄8" ProPEX ring is properly expanded and on the tubing, refer to **Steps 3-5** on **pages 26 - 27** for further instruction.

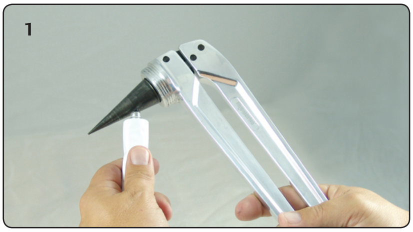
Important Tips for a Proper 3⁄8" ProPEX Connection

- When the temperature is above 40°F/4.5°C, ProPEX connections to 3⁄8" Wirsbo AQUAPEX tubing requires four to five expansions. When the temperature is below 40°F/4.5°C, only four expansions are necessary.
- The thicker ProPEX Ring used for 3⁄8" ProPEX connections shrinks over the fitting faster than other size rings.

Using the ProPEX® Auto Rotation Adapter

1. Lightly grease the cone of a standard ProPEX® Expander Tool (manual, air or battery). (Only use the Uponor-supplied graphite grease. Other types of grease may affect the tubing, fittings and connections.)
2. Thread the ProPEX Auto Rotation Adapter onto the tool. Remove excess graphite grease from adapter cone, then lightly grease cone.
3. Select a standard expander head only. (H-heads are not compatible.) See **page 27**.
4. Thread the standard expander head onto the ProPEX Auto Rotation Adapter.
5. Next, square-cut the PEX tubing perpendicular to the length of the tubing.
6. Slide the ProPEX Ring over the tubing's end. Extend the ring's end over the tubing's end no more than 1⁄16 inch.
7. Gently slide the expander head into the tubing until it stops. Do not force the expander head into the tubing.
8. Perform the expansion and repeat. (See **Step 3** on **page 27** for recommended number of expansions.) After each expansion, remove expander tool from tubing to allow rotation. Reinsert tool into tubing for the next expansion.
9. Expansion is complete when the tubing and ring are snug against the shoulder on the expander head.
10. Immediately remove the ProPEX Expander Tool, feeling resistance as the fitting is inserted.

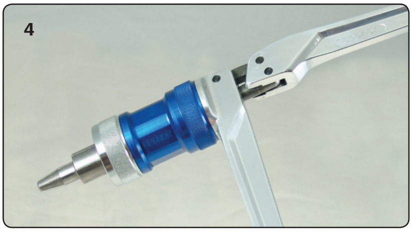
1



2

3	Tubing Size	Ring Marking	Number of Expansions		
			Manual	Air Exp	Bat Exp
	3⁄8"	3⁄8"	4-5	4-5	4-5
	1⁄2"	1⁄2"	3-4	3-4	3-4
	5⁄8"	5⁄8"	6-7	6-7	6-7
	3⁄4"	3⁄4"	7-9	7-9	7-9
	1"	1"	12-14	12-14	12-14

4



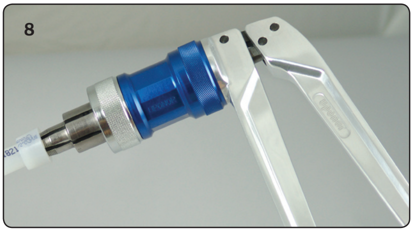
5

Note:
- Do not rotate the tubing or the expander tool.
- Expander head may not rotate after each expansion on one-inch tubing. This will not impact the quality of the connection.

6

7

8



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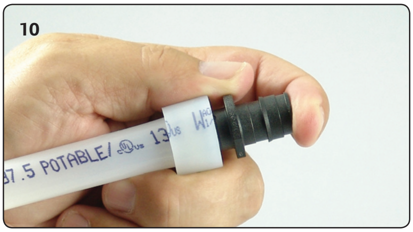


Disconnecting a ProPEX Brass Fitting

ProPEX Fittings are manufactured connections and can be concealed in walls, ceilings and floors. However, when necessary, ProPEX Fittings can be disconnected. (EP fittings cannot be reclaimed or reused.) To disconnect a ProPEX Fitting:

1. Ensure the system is not pressurized.
2. Use a heat gun to heat one side of the ProPEX Ring. When the ring is clear, use a utility knife to carefully cut through the ring. Care should be taken to cut only the ring and not the tubing. This will protect the fitting from being gouged by the knife. Remove the ProPEX Ring from the tubing with pliers or another tool to avoid touching the hot ring.

Note: Do not gouge the fitting when cutting the ProPEX Ring. Nicks and gouges in the fitting may result in leaks. If gouged, discard the fitting.

3. When the ProPEX Ring is removed, apply heat directly around the fitting and tubing connection. Gently work the tubing back and forth while pulling slightly away from the fitting until the tubing separates from the fitting.
4. When the tubing is removed from the fitting, square-cut the tubing two inches (minimum) from the end of the tubing.
5. Use a new ProPEX Ring and follow the steps to make a new ProPEX connection.

Note: Allow the fitting to cool before making another connection.

Troubleshooting ProPEX Connections

Trouble-free ProPEX installations begin with a ProPEX Expander Tool that is maintained in proper working condition. If the tool's conical or segment fingers are damaged, it is very difficult to make a proper connection. The following troubleshooting suggestions are designed to assist with problems in the field:

For Fittings That will not Seal:

- Make sure the expander head is securely screwed onto the tool (hand-tightened).
- Make sure the expander head segment fingers are not bent. If the head does not completely close when the battery tool's drive unit is fully retracted or the handles of the manual tool are open, replace the head.
- Examine the tool for excess graphite grease on the conical or expander-head segment fingers. Remove excess graphite grease prior to making ProPEX connections.
- Examine the fitting for any damage. Sharp nicks and gouges will cause the fitting to leak.

- Ensure 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. The longer the tubing and ProPEX Ring are held in the expanded position, the greater the chance for a leak, due to over-expansion.
- Rotate the tool one-eighth turn after **each** expansion.

If Expansion is Difficult:

- Ensure the internal cone is properly greased.

If the Expansion Head Slips out of the Tubing When Making Expansions:

- Ensure the tubing and ProPEX Ring are dry.
- Check to see that graphite grease is not entering the tubing.
- Examine the expander head segment fingers to make sure that none are bent.

If the ProPEX Ring Slides Down the Tubing During Expansion:

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

If More Than the Recommended Number of Expansions are Needed to Make a Connection:

- Make sure that the head is hand-tightened to the expander tool.
- Examine the expander head segment fingers to make sure that none are bent.
- Be sure to completely cycle the tool on each expansion (e.g., close the manual tool handle or release the battery expander tool trigger.)

Cold-weather Expansions

- Temperature affects the time required for the tubing and ring to shrink onto the fitting. The colder the temperature, the slower the contraction time.
- Warming ProPEX fittings and ProPEX rings reduces contraction time. Put fittings and rings in pockets prior to installation to keep them warm.
- ProPEX connections must be made at temperatures above 5°F/-15°C.
- Fewer expansions are neccessary in temperatures below 40°F/4.5°C.

Proper Expander Tool and Head Maintenance

The ProPEX expander tools are sturdy, but must be handled with care to prevent possible damage to the cone and the expander heads:

- Remove and clean the segment fingers as needed.
- Remove the segments from the attachment ring by pushing the segment finger down toward the opening in the ring. Once the first segment is removed, the rest follow easily.
- Place the segments on a flat surface with the ridges facing up. The fingers should lay flat without any curve in the middle. If the segments are bent, replace the head immediately.
- To reassemble, replace the segment fingers one at a time to the attachment ring by sliding the grooved portion of the segment fingers over the spring in the attachment ring. The narrow end of the segment fingers point away from the solid side of the attachment ring. Hold these segment fingers in place with your thumb as the remaining segment fingers are inserted.
- Once the expander head is cleaned and reassembled, use a lint-free cloth to apply a light coat of graphite grease to the cone prior to making any ProPEX connections.
- Apply the graphite grease daily if used regularly.
- Keep all other parts of the tool free of graphite grease.
- The hand expander tool handles will open and close smoothly if the tool is properly lubricated.
- Failure to properly lubricate the tool may result in improper connections.

Caution: Excessive graphite grease may result in improper connections. Only use a small amount of graphite grease to keep the tool working properly.

- Once a month, soak the heads in degreasing agent to remove any graphite grease between the segments. Clean the cone using a clean, dry cloth.
- Store the tool and expander heads in the case. Store the tool with an expansion head in place to protect the cone.
- Store the tool in a dry location to prevent rust.

Handling Guidelines for EP Fittings

Although not comprehensive, the following highlights the most common handling guidelines for EP fittings:

- Do not solder within 18 inches of any EP fitting in the same water line.
- Do not subject EP fittings to impact.
- Do not use adhesives or adhesive tape with EP fittings.[1]
- Do not expose EP fittings to open flame.
- Do not allow solder, flux, pipe dope, solvents or to come into contact with EP fittings as immediate damage may result.
- Never pull or drag tubing by the installed EP fittings.
- Do not expose EP fittings to excessive bending loads (greater than 100 lbs.).
- Do not use EP fittings where temperatures and pressures exceed ratings.
- Do not spray on or allow organic chemicals, strong acids or strong bases to contact EP fittings.
- Do not use petroleum- or solvent-based paints, greases or sealants on EP fittings.
- Do not allow rodents, insects or other pests to contact EP fittings.

[1] You may temporarily affix adhesive tape to EP fittings during installation. However, to protect the integrity of the system, the tape should not be permanent. Remove the tape and residual adhesive after completing the installation.

Section 3 —

U.S. Construction Codes

International Building Code (IBC)

603.1 (10)

Combustible piping and tubing may be installed in Type I and Type II buildings required to be of noncombustible construction, provided the tubing is installed in a wall or concrete floor slab or the tube has a flamespread index (FS) rating of not more than 25 and a smoke developed index (SD) rating of not more than 50 when tested in accordance with ASTM E84.

602.3

Combustible tubing and tubing may be installed in interior walls of Type III construction.

602.5

Combustible tubing and tubing may be installed throughout Type V construction.

310.3

Required dwelling unit and guestroom separations. Walls and floors separating dwelling units in Group R-1 occupancies shall have fire partitions or horizontal assemblies as required by Sections 708 and 710.

703.2

The fire-resistant rating of building elements shall be determined in accordance to ASTM E119.

708.2

Partition walls shall be constructed of materials permitted by the type of construction.

708.3

The fire-resistant rating of a partition wall shall be one hour.

710.3

The fire-resistant rating of a floor assembly shall not be less than required by the type of building construction. Floor assemblies separating dwelling units or guestroom shall not be less than one hour.

711.3.1.2

Through-penetrations shall be protected by an approved firestop system as tested in accordance with ASTM E814. The firestop rating shall have an F rating not less than the fire-resistant rating of the assembly.

Firestop systems should be evaluated by Uponor for chemical compatibility with Wirsbo AQUAPEX tubing.

UL and Warnock Hersey provide listings for installations in a one-hour wood-floor assembly; two-hour poured-in-place concrete-floor assembly; one-hour load-bearing wood wall; and a one-hour non-load-bearing metal-stud wall.

International Mechanical Code (IMC)

602.2.1

Materials exposed in plenums shall have a FS of 25 or less and a SD of 50 or less when tested in accordance with ASTM E84.

Uniform Mechanical Code (UMC)

602.2

Materials exposed in plenums shall have a FS of 25 or less and a SD of 50 or less when tested in accordance with ASTM E84.

A fire-resistant wrap such as fiberglass insulation will achieve 25 FS/50 SD classifications for large-diameter Wirsbo AQUAPEX tubing, thus permitting installations in plenums, ceiling spaces and exposed locations.

International Plumbing Code (IPC)

308

Horizontal spacing of PEX tubing requires supports every 32 inches. Vertical supports are required at the base of each floor with a mid-story guide.

Table 605.3 — Water-service pipe

- PEX tubing approved for water-service applications

Table 605.4 — Water-distribution pipe

- PEX tubing approved for water-distribution applications

Table 605.5 — Pipe fittings

- ProPEX F1960 fittings approved for use with PEX tubing

Uniform Plumbing Code (UPC)

314.0

Horizontal spacing of PEX tubing requires supports every 32 inches. Vertical supports are required at the base and each floor with a mid-story guide.

604.0

- 604.1 — PEX approved for hot- and cold-water-distribution applications and water-service applications.
- 604.11 — PEX tubing to be marked with the fitting standards for which the tubing is approved.
- 604.11.1 — ProPEX F1960 fittings are approved in the UPC.
- 604.11.2 — PEX tubing cannot be installed in the first 18 inches of tubing connected to a water heater.

Section 4 —

Canadian Construction Codes

National Building Code of Canada (NBC)

3.1.5.16.
Combustible piping and tubing may be installed in a building required to be of noncombustible construction, provided the tubing is installed in a wall or concrete floor slab, or the tube has a flamespread (FS) rating of not more than 25.

Note: Some building officials are interpreting the code because of the exclusion of ceilings, in such a way as to require a FS Rating of 25 for all combustible tubing in any ceiling space.

In addition a smoke developed (SD) classification of not more than 50 (not required if in walls or concrete floors) is required for the following buildings when more than 118 feet in height:

- Theatres and auditoriums
- Office buildings
- Retail stores
- Industrial buildings

The above-mentioned buildings, when 59 feet high, are required to have combustible piping with a SD classification of 50 or less when they have an excessive occupant load.

Hospitals and prisons, when more than 59 feet high, require the tubing to have a SD classification of 50 or less and a FS rating of 25 or less.

Condominium or apartment buildings that are more than 59 feet in height require a 25 FS or less and a SD classification of 50 or less.

3.1.9.1.
Requires that pipes penetrating a fire-resistant assembly be firestopped in accordance with standard ULC S115, "Standard Method of Fire Tests of Firestop Systems."

3.1.9.2.
Requires when plastic pipe is installed in walls or floors requiring a fire-resistant rating that the assembly must be tested in accordance with standard ULC S101, "Standard Methods of Fire-endurance Tests of Building Construction and Materials."

3.1.12.1.(2)
Requires that the FS rating and SD classification of a material shall be conducted in conformance with standard ULC S102.2, "Standard Method of Test for Surface-burning Characteristics of Flooring, Floor Covering and Miscellaneous Materials and Assemblies."

3.6.4.3.
Contains requirements for plenums. All materials within the plenum shall have a FS rating of not more than 25 and a SD classification of not more than 50.

Building Code and Fire-resistant Construction

Building-code requirements limit the use of Wirsbo AQUAPEX tubing for some types of building construction and some applications within buildings.

A fire-resistant wrap such as fiberglass insulation will achieve 25 FS/50 SD classifications for large-dimension Wirsbo AQUAPEX tubing, thus permitting installations in plenums, ceiling spaces and exposed locations.

UL and Warnock Hersey provide listings for installations in a one-hour wood-floor assembly; two-hour poured-in-place concrete-floor assembly; one-hour load-bearing wood wall; and a one-hour non-load-bearing metal stud wall.

National Plumbing Code of Canada (NPC)

2.3.4.5.(2)

Stipulates a maximum horizontal spacing of supports for PEX of 31.5 inches.

2.3.4.4.

Defines support for vertical piping as follows: vertical piping shall be supported at its base and at the floor level of alternate stories by rests, each that can bear the weight of pipe that is between it and the rest above it. The maximum spacing of supports shall be 24.6 inches.

Section 5 —

Fire-resistant Construction

Fire-resistant Standards

National building codes, such as the IBC, require that products used in construction meet specific standards. Uponor PEX has achieved the following fire-resistant construction ratings when tested in accordance with the applicable standards:

- **ASTM E119 (ANSI/UL 263)**

Uponor has the following assemblies listed through UL:

- UL Design No. L557 rating applies to ½" to 2" Wirsbo AQUAPEX tubing, fittings and manifolds installed in one-hour wood-frame floor/ ceiling assemblies. See **pages 41-43**.
- UL Design No. K913 rating applies to ½" to 2" Wirsbo AQUAPEX tubing, fittings and manifolds installed in one- and two-hour concrete floor/ ceiling unrestrained (and restrained) assemblies. See **pages 38-40**.
- UL Design No. U372 rating applies to ½" to 2" Wirsbo AQUAPEX tubing, fittings and manifolds installed in one-hour wood-stud/gypsum wallboard wall assemblies. See **pages 41-43**.
- UL Design No. V444 rating applies to ½" to 2" Wirsbo AQUAPEX tubing, fittings and manifolds installed in one-hour steel-stud/gypsum wallboard wall assemblies. See **pages 38-40**.

- **CAN/ULC S101**

- ITS Design No. UW/FCA 60-01 rating applies to ½" to 2" Wirsbo AQUAPEX tubing, fittings and manifolds installed in one-hour wood-frame floor/ceiling assemblies. See **pages 47-50**.
- ITS Design Nos. UW/FCA 120-01 and UW/FCA 120-02 ratings apply to ½" to 2" Wirsbo AQUAPEX tubing, fittings and manifolds installed in one- and two-hour concrete floor/ ceiling unrestrained (and restrained) assemblies. See **pages 44-46**.
- ITS Design No. UW/FCA 60-02 rating applies to ½" to 2" Wirsbo AQUAPEX tubing, fittings and manifolds installed in one-hour wood-stud/gypsum wallboard assemblies. See **pages 47-50**.
- ITS UW/FCA 60-01 rating applies to ½" to 2" Wirsbo AQUAPEX tubing, fittings and manifolds installed in one-hour steel-stud/gypsum wallboard wall assemblies. See **pages 44-46**.

- **ASTM E814 or CAN/ULC S115**

Numerous firestop manufacturers have tested their products with PEX tubing. These tests establish the installation procedures for installing the firestop around the PEX tubing at the penetration. These test assemblies are divided into sections based on the type of penetration (e.g., wall, floor and ceiling, etc.).

Not all caulks are approved for all penetrations. Ensure the penetration is sealed in accordance with the appropriate test assembly using that manufacturer's recommended type of firestop material. Larger penetrations may not use a caulk type of firestop, but rather a wrap or collar assembly may be required.

Refer to the respective firestop manufacturer for more information pertaining to the appropriate application of their products.

An example of each UL assembly is shown on the following pages. Be mindful of information stated in the published listings to ensure compliance during installation.

Concrete Assemblies — Fire-resistant Construction — United States

1. Wirsbo AQUAPEX Tubing - FS/SD ratings in accordance with ASTM E84
   - FS 25/SD 50 rating. Refer to **pages 15-16** for details.

2. Firestop must be listed to ASTM E814 requirements.
   - Firestopping to be compatible with Wirsbo AQUAPEX tubing.

3. Uponor installed in ASTM E119 (ANSI/UL 263) rated floor/ceiling concrete assemblies.
   - Uponor Design No. K913 (See **Table 5-1**.)

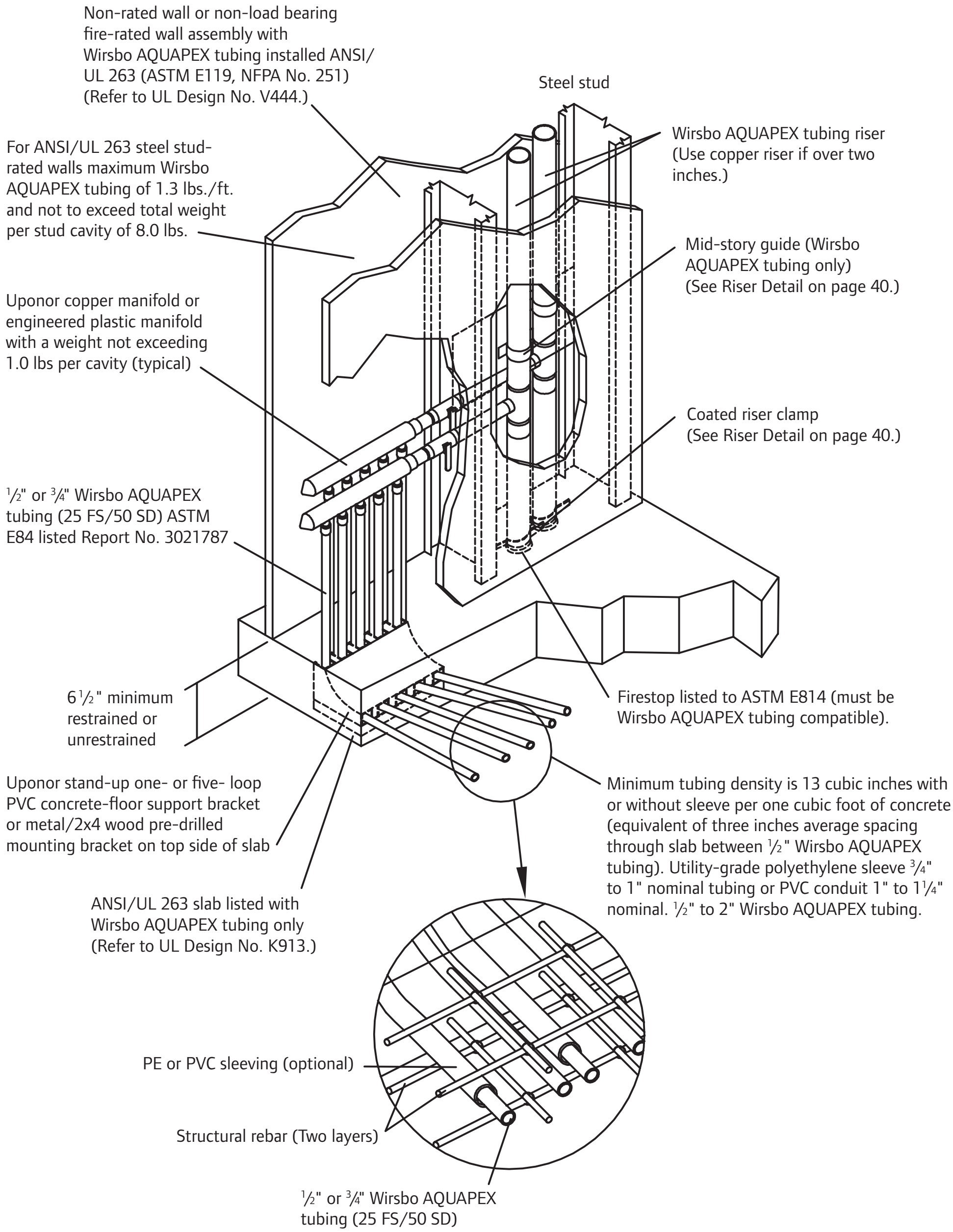
Additional Notes:
- Maximum 13 cubic inches tube density with or without sleeve, per one cubic foot of concrete.
- Number of support brackets is unlimited.
- Utility-grade polyethylene sleeve, 3/4"- to one-inch nominal tubing or PVC conduit one- to 1 1/4-inch nominal.
- Maximum 2" Wirsbo AQUAPEX tubing in ASTM E119 (ANSI/UL 263) slab.

4. Uponor installed in ASTM E119 (ANSI/UL 263) rated non-load bearing steel-stud wall assemblies Underwriters Laboratories - Uponor Design No. V444.
   - Maximum amount of Wirsbo AQUAPEX tubing per stud cavity is 1.3 lbs./ft. and shall not exceed a total weight per stud cavity of 8.0 lbs.
   - Steel and plastic bend supports, fittings and brass and copper manifolds may be used as required.
   - 2" Wirsbo AQUAPEX tubing risers supported on steel or wood bracing on each floor with mid-story guide.

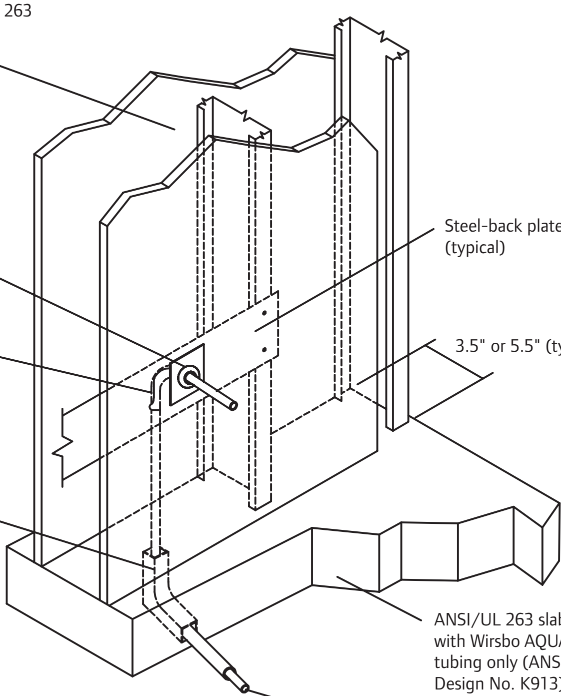
Wirsbo AQUAPEX tubing is UL-classified for non-metallic, plumbing-system components, fire-resistant classification Design Nos. K913 and V444. See UL Fire-resistant Directory.

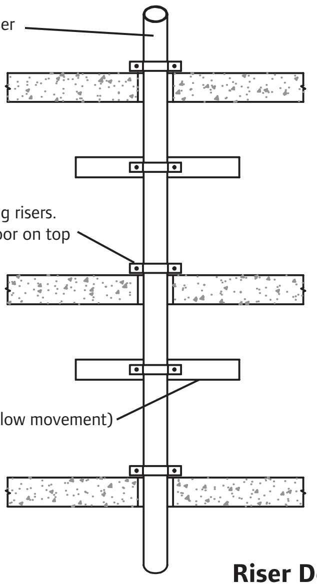
Restrained Assembly Rating (hour)	Unrestrained Assembly Rating (hour)	Minimum Total Slab Thickness (inch)	Minimum Concrete Cover Over Positive Reinforcement (inch)
2	1 1/2	6 1/2	1
2	2	6 1/2	1 1/2

Table 5-1: Concrete Floor/Ceiling Assembly Ratings



Manifold Detail:
Concrete Floor/Ceiling Assembly (UL Design No. K913)
Steel-stud Wall Assembly (UL Design No. V444)



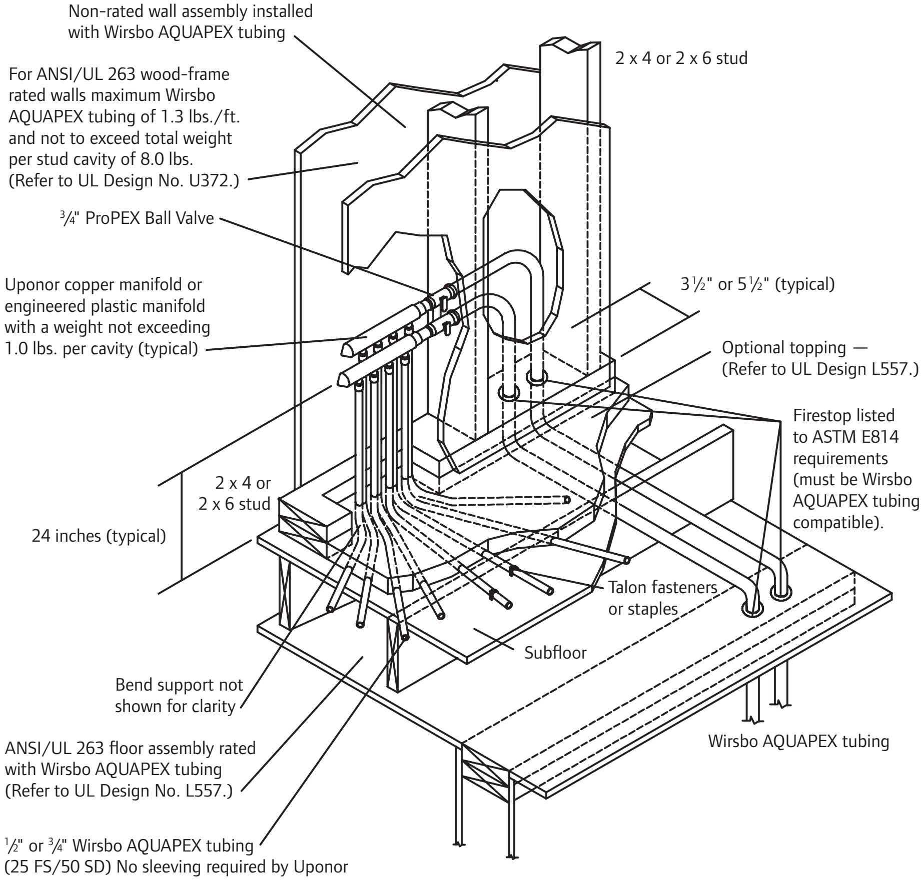


Fixture Detail:
Concrete Floor/Ceiling Assembly
(UL Design No. K913)
Steel-stud Wall Assembly
(UL Design No. V444)

Riser Detail

Wood-frame Assemblies — Fire-resistant Construction — United States

1. Wirsbo AQUAPEX Tubing - FS/SD ratings in accordance with ASTM E84
   - 25 FS/50 SD Rating. Refer to **pages 15-16** for details.
2. Firestop must be listed to ASTM E814 requirements.
   - Firestopping to be compatible with Wirsbo AQUAPEX tubing.
3. Uponor installed in ASTM E119 (ANSI/UL 263) rated wood frame assemblies
   - Uponor Design Nos. L557 and U372
   - Combustible pipe: One or more Wirsbo AQUAPEX tubing runs, sized from 1/2 to two inch, such that the weight of PEX tubing per joist

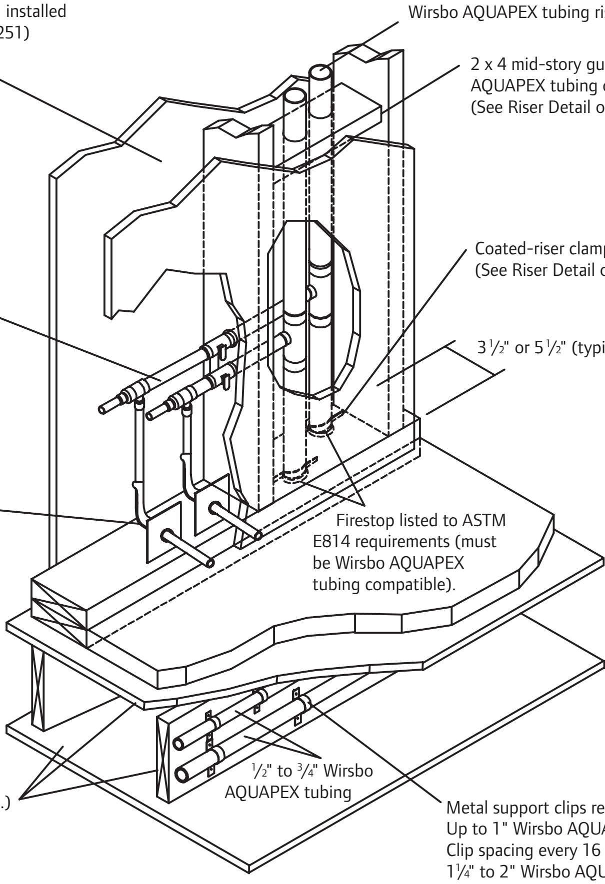


Manifold Detail:
Wood-frame Floor/Ceiling Assembly (UL Design No. L557)
Wood-frame Wall Assembly (UL Design No. U372)

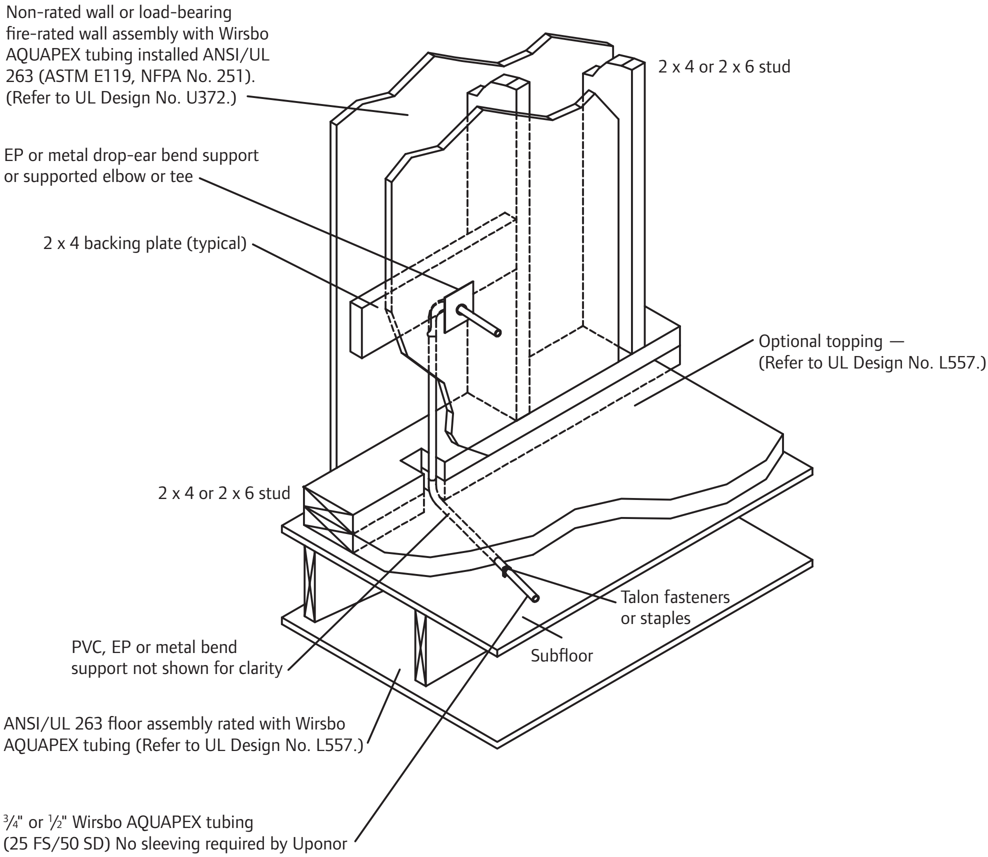
cavity does not exceed 0.95 lbs./ft. (equivalent to two of 2" or 16 ½" Wirsbo AQUAPEX tubes per foot of joist cavity.)

- Support pipes with metal clips 16 inches on center for pipes up to one-inch diameter, and metal clips 24 inches on center for pipes over one-inch diameter.

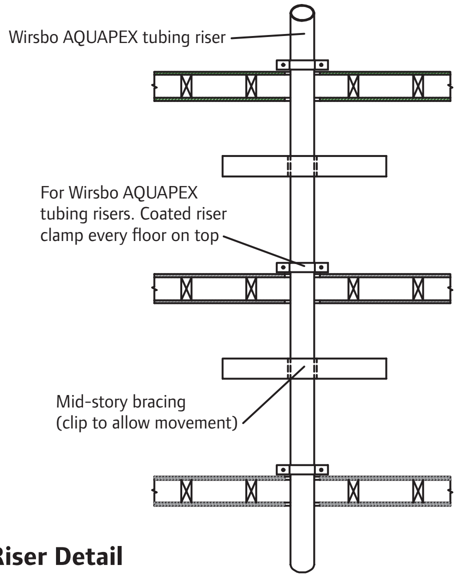
Wirsbo AQUAPEX tubing is UL-classified for non-metallic, plumbing-system components, fire-resistant classification Design Nos. L557 and U372. See UL Fire-resistant Directory.



Fixture Detail 1:
Wood-frame Floor/Ceiling Assembly (UL Design No. L557)
Wood-frame Wall Assembly (UL Design No. U372)



Fixture Detail 2:
Wood-frame Floor/Ceiling Assembly
(UL Design No. L557)
Wood-frame Wall Assembly
(UL Design No. U372)



Riser Detail

Section 5 — Fire-resistant Construction

Concrete Assemblies — Fire-resistant Construction — Canada

1. Wirsbo AQUAPEX Tubing - FS/SD ratings in accordance with CAN/ULC S102.2 Standard
   - FS 25/SD 50 Rating. Refer to **pages 15-16** for details.
2. Firestop must be listed to CAN/ULC S102.2 requirements.
   - Firestopping to be compatible with Wirsbo AQUAPEX tubing.

Uponor Installed in CAN/ULC S101-rated Floor/Ceiling Concrete Assemblies

Intertek Testing Services (ITS) - Uponor Design Numbers:

1. UW/FCA 120-01
   - Two-hour restrained assembly rating
   - Two-hour unrestrained assembly rating
   - Minimum 6½-inches concrete thickness
   - Minimum one-inch concrete cover under steel reinforcement
2. UW/FCA 120-02
   - Two-hour restrained assembly rating
   - One- and-one-half hours unrestrained assembly rating
   - Minimum 6½-inch concrete thickness
   - Minimum one-inch concrete cover under steel reinforcement

Both designs with:

- Maximum 14 cubic inches of tube density with or without sleeve per one cubic foot of concrete
- Number of support brackets is unlimited
- Polyethylene sleeve ¾"- to one-inch nominal tubing or PVC sleeve — one- to 1¼-inch nominal tubing
- ½" to 2" Wirsbo AQUAPEX tubing

Uponor Installed in CAN/ULC S101-rated Steel-stud Wall Assemblies

ITS Design No. UW/WA 60-01

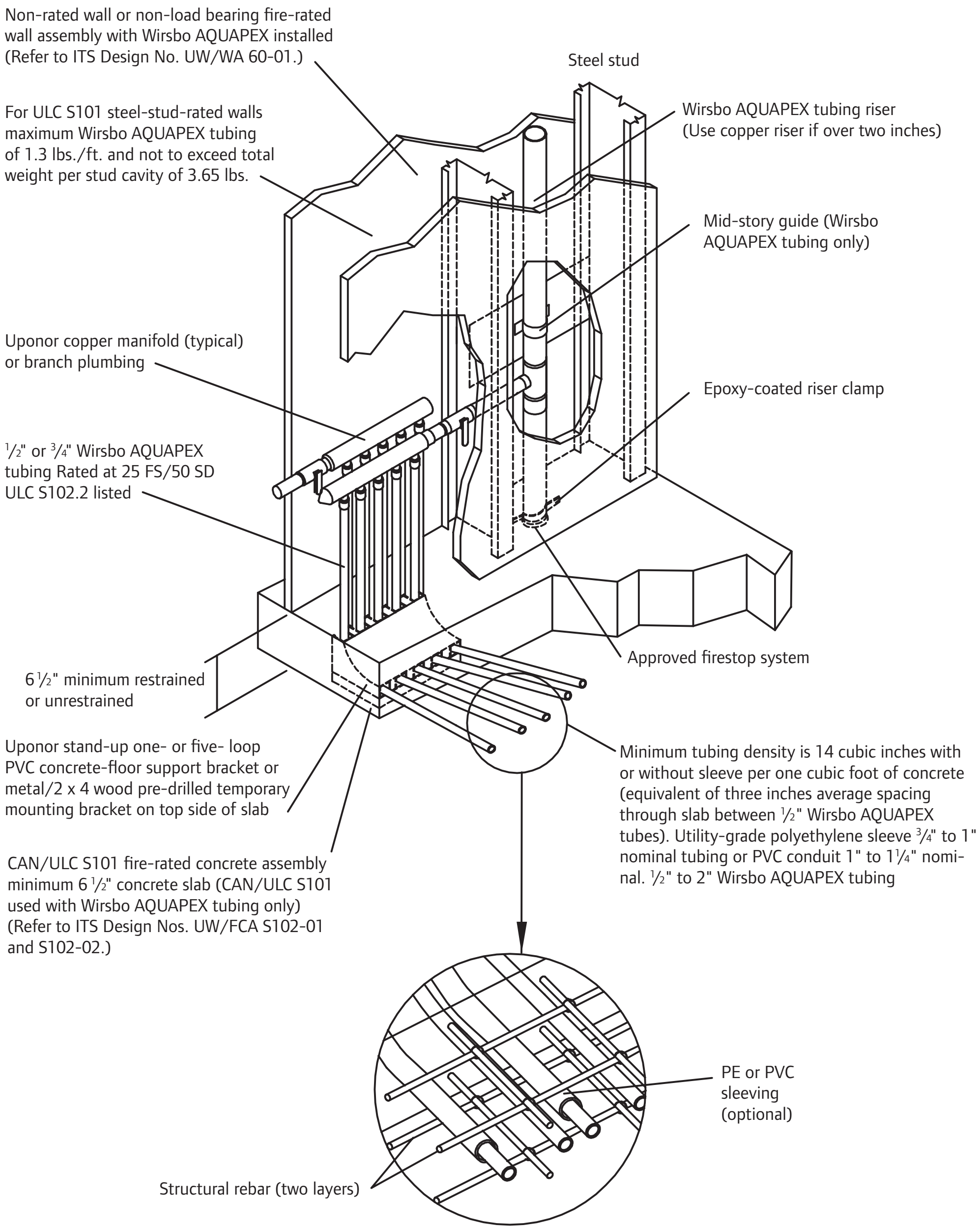
- Maximum amount of Wirsbo AQUAPEX tubing per stud cavity is 1.3 lbs./ft. and shall not exceed a total weight per stud cavity of 3.65 lbs.
- Steel and plastic bend supports, fittings and brass and copper manifolds may be used as required.
- 2" Wirsbo AQUAPEX tubing risers supported on steel or wood bracing located on 26 inches on center maximum

Firestopping

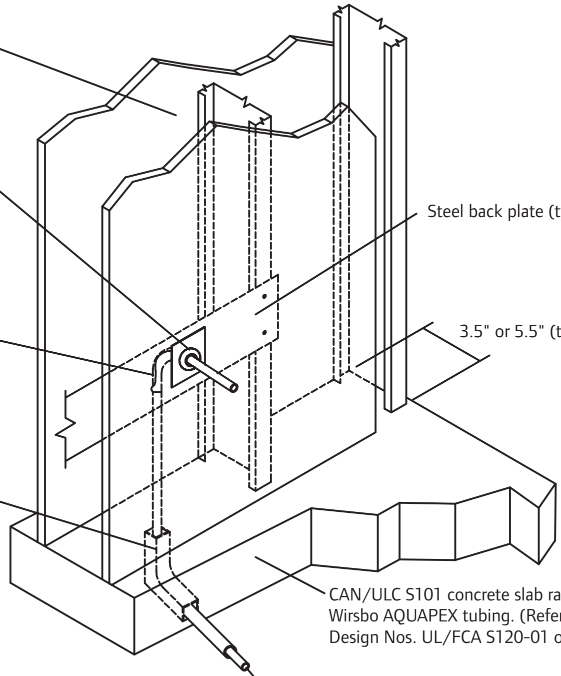
Use approved firestop system.

Note: Firestopping must be chemically compatible with Wirsbo AQUAPEX tubing. Contact Uponor Ltd. for more information.

Note: Ontario, Canada, only: In non-sprinkler buildings, firestop must be tested with 50 pascal pressure differential.



Manifold Detail:
Concrete Floor/Ceiling Assembly (ITS Design Nos. UW/FCA S120-01 or S120-02)
Steel-stud Wall Assembly (ITS Design No. UW/WA 60-01)



Manifold Detail:
Concrete Floor/Ceiling Assembly (ITS Design Nos. UW/FCA S120-01 or S120-02)
Steel-stud Wall Assembly (ITS Design No. UW/WA 60-01)

Wood-frame Assemblies — Fire-resistant Construction — Canada

1. Wirsbo AQUAPEX Tubing - FS/SD ratings in accordance with CAN/ULC S102.2 Standard
   - FS 25/SD 50 Rating. Refer to **pages 15-16** for details.
2. Firestop must be listed to CAN/ULC S102.2 requirements.
   - Firestopping to be compatible with Wirsbo AQUAPEX tubing.

Uponor Installed in CAN/ULC S101-rated Wood-frame Floor/ Ceiling Assemblies

ITS Design Number UW/FCA 60-01

1. Topping optional
2. Subflooring — minimum ⁵⁄₈-inch plywood. If topping is used, sub-floor may be ⁵⁄₈-inch oriented strand board (OSB)
3. Structural members — nominal 2" x 10" solid sawn wood, open web wood or wood I-joists (10 inches to 24 inches depth) installed at 24 inches on center maximum
4. Resilient channels (optional) — minimum 24-gauge steel installed at 16 inches on center maximum
5. Gypsum board — minimum one layer of ⁵⁄₈-inch Type X gypsum wallboard when solid sawn wood joists are used
   - Two layers of ¹⁄₂-inch Type X or ⁵⁄₈-inch Type X gypsum wallboard when wood I-joists (10 inches to 24 inches depth) are used
6. Combustible tubing — one or more Wirsbo AQUAPEX tubing runs, sized from ¹⁄₂-inch to two inches, such that the weight of PEX tubing per joist cavity does not exceed 0.95 lbs./ ft. (equivalent to two 2" or 16 ¹⁄₂" Wirsbo AQUAPEX tubes per foot of joist cavity)

- Support pipes with metal clips 16 inches on center for pipes up to one-inch diameter, metal clips 24 inches on center for pipes over one-inch diameter

Uponor Installed in CAN/ULC S101-rated Wood-stud Wall Assemblies

ITS Design Number UW/WA 60-02

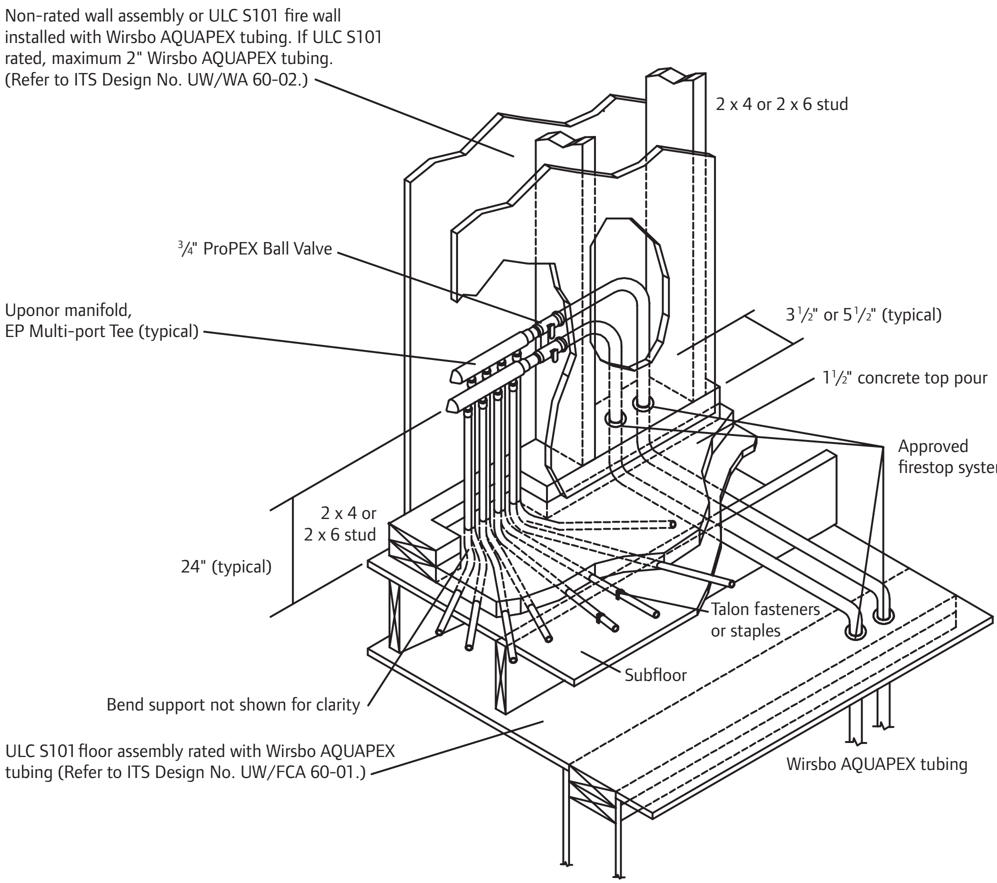
- Maximum amount of Wirsbo AQUAPEX tubing per stud cavity is 1.3 lbs./ft. and shall not exceed a total weight per stud cavity of 8.0 lbs.
- Steel and plastic bend supports, fittings and brass and copper manifolds may be used as required.
- 2" Wirsbo AQUAPEX tubing risers supported on steel or wood bracing located on 26 inches on center maximum

Firestopping

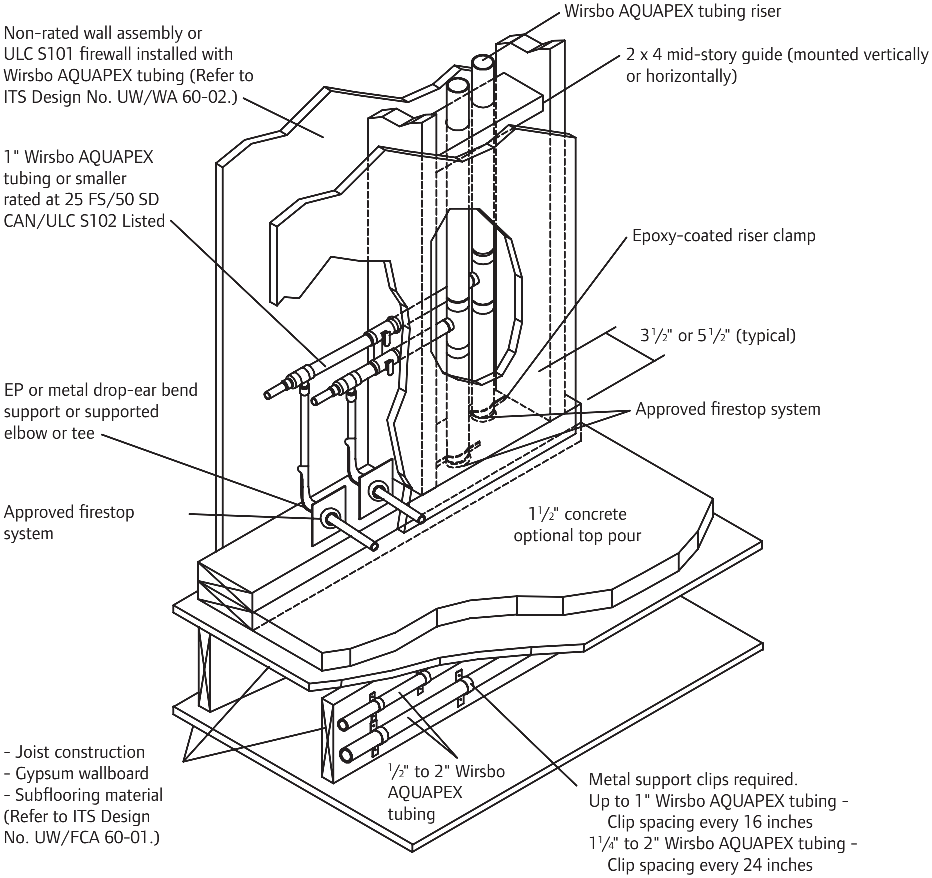
Use approved firestop system.

Note: Firestopping must be chemically compatible with Wirsbo AQUAPEX tubing. Contact Uponor Ltd. for more information.

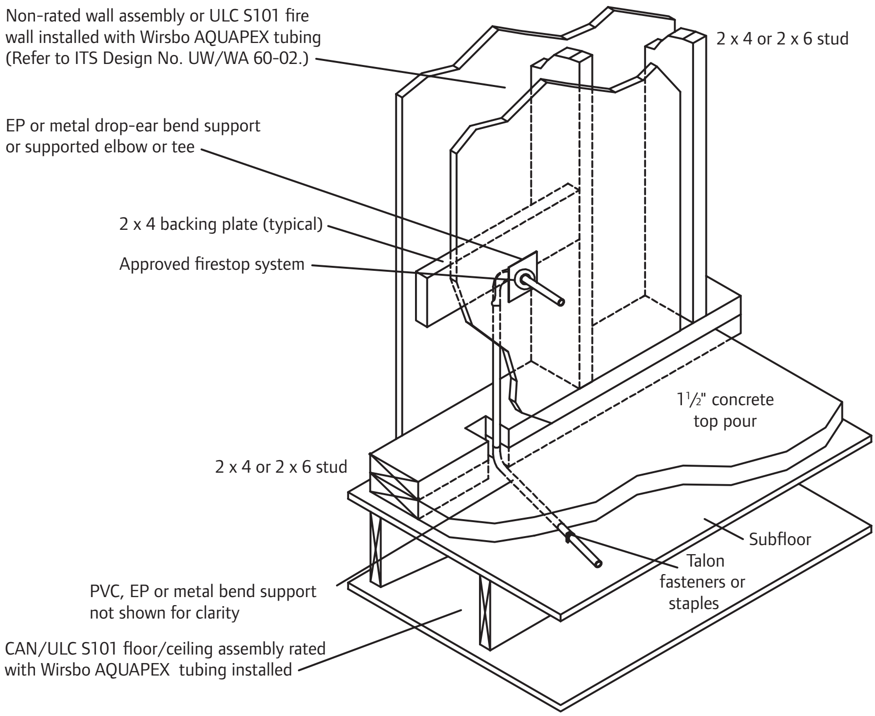
Note: Ontario, Canada, only: In non-sprinkler buildings, firestop must be tested with 50 pascal pressure differential.



Manifold Detail:
Wood-frame Floor/Ceiling Assembly (ITS Design No. UW/FCA 60-01)
Wood-frame Wall Assembly (ITS Design No. UW/WA 60-02)



Fixture Detail 1:
Wood-frame Floor/Ceiling Assembly (ITS Design No. UW/FCA 60-01)
Wood-frame Wall Assembly (ITS Design No. UW/WA 60-02)



Fixture Detail 2:
Wood-frame Floor/Ceiling Assembly (ITS Design No. UW/FCA 60-01)
Wood-frame Wall Assembly (ITS Design No. UW/WA 60-02)

Section 6 — Temperature/ Pressure Ratings

Hydrostatic Temperature and Pressure Ratings

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 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 is the policies and procedures for developing HDB ratings for thermoplastic piping materials or pipe.

Uponor maintains standard-grade ratings for Wirsbo AQUAPEX tubing as tested in accordance with TR-3. Uponor PEX products have the following pressure and temperature ratings:

- 200ºF/93ºC at 80 psi
- 180ºF/82ºC at 100 psi
- 73.4ºF/23ºC at 160 psi

These listings are published in PPI TR-4, a culmination report of the listings that are maintained with the Plastic Pipe Institute.

Interpolation Method

Determine pressure ratings at different temperatures by using a linear relationship between the standard-grade ratings. See **Table 6-1** for temperature and pressure ratings.

Temperature and Pressure Ratings ºF/ºC	psi
200.0/93.3	**80**
190.0/87.8	90
180.0/82.2	**100**
170.0/76.7	106
160.0/71.1	111
150.0/65.6	117
140.0/60.0	123
130.0/54.4	128
120.0/48.9	134
110.0/43.3	139
100.0/37.8	145
90.0/32.2	151
80.0/26.7	156
73.4/23.0	**160**
60.0/15.6	168
50.0/10.0	173
40.0/4.4	179

Table 6-1: Temperature and Pressure Ratings

Surge-pressure Calculations

The following calculations represent the amount of surge pressure generated in a plumbing distribution system due to sudden changes in flow. This change in flow is often a result of quick-acting valves such as washing machine valves.

Table 6-2 shows the results of the pressures generated for different tubing systems. These do not negate any local code requirements for water hammer arresters.

Use the following formulas to calculate surge pressure in a system:

Ps = (aV)/(A2)

a = (A1)/[1+((K(DR-2))/E)]^½

where:

Ps = Surge pressure (psi)

a = Wave velocity (fps)

V = Velocity change (fps)

A1 = 4,675 (constant)

A2 = 2.31*g (constant)

g = Gravitational acceleration (32.2 ft/s^2)

K = Bulk modulus of water (294,000 lbs./in^2)

DR = Dimension ratio of the tubing

E = Modulus of elasticity of the tubing (psi)

Velocity (feet per second)	Inlet Pressure (psi)	PEX Calculated Surge + Inlet Pressure (psi)	CPVC Calculated Surge + Inlet Pressure (psi)	Copper Type L Calculated Surge + Inlet Pressure (psi)
8	45	167	199	482
12	45	228	277	701
8	60	182	214	497
12	60	243	292	716

Table 6-2: Calculated Surge Pressure

Section 7 —
Pipe Sizing by Fixture Units

Flow Rates and Fixture Units

Each fixture has a weighted value. **Table 7-1** is a conversion between flow rate in gallons per minute (gpm) and water-supply fixture units. This table can be used to determine the load for sizing the water-distribution system. The tables on **pages 55-57** can assist the designer to stay within the acceptable range of fixture units for a given tubing arrangement. The fixture unit tables reflect the amount of fixture unit values usable for the given service tube size, building tube size and the length of tubing used to supply the fixtures.

GPM	F.U.	GPM	F.U.	GPM	F.U.	GPM	F.U.
1	0	21	32	41	90	62	185
2	1	22	34	42	95	64	195
3	3	23	36	43	99	66	205
4	4	24	39	44	103	68	215
5	6	25	42	45	107	70	225
6	7	26	44	46	111	72	236
7	8	27	46	47	115	74	245
8	10	28	49	48	119	76	254
9	12	29	51	49	123	78	264
10	13	30	54	50	127	80	275
11	15	31	56	51	130	82	284
12	16	32	58	52	135	84	294
13	18	33	60	53	141	86	305
14	20	34	63	54	146	88	315
15	21	35	66	55	151	90	326
16	23	36	69	56	155	92	337
17	24	37	74	57	160	94	348
18	26	38	78	58	165	96	359
19	28	39	83	59	170	98	370
20	30	40	86	60	175	100	380

Table 7-1: Conversion Between Flow Rate and Fixture Units (F.U.)

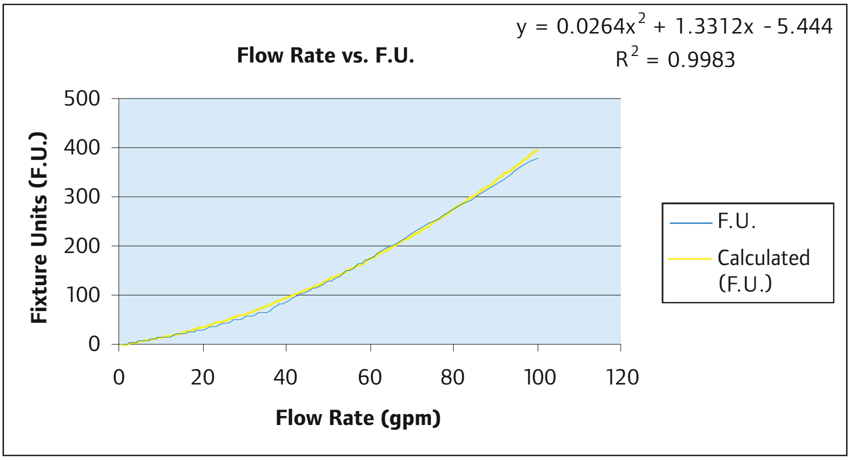


Figure 7-1: Mathematical Representation of Conversion Between Flow Rate and Fixture Units (F.U.)

Figure 7-1 is a mathematic representation of the conversion between flow rate and fixture units. The equation can be used to determine the fixture unit load (y) based on a given flow rate demand (x).

Caution: Tables 7-2, **7-3** and **7-4** on the following pages are for discussion purposes only. These excerpts from the Uniform Plumbing Code (UPC) cannot be used for design purposes. When removed from the code the excerpts are no longer applicable to subsequent changes, thus unusable for design. Refer to the applicable local code when designing a system.

An example of the table usage is shown below:

Given:

Service pipe size of one inch.
Building supply pipe size of one inch.
Length of branch is 100 feet.

Result:

Total value of fixture units should not exceed 25.

Refer to the applicable local code to determine individual fixture weight.

Pressure Range 30 to 45 psi

Inch	mm
1/2	15
3/4	20
1	25
1 1/4	32
1 1/2	40
2	50
2 1/2	65

Meter and Street Service (inches)	Building Supply and Branches (inches)	Maximum Allowable Length of Feet (meters) 40 (12)	60 (18)	80 (24)	100 (30)	150 (46)	200 (61)	250 (79)	300 (91)	400 (122)	500 (152)	600 (183)	700 (213)	800 (244)	900 (274)	1,000 (305)
3/4	1/2*	6	5	4	3	2	1	1	1	0	0	0	0	0	0	0
3/4	3/4	16	16	14	12	9	6	5	5	4	4	3	2	2	2	1
3/4	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
3/4	1 1/4	36	33	331	28	24	23	21	19	17	16	13	12	12	11	11
1	1 1/4	54	47	42	38	32	28	25	23	19	17	14	12	12	11	11
1 1/2	1 1/4	78	68	57	48	38	32	28	25	21	18	15	12	12	11	11
1	1 1/2	85	84	79	65	56	48	43	38	32	28	26	22	21	20	20
1 1/2	1 1/2	150	124	105	91	70	57	49	45	36	31	26	23	21	20	20
2	1 1/2	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
1 1/2	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	2 1/2	445	418	390	370	330	300	280	265	240	220	198	175	158	143	133

*Building supply, 3/4-inch (20mm) nominal size minimum.

Table 7-2: Fixture-unit Table for Determining Water Tubing and Meter Sizes

Pressure Range 46 to 60 psi*

Inch	mm
1/2	15
3/4	20
1	25
1 1/4	32
1 1/2	40
2	50
2 1/2	65

Meter and Street Service (inches)	Building Supply and Branches (inches)	Maximum Allowable Length of Feet (meters)														
		40 (12)	60 (18)	80 (24)	100 (30)	150 (46)	200 (61)	250 (79)	300 (91)	400 (122)	500 (152)	600 (183)	700 (213)	800 (244)	900 (274)	1,000 (305)
3/4	3/4	20	20	19	17	14	11	9	8	6	5	4	4	3	3	3
3/4	1	39	39	36	33	28	23	21	19	17	14	12	10	9	8	8
1	1	39	39	39	36	30	25	233	20	18	15	12	10	9	8	8
3/4	1 1/4	39	39	39	39	39	39	34	32	27	25	22	19	19	17	16
1	1 1/4	78	78	76	67	52	44	39	36	30	27	24	20	19	17	16
1 1/2	1 1/4	78	78	78	78	66	52	44	39	33	29	24	20	19	17	16
1	1 1/2	85	85	85	85	85	85	80	67	55	49	41	37	34	32	30
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
1	2	85	85	85	85	85	85	85	85	85	85	85	85	85	83	80
1 1/2	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	2 1/2	654	640	610	580	535	500	470	440	400	365	335	315	285	267	250

*Available static pressure after head loss.

Table 7-3: Fixture-unit Table for Determining Water Tubing and Meter Sizes

Pressure Range Over 60 psi*

Inch	mm
1/2	15
3/4	20
1	25
1 1/4	32
1 1/2	40
2	50
2 1/2	65

Meter and Street Service (inches)	Building Supply and Branches (inches)	Maximum Allowable Length of Feet (meters)														
		40 (12)	60 (18)	80 (24)	100 (30)	150 (46)	200 (61)	250 (79)	300 (91)	400 (122)	500 (152)	600 (183)	700 (213)	800 (244)	900 (274)	1,000 (305)
3/4	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
3/4	1 1/4	39	39	39	39	39	39	39	39	34	28	26	25	23	22	21
1	1 1/4	78	78	78	78	74	62	53	47	39	31	26	25	23	22	21
1 1/2	1 1/4	78	78	78	78	78	74	65	54	43	34	26	25	23	22	21
1	1 1/2	85	85	85	85	85	85	85	85	81	64	51	48	46	43	40
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
1	2	85	85	85	85	85	85	85	85	85	85	85	85	85	85	85
1 1/2	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	2 1/2	654	654	654	654	654	650	610	570	510	460	430	404	380	356	329

*Available static pressure after head loss.

Table 7-4: Fixture-unit Table for Determining Water Tubing and Meter Sizes

Section 7 — Pipe Sizing by Fixture Units

Section 8 —
Pressure Loss and Velocity

Pressure Loss and Velocity

Use **Table 8-1** (**page 60**) and **Table 8-2** (**page 61**) as quick references for designing a system. The tables show water temperatures at 60ºF/15.6ºC and 120ºF/48.9ºC. They provide flow rates, pressure loss per 100 feet of tubing and velocity for each size of Wirsbo AQUAPEX tubing.

Table Use

1. Select the required flow rate.
2. Follow the flow-rate line to the desired velocity.
3. Determine the appropriate tubing size.
4. Determine the pressure loss per 100 feet of tubing.

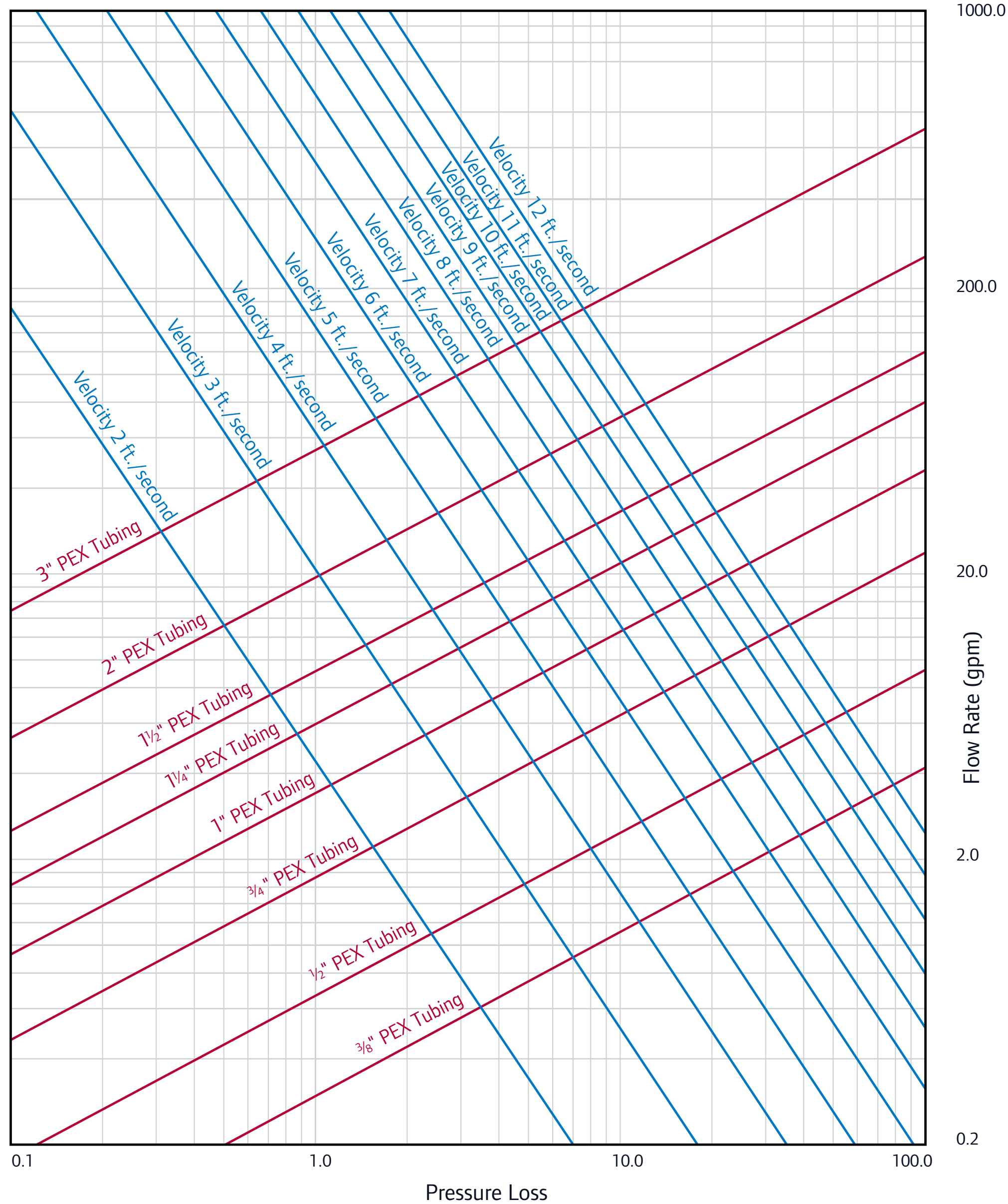


Table 8-1: Pressure Loss (psi) per 100 Feet of Uponor AquaPEX Tubing at 60ºF/15.6ºC

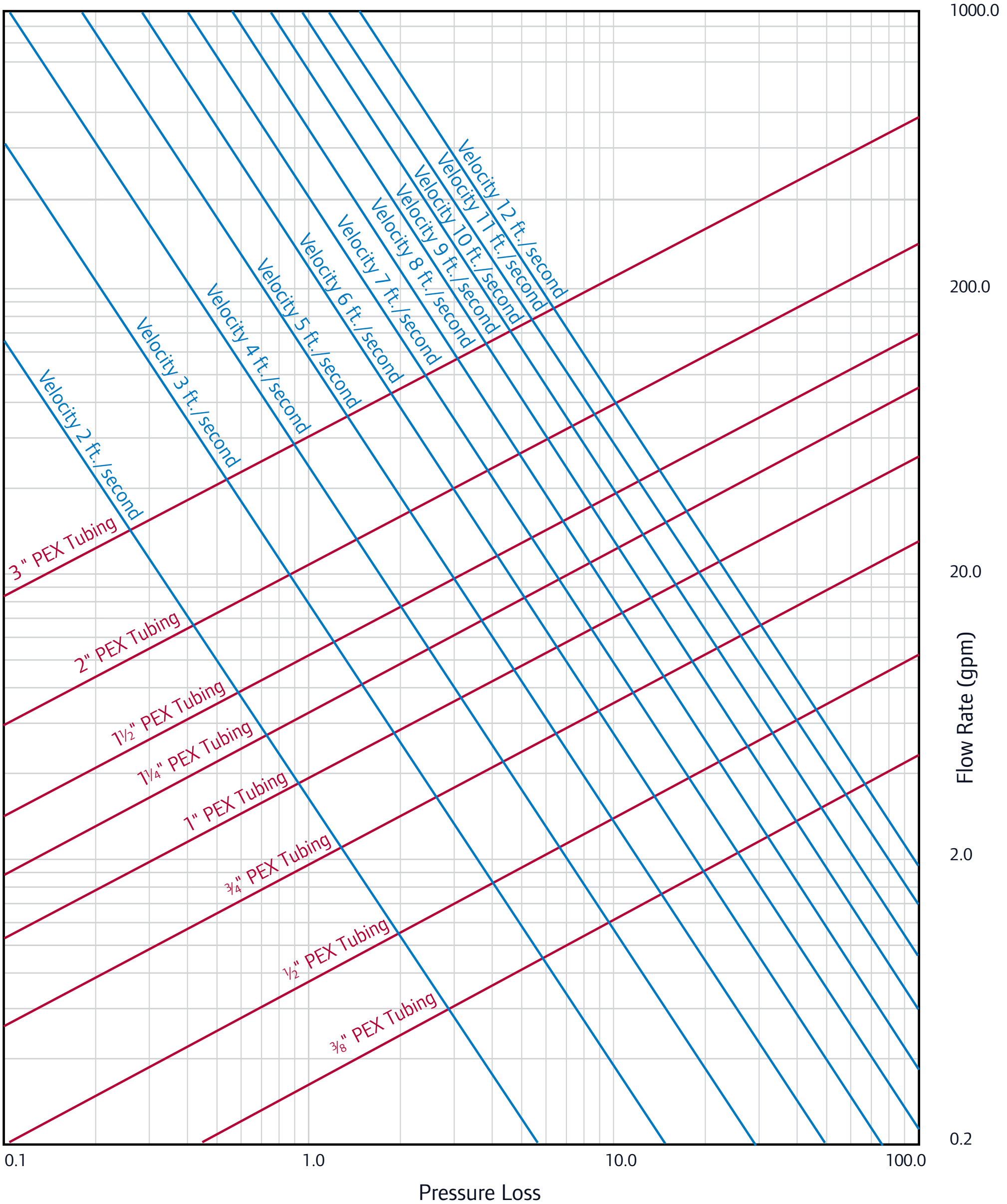
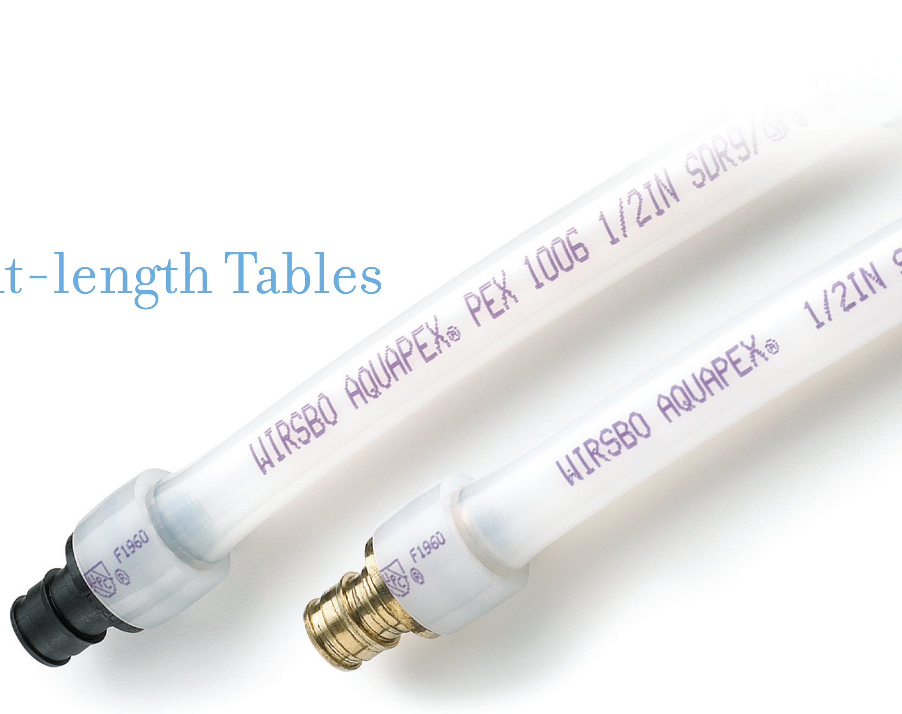


Table 8-2: Pressure Loss (psi) per 100 Feet of Uponor AquaPEX Tubing at 120ºF/48.9ºC

Section 9 —

Equivalent-length Tables



Tubing Pressure Loss

This section provides the equivalent length of tubing pressure loss for several ProPEX fittings. The equivalent length is used to approximate the impact of the fittings in regards to pressure loss across the tubing length. The equivalent length for each fitting is shown in **Tables 9-1** (**page 63**), **9-2**, **9-3** (**page 64**), **9-4**, **9-5** (**page 65**) and **9-6** (**page 65**). Add the equivalent length to the total tubing length for each fitting installed along the tubing run. The total pressure loss is then computed from the adjusted total tubing length.

Uponor is in the process of evaluating additional fittings through third-party testing. As more fittings are evaluated, their equivalent-length number will be added to this section.

1/2" ProPEX Fittings

Elbows	Equivalent Length (ft.)
1/2" Brass Elbow	3.0
1/2" EP Elbow	3.7
Couplings	
1/2" Brass Coupling	1.0
1/2" EP Coupling	1.0
Brass Tees	
1/2" x 1/2" x 1/2" Flow-through	1.0
1/2" x 1/2" x 1/2" Branch	2.0
EP Tees	
1/2" x 1/2" x 1/2" Flow-through	1.0
1/2" x 1/2" x 1/2" Branch	2.3

Table 9-1: Equivalent-length Pressure Loss for 1/2" ProPEX Fittings

3/4" ProPEX Fittings

Elbows	Equivalent Length (ft.)
3/4" Brass Elbow	2.2
3/4" EP Elbow	2.3
Couplings	
3/4" Brass Coupling	0.3
3/4" EP Coupling	0.2
Brass Tees	
3/4" x 3/4" x 3/4" Flow-through	0.3
3/4" x 3/4" x 3/4" Branch	0.8
EP Tees	
3/4" x 3/4" x 3/4" Flow-through	0.2
3/4" x 3/4" x 3/4" Branch	0.8
Brass Reducing Tees	
3/4" x 3/4" x 1/2" Flow-through	0.3
3/4" x 3/4" x 1/2" Branch	2.0
EP Reducing Tees	
3/4" x 3/4" x 1/2" Flow-through	0.2
3/4" x 3/4" x 1/2" Branch	2.3

Table 9-2: Equivalent-length Pressure Loss for 3/4" ProPEX Fittings

1" ProPEX Fittings

Elbows	Equivalent Length (ft.)
1" Brass Elbow	3.4
1" EP Elbow	4.6
Couplings	
1" Brass Coupling	0.2
1" EP Coupling	0.2
Brass Tees	
1" x 1" x 1" Flow-through	0.2
1" x 1" x 1" Branch	2.0
EP Tees	
1" x 1" x 1" Flow-through	0.2
1" x 1" x 1" Branch	2.0
Brass Reducing Tees	
1" x 1" x 3/4" Flow-through	0.2
1" x 1" x 3/4" Branch	0.8
1" x 1" x 1/2" Flow-through	0.2
1" x 1" x 1/2" Branch	2.0
EP Reducing Tees	
1" x 1" x 3/4" Flow-through	0.2
1" x 1" x 3/4" Branch	0.8
1" x 1" x 1/2" Flow-through	0.2
1" x 1" x 1/2" Branch	2.3

Table 9-3: Equivalent-length Pressure Loss for 1" ProPEX Fittings

$1^1/_4$" ProPEX Fittings

Elbows	Equivalent Length (ft.)
$1^1/_4$" Brass Elbow	9.61
$1^1/_4$" EP Elbow	10.03
Couplings	
$1^1/_4$" Brass Coupling	1.48
Brass Tees	
$1^1/_4$" Flow-through	1.64
$1^1/_4$" Branch	8.78
EP Tees	
$1^1/_4$" Flow-through	3.78
$1^1/_4$" Branch	8.56

Table 9-4: Equivalent-length Pressure Loss for 1¼" ProPEX Fittings

$1^1/_2$" ProPEX Fittings

Elbows	Equivalent Length (ft.)
$1^1/_2$" Brass Elbow	10.85
$1^1/_2$" EP Elbow	11.50
Couplings	
$1^1/_2$" Brass Coupling	2.73
Brass Tees	
$1^1/_2$" Flow-through	2.07
$1^1/_2$" Branch	11.62
EP Tees	
$1^1/_2$" Flow-through	1.83
$1^1/_2$" Branch	10.60

Table 9-5: Equivalent-length Pressure Loss for 1½" ProPEX Fittings

2" ProPEX Fittings

Elbows	Equivalent Length (ft.)
2" Brass Elbow	11.29
Couplings	
2" Brass Coupling	1.38
Brass Tees	
2" Flow-through	1.56
2" Branch	12.07

Table 9-6: Equivalent-length Pressure Loss for 2" ProPEX Fittings

Section 10 — Construction Methods

Techniques and Categories

This section profiles potable-water-construction techniques that are primarily found in multi-family and commercial buildings, generally referred to as fire-resistant construction buildings where both plumbing and building codes apply. Each method includes a detailed illustration, as well as how, where and what to look for when installing potable water in fire-resistant construction buildings. Listed below are five general categories of construction methods. Note that these are the majority of construction techniques found in North America. Other construction techniques are sometimes used; contact Uponor for further guidance in these situations.

- Structural-column construction
- Shear-wall construction
- Wood-frame construction
- Risers
- Horizontal runs including hallways

Local-code Approvals

Before installing any tubing, please discuss the installation with local building and plumbing officials. While the Uponor plumbing systems described in this section meet the requirements of most building and plumbing codes found in the United States and Canada, some inspectors are not aware of these types of installations. **Sections 3** and **4** in this design manual provide supporting information and listings for United States and Canadian code compliances.

Site Preparations

There are four phases to a construction schedule:

Phase 1: Preparatory

Ensure the latest changes to the design are incorporated into the drawings and work schedule to avoid work stoppage or distractions. Coordinate work with other trade personnel on the site for an effective and efficient installation. Many other subcontractors may not be aware of the construction techniques described in this section. Work with the general contractor to ensure that he is aware of the construction techniques so that appropriate scheduling decisions can be made.

Typical discussions will occur with the following subcontractors:

Re-bar — The re-bar subcontractor must be aware of tubing that will be installed between re-bar levels in structural-column and shear-wall construction designs. The re-bar subcontractor must be aware of the time needed to install tubing between re-bar levels.

Concrete — The concrete subcontractor must be aware of any additional or different forming requirements. They must also be aware of what types of tubing penetrations will occur through the concrete surface. This will allow the concrete subcontractor to plan accordingly for concrete surface finishing.

Framing and Sheet Rock — The framing and sheet rock (drywall) subcontractors must be aware of any tubing penetrations or access panels that they are not familiar with to plan accordingly.

Firestop — If the installing tubing contractor is not installing firestop systems around the appropriate tubing assembly penetrations, the firestop installer must be aware that the appropriate firestop system must be selected for Wirsbo AQUAPEX tubing, which may be different from that used for other plumbing system types. The firestop system installer must take special care that the firestop system used is for PEX tubing; that the selected firestop system is for the penetration assembly as installed; that the firestop system meets all local and regional codes; and that the firestop system is chemically compatible with Wirsbo AQUAPEX tubing.

Phase 2: Startup

Every construction technique is different, so initial installation tips will be listed in each specific construction technique outlined in this section.

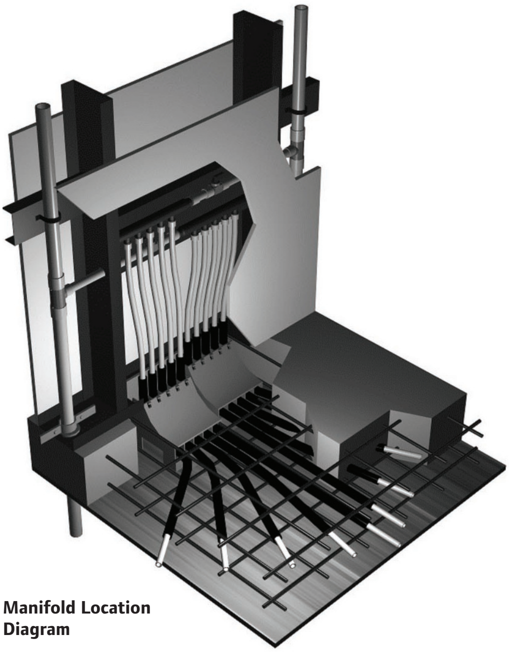
Remember to keep the jobsite clear of debris and unnecessary tools. Pre-plan each upcoming day's work schedule to ensure availability of materials and labor requirements.

Phase 3: In Progress

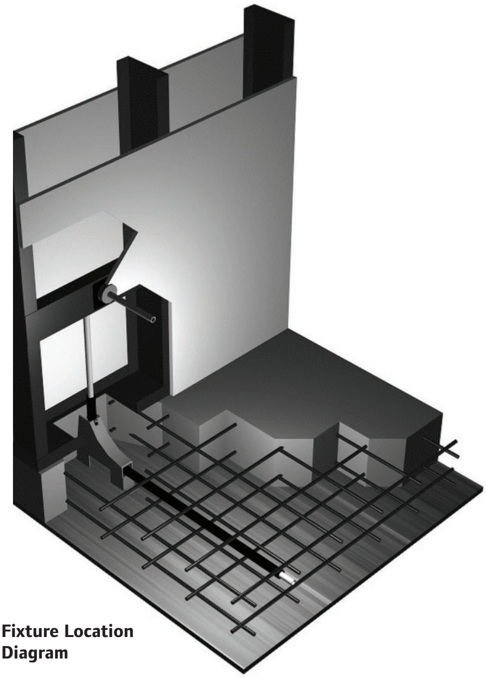
Coordinate the tubing installation to minimize other trade traffic around exposed tubing during in-slab construction.

Phase 4: Completion

Once the tubing installation is completed with all connections made, pressure-test to a minimum of 25 psi above working pressure (or to local and regional code requirements) for at least 24 hours to ensure system integrity. On larger jobs, pressure testing may be made floor-by-floor or in sections suitable to the project. Keep the system under pressure during the concrete pour or during wallboard installation or when other trades are working around exposed tubing. Pressurize the system with air. If water is used, drain and blow out the system in freezing conditions. Water is not recommended when weather is close to freezing temperatures.



Manifold Location Diagram



Fixture Location Diagram

Structural-column Construction

Installation

When installing the tubing on to re-bar, the Wirsbo AQUAPEX tubing may be sleeved to avoid any construction damage to the tubing on the floor deck. Sleeving also allows for removal and replacement of tubing should it get damaged during different construction phases. Uponor provides corrugated pre-sleeved tubing to simplify installation and time. Should the contractor choose to do his own pre-sleeving, he should use utility-grade polyethylene tubing or rigid PVC tubing with appropriate PVC bends. If the contractor is sleeving his own tubing, this must be done before installation as time is limited on the jobsite. Contractor pre-sleeving usually involves cutting the sleeved tubing to the appropriate lengths and bundling and identifying the sleeved tubing for each location.

Before the first layer of structural re-bar is installed, the general contractor usually marks the tubing layout on the floor deck. The tubing installation contractor will then use these lines to locate the tubing bend supports. These bend support brackets are required to rigidly hold the tubing in place during the concrete pour. Accurate placement of these support brackets is required so that the tubing ends up in the wall cavity of the steel frame that is erected after the concrete pour. Uponor provides PVC support brackets in a five- and single-loop configuration. The five-loop bracket is used at the manifold, with the single-loop-bracket typically used at the fixture locations. The brackets are normally nailed or stapled in place to the wood-deck concrete forms.

The tubing layout lines are also used for locating canning sleeves for risers and waste/vent pipes.

After the first layer of structural re-bar is installed, the contactor will place the pre-sleeved tubing into the manifold end support bracket and run the tubing out to the fixture location support bracket. The pre-sleeved tubing is tied to the structural re-bar on three-foot intervals with construction tie-wire. Ensure the tie-wire does not damage the sleeving. This will ensure the interior Wirsbo AQUAPEX tubing is not damaged. Tie-wire is also used to hold the sleeving in place as it bends through the support brackets. Tabs are provided on the support brackets to help tie-wiring. Sufficient length of tubing should be available to make connections to the manifold and the fixture.

The re-bar subcontractor now installs the second layer of re-bar onto placement chairs at the required height. Pre-construction meetings should make the re-bar subcontractor aware of working carefully around the installed sleeved tubing so as not to damage the tubing.

After the concrete floor is poured and the steel frame walls are erected, exposed sleeving may be removed to be flush with the top of the floor. Carefully cut the sleeving, taking care not to damage the PEX tubing within the sleeving. An alternate method to remove excess sleeving is to gently soften the sleeving with a low flame directed at floor level. The flame will soften the sleeving to the point where the contractor can pull and break off the sleeving at floor level. Again, take care not to damage the PEX tubing within the sleeving.

After the concrete floor is poured and the steel frame walls are erected, risers may be installed. Uponor makes PEX tubing in sizes up to two inches, which is suitable and desired for this type of construction. The PEX riser is held in place with an epoxy-coated riser clamp. A riser clamp is placed at the base of every floor. A mid-story guide is required on the riser between every floor. The clamp must be metal with no sharp edges if the wall containing the riser is required to be fire-resistant construction. Discarded steel wall framing is typically used as a backer plate for the mid-story guide.

Before connecting the in-slab PEX loops to a manifold, connect the manifold to the riser with suitable hardware. Uponor provides both copper and EP manifolds. Selection of which Uponor manifold to use will depend on the number of loops required at the manifold. An isolation valve is recommended between the manifold and the riser and may be dictated by local codes. If an isolation valve is used, ensure that an access door is installed for the valves.

Manifolds should be secured to a backing plate. Discarded steel wall framing is typically used as a backer plate for the manifolds. Suitable mounting hardware or clips should be used.

The in-slab PEX loops can now be connected to the manifolds with ProPEX connections.

At the fixture location, an Uponor drop-ear bend support should be used to ensure a continuous PEX run from the manifold connection to the valve connection at the fixture location. The drop-ear bend support is held in place with a backer plate made from discarded steel wall framing.

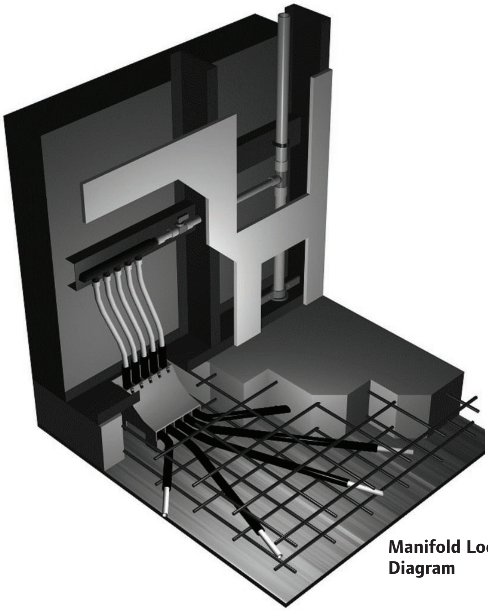
Pressure test caps are now placed on the tubing at the fixture end. The pressure tests are now conducted on the installed plumbing system to fulfill Uponor's recommendations and local code requirements.

Where

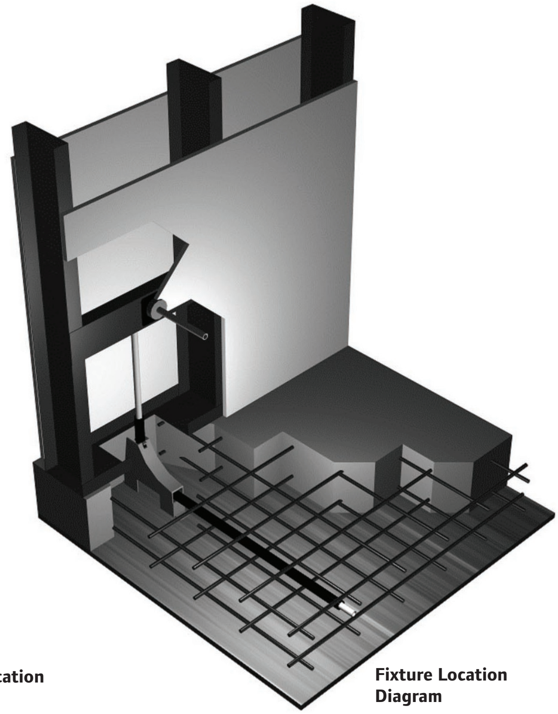
This application is used primarily in multi-family residential applications, hotels and office buildings. Advantages are a reduced number of risers, reduced insulation costs and reduced firestop costs due to fewer penetrations. The majority of in-suite plumbing rough-in work is done during the re-bar stages of construction. This reduces the coordination with other trades that is typical with traditionally installed in-wall plumbing systems.

What to Look For

- Pre-construction meetings are one of the most important steps to ensure all trades are informed as to this type of construction and to set up scheduling that may be different from traditional plumbing installations.
- Pre-approval from the local plumbing and building inspector should be done to ensure timely approvals at the inspection stage.
- Care must be taken to ensure that the PEX risers are installed in full compliance with Uponor's fire-resistant construction listings. Refer to **Section 5** for more information.
- Canning sleeve sizes should be sized according to the firestop system used. Firestop systems for PEX tubing generally use smaller annular spaces than other piping systems. Having a smaller through-floor penetration at the riser generally results in lower firestop costs.
- Ensure that insulation of the risers is done to local codes and unique energy requirements for the project. It is good practice to insulate the hot risers regardless of local requirements.



Manifold Location Diagram



Fixture Location Diagram

Shear-wall Construction

Installation

When installing the tubing on to re-bar, Wirsbo AQUAPEX tubing may be sleeved to avoid any construction damage to the tubing on the floor deck. Sleeving also allows for removal and replacement of tubing should it get damaged during construction phases. In shear-wall construction, sleeving serves an extra function whereby the tubing can be pulled back to accommodate shear-wall concrete forms. Uponor provides corrugated pre-sleeved tubing to simplify installation and time. Should the contractor choose to do his own pre-sleeving, he should use utility-grade polyethylene tubing or rigid PVC tubing with appropriate PVC bends.

If the contractor is sleeving his own tubing, this must be done before installation as time is limited on the jobsite. Contractor pre-sleeving usually involves cutting the sleeved tubing to the appropriate lengths and bundling and identifying the sleeved tubing for each location.

Before the first layer of structural re-bar is installed, the general contractor usually marks the tubing layout on the floor deck. The tubing installation contractor will then use these lines to locate the tubing bend supports. These bend support brackets are required to rigidly hold the tubing in place during the concrete pour. Accurate placement of these support brackets is required so that the tubing winds up in the wall cavity of the steel frame which is erected after the concrete floor is poured and the concrete shear walls are erected. Uponor provides PVC support brackets in five- and single-loop configurations. The five-loop bracket is used at the manifold location, with the single-loop bracket typically used at the fixture locations.

The brackets are normally nailed or stapled in place to the wood deck concrete forms.

The tubing layout lines are also used for locating canning sleeves for risers and waste/vent pipes.

After the first layer of structural re-bar is installed, the contactor will place the pre-sleeved tubing into the manifold location support bracket and run the tubing out to the fixture location support bracket. The pre-sleeved tubing is tied to the structural re-bar on three-foot intervals with construction tie-wire. Take care not to have the wire damage the sleeving. This will ensure the interior Wirsbo AQUAPEX tubing is not damaged. Tie-wire is also used to hold the sleeving in place as it bends through the support brackets. Tabs are provided on the support brackets to help tie-wiring. Please ensure that sufficient length of tubing is available to make connections to the manifold and the fixture.

To accommodate the base of the concrete shear wall forms, the Wirsbo AQUAPEX tubing will be pulled back below the concrete surface of the floor. Exposed sleeving will have to be cut flush with floor surface so as to provide a flat base for the shear wall forms.

The re-bar sub-contractor will now install the second layer of re-bar onto placement chairs at the required heights. Pre-construction meetings should make the re-bar sub-contractor aware of working carefully around the installed sleeved tubing so as not to damage the tubing.

After the concrete floor is poured, the shear wall concrete forms are positioned and the walls are poured. Further installation of the plumbing system can not proceed until the shear wall is cured and the forms are removed. Once the forms are removed, push back the Wirsbo AQUAPEX tubing to a height suitable for connection to the manifolds.

After the steel frame walls are erected, any exposed sleeving may be removed to be flush with the top of the floor. Carefully cut the sleeving, taking care not to damage the PEX tubing within the sleeving. An alternate method to remove excess sleeving is to gently soften the sleeving with a low flame directed at floor level. The flame will soften the sleeving to the point where the contractor can pull and break off the sleeving at floor level. Again, take care not to damage the PEX tubing within the sleeving.

After the steel frame walls are erected, risers may be installed. Uponor makes PEX tubing in sizes up to two inches, which is suitable and desired for this type of construction. The PEX riser is held in place with an epoxy-coated riser clamp. A riser clamp is placed at the base of every floor. A mid-story guide is required on the riser between every floor. The clamp must be metal with no sharp edges if the wall containing the riser is required to be of fire-resistant construction. Discarded steel wall framing is typically used as a backer plate for the mid-story guide.

Before connecting the in-slab PEX loops to a manifold, connect the manifold to the riser with suitable hardware. Uponor provides both copper and EP manifolds. Selection of which Uponor manifold to use will depend on the number of loops required at the manifold. An isolation valve is recommended between the manifold and the riser and may be dictated by local codes. If an isolation valve is used, ensure that an access door is installed for the valves.

Manifolds should be secured to a backer plate. Discarded steel wall framing is typically used as a backer plate for the manifolds. Suitable mounting hardware or clips should be used.

The in-slab PEX loops can now be connected to the manifolds with ProPEX connections.

At the fixture location, an Uponor drop-ear bend support should be used to ensure a continuous PEX run from the manifold connection to the valve connection at the fixture location. The drop-ear bend support is held in place with a backer plate made from discarded steel wall framing.

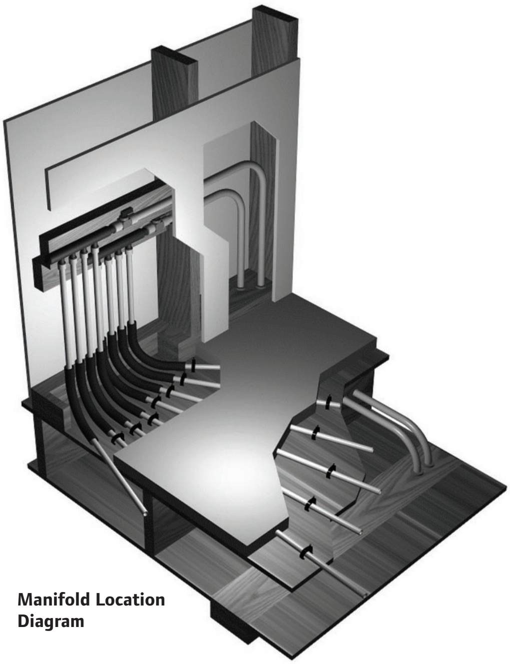
Pressure-test caps are now placed on the tubing at the fixture end. Pressure tests are conducted on the installed plumbing system to fulfill Uponor's recommendations and local code requirements.

Where

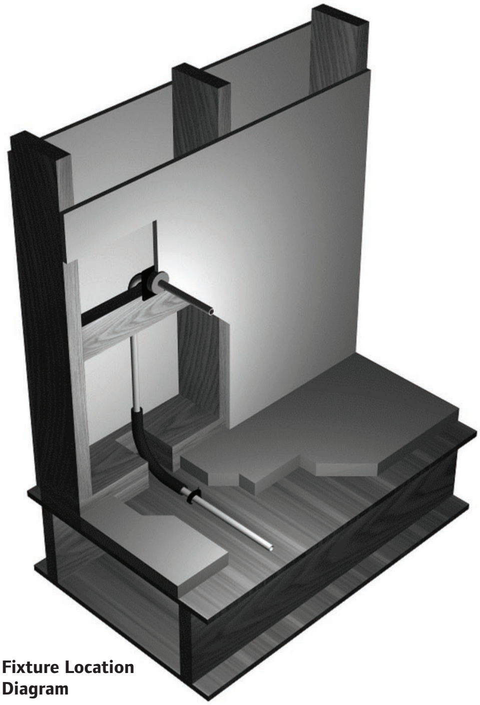
This application is used primarily in multi-family residential applications. Hotels and office buildings are also suitable applications. Advantages are a reduced number of risers, reduced insulation costs, and reduced firestop costs due to fewer penetrations. The majority of in-suite plumbing rough-in work is done during the re-bar stages of construction. This reduces the coordination with other trades that is typical with traditionally installed in-wall plumbing systems.

What to Look For

- Pre-construction meetings are one of the most important steps to ensure all trades are informed as to this type of construction and to set up scheduling that may be different from traditional plumbing installations.
- Pre-approval from the local plumbing and building inspector should be done to ensure timely approvals at the inspection stage.
- Care must be taken to ensure that the PEX risers are installed in full compliance with Uponor's fire-resistant construction listings. Refer to **Section 5** for more information.
- Canning sleeve sizes should be sized according to the firestop system used. Firestop systems for PEX tubing generally use smaller annular spaces than other piping systems. Having a smaller through-floor penetration at the riser generally results in lower firestop costs.
- Ensure that insulation of the risers is done to local codes and any unique energy requirements for the project. It is good practice to insulate the hot risers regardless of local requirements.



Manifold Location Diagram



Fixture Location Diagram

Wood-frame Construction

Installation

Before installing the tubing, the wall-floor plates must be cut to accommodate the transition of the tubing into the wall cavity. This can be achieved by notching the wall floor plates with a circular saw. A chisel can then be used to remove the notched floor plates.

The tubing is now installed with individual ½" Wirsbo AQUAPEX tubing running from the manifold location to the fixture location. Use Uponor-supplied bend or tube supports to make a 90-degree bend in the wall cavity. Ensure that adequate tubing is available for connections to the manifolds and fixtures. Clip the tubing to the floor with pre-nail-loaded plastic clips or other suitable hardware. Tubing should be clipped every two feet to prevent floating in the 1½-inch concrete over-pour.

Next, install the hot and cold supplies to the manifold locations. Unlike traditional riser methods, hot- and cold-water trunk lines are installed in the ceiling cavity on the building's main or second floor. ¾" or 1" Wirsbo AQUAPEX tubing is run from these trunk lines to individual in-suite manifolds. Refer to **Section 7** for sizing information. Isolation valves may be installed at the trunk line on every supply line to aid in any future maintenance requirements. PEX supply runs are typically installed in the joist cavity between floors. These runs may run parallel to the joists and/or through each joist. When installing PEX tubing joist cavities that are typically of fire-resistant construction follow the installation requirements in **Section 5**.

Once the supply tubes are run to the manifold locations, hook up the supply tubes to the manifolds. Uponor provides both copper and EP manifolds. An isolation valve is recommended to be placed near the manifold; this may be dictated by local codes. If an isolation valve is used, ensure that an access door is installed for the valve.

Secure the manifolds to a backer plate with suitable mounting hardware or clips. Discarded wood framing is typically used as a backer plate for the manifolds.

The PEX loops can now be connected to the manifolds with ProPEX connections.

At the fixture location, an Uponor drop-ear bend support should be used to ensure a continuous PEX run from the manifold connection to the valve connection at the fixture location. The drop-ear bend support is held in place with a backer plate.

Pressure-test caps are now installed at the fixture location. Pressure tests are then conducted on the installed plumbing system to fulfill Uponor's recommendations and local code requirements.

Where

This application is used primarily in multi-family residential applications, motels and office buildings. Advantages are quick installation times and reduced insulation costs. The majority of in-suite plumbing rough-in work is done before the concrete over-pour takes place. This reduces the coordination with other trades that is typical with traditionally installed in-wall plumbing systems.

What to Look For

- Pre-construction meetings are one of the most important steps to ensure all trades are informed as to this type of construction and to set up scheduling that may be different from traditional plumbing installations.
- Pre-approval from the local plumbing and building inspector should be done to ensure timely approvals at the inspection stage.
- Care must be taken to ensure that the PEX supply mains are installed in full compliance with Uponor's fire-resistant construction listings. Refer to **Section 5** for further information.

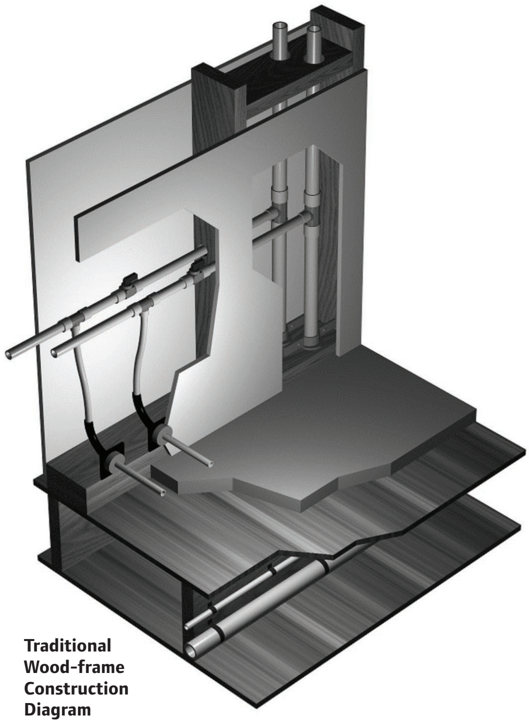
Traditional Wood-frame Construction

Installation

Wirsbo AQUAPEX tubing is run in the walls like a traditional plumbing system. Uponor drop-ear bend supports should be used to ensure a rigid connection to fixtures or their shut-off valves. Discarded wood framing can be used as a backer plate for the drop-ear bend supports.

After the wood frame walls are erected, risers may be installed. Uponor makes PEX tubing in sizes up to two inches, which is suitable and desired for this type of construction. The PEX riser is held in place with an epoxy-coated riser clamp. A riser clamp is placed at the base of every floor. A mid-story guide is required on the riser between every floor. The clamp must be metal with no sharp edges if the wall containing the riser is required to be of fire-resistant construction. Discarded wood framing is typically used as a backer plate for the mid-story guide. Alternately, the mid-story guide may be a penetration through a horizontal cross member in the wall cavity.

An alternate procedure to individual risers is to use individual supply mains to each suite. Unlike traditional riser methods, hot and cold trunk lines are installed in the ceiling cavity on the building's main or second floor. ¾" or 1" Wirsbo AQUAPEX tubing is installed from these trunk lines to individual in-suite manifolds. Refer to **Section 7** for sizing information. Isolation valves may be installed at the trunk lines on every supply line to aid in any future maintenance requirements. PEX supply lines are typically installed in the joist cavity between floors.



Traditional Wood-frame Construction Diagram

These lines may be run parallel to the joists and/or through each joist. When installing PEX tubing in joist cavities that are fire-resistant construction follow the installation requirements in **Section 5**.

Once the supply lines are run to the suite, an isolation valve is recommended to be placed near the manifold; this may be dictated by local codes. If an isolation valve is used, ensure that an access door is installed for the valve.

Pressure-test caps are now installed at the fixture location. Pressure tests are then conducted on the installed plumbing system to fulfill Uponor's recommendations and local code requirements.

Where

This application is used primarily in multi-family residential applications, motels and office buildings. This type of system would be used where there is no concrete over-pour or radiant floor heating in the concrete. While more time-consuming than the previous construction technique, Wirsbo AQUAPEX tubing still provides a quicker installation than traditional plumbing systems.

What to Look For

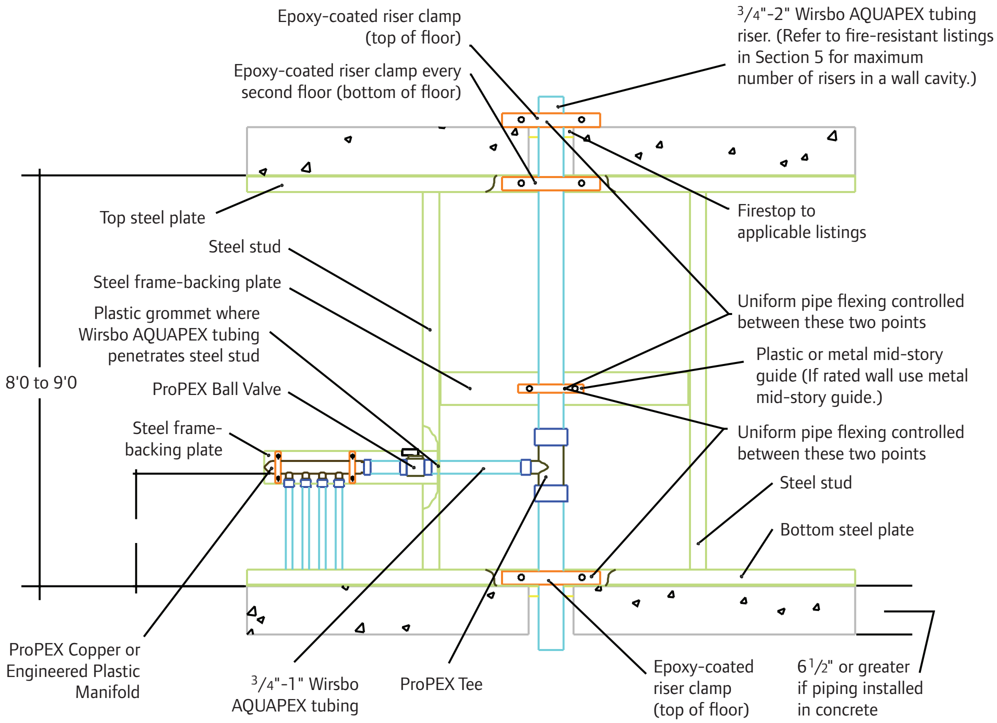
- Pre-approval from the local plumbing and building inspector should be done to ensure timely approvals at the inspection stage.
- Care must be taken to ensure that the PEX supply mains are installed in full compliance with Uponor fire-resistant construction listings. Refer to **Section 5** for further information.

Risers

Risers typically are Wirsbo AQUAPEX tubing from ¾" to 2". Refer to **Section 7** for sizing guidelines.

Epoxy-coated riser clamps are used at the base of each floor. In conjunction with the riser clamps at the base of each story, a riser clamp should be used at the top of every other story, limiting the expansion and contraction of the tubing to 20 feet. This translates to an expansion of about 1.5 inches in 20 feet at a 70ºF/21ºC temperature rise (installed at 70ºF/21ºC and a service temperature of 140ºF/60ºC). In this application, the tubing will snake slightly in areas where it is not constrained.

Mid-story guides are required. Use discarded framing as a backer plate for the guide. The guide must be metal with no sharp edges if the riser is in a wall that is required to be of fire-resistant construction.



Detailed Riser Installation

The mid-story clamp must allow for some movement of the tubing. A tubing clamp can be used in place of the mid-story guide, limiting the expansion and contraction of the tubing to roughly 10 feet. In this application, it is important that the tubing clamp be fastened to a rigid support brace.

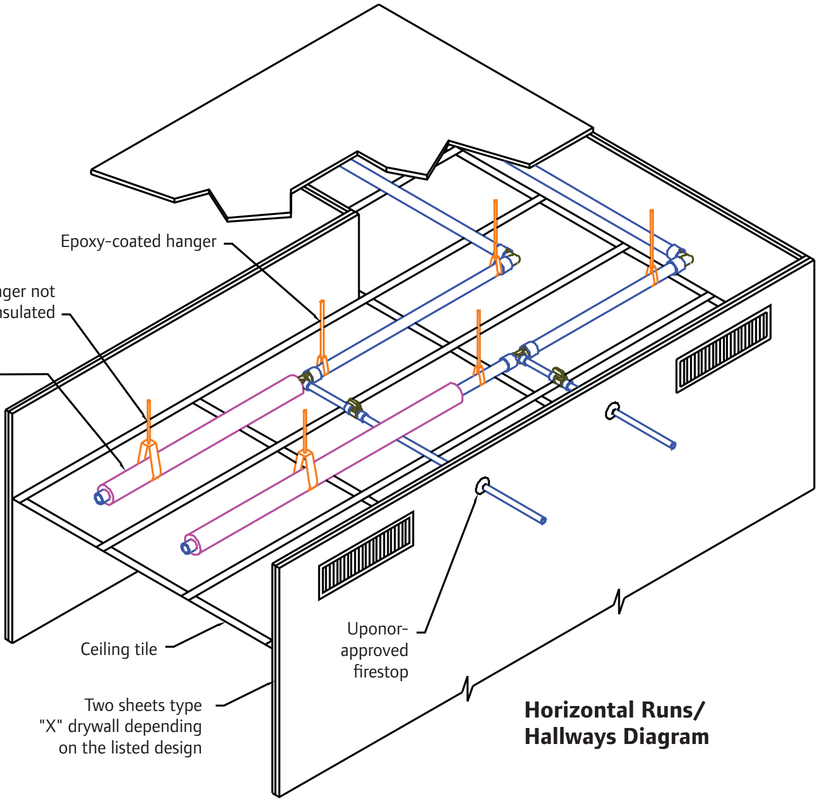
Firestopping of through-floor penetrations must be installed in accordance with appropriate firestop listings. The firestop used must be compatible with Wirsbo AQUAPEX tubing. Some listings will allow for multiple penetrations through the same hole. Ensure that the annular space between the tubing and the substrate of the penetration meets the firestop listing.

Isolation valves should always be installed between the riser and the manifold. Access doors should be provided to the isolation valves. The access door may be required to be fire-rated if the riser is in a wall requiring a fire-resistant rating.

The riser will expand and contract with water-temperature change. All flexing is contained between riser clamps negating the requirement for expansion loops.

All tubing penetrating steel stud walls should be protected from sharp edges using suitable mounting hardware such as plastic grommets.

Manifolds should be mounted with suitable mounting clips or hardware to a backer plate of steel or wood framing in wood-frame applications.



Horizontal Runs/ Hallways Diagram

Horizontal Runs/Hallways

All horizontal runs of Wirsbo AQUAPEX tubing should be hung with epoxy-coated clevis hangers. Clevis hangers are not required to be epoxy coated when supporting insulated tubing. Spacing of the hangers, regardless of tubing size, is 32 inches on center unless the tubing is running in a horizontal assembly that is required to be of fire-resistant construction. In this application, hanger spacing must not exceed 24 inches for 1¼- to two-inch tubing and 16 inches for ½- to one-inch tubing.

If tubing is uninsulated and in a return air plenum, tubing must be separated by 18 inches. This only applies to tubing sizes up to ¾-inch in the United States and up to one inch in Canada. Larger sizes may not be used without fire-rated insulation.

Tubing in return air plenums may be run closer together if it is covered with ½-inch fire-rated insulation. Refer to **Section 1** for listings.

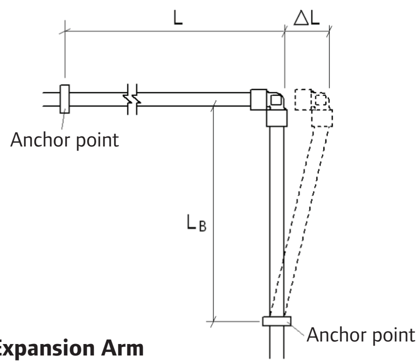
Tubing in hallway drop-ceiling applications requires special attention in their use due to variances and interpretations of North American building codes. Always check with local code officials before running Wirsbo AQUAPEX tubing in hallway drop ceilings. In many cases, this application is allowed if the tubing is covered with fire-rated insulation. Refer to the listings in **Section 5**.

An alternative method to using the clevis hangers is to use a support channel in conjunction with the clevis hangers. The clevis hangers are installed as discussed on **page 80** in conjunction with a support channel. The channel continuously supports the tubing in this application, allowing the spacing between clevis hangers to be lengthened. Typical channels are eight feet long. The channels overlap approximately six inches, and a clevis hanger is placed at the overlap of the channels, allowing the hangers to be separated by approximately 90 inches. The tubing is then strapped to the channel approximately every 30 inches with an approved strap. There are numerous clevis hangers and channel solutions commercially available.

Expansion Compensating Devices

It is generally accepted that an expansion loop is installed every 50 feet of straight length tubing. Always install the loop at the mid point of two fixed points. An expansion loop may not be required for installations where the tubing does not penetrate a fire-rated assembly, which constrains the movement of the tubing or where there are no restraining devices.

An example: The tubing runs the length of a hallway, without in-line tees, and turns a corner at the end. In this case, the tubing is not fixed; the tubing is allowed to expand without restriction. Use the formula for an expansion arm to calculate the minimum distance to the next fixed point. In this same application where in-line tees are used, it may be necessary to use an expansion loop to minimize the movement of the tees.



Expansion Arm

Expansion Arm

The flexible arm should be long enough to prevent damage, and support clamps should be placed far enough from the wall to allow for longitudinal thermal expansion.

Use the formula below to calculate the minimum length of the expansion arm:

LB = C x SQRT(D x ΔL)

L is total distance of tubing run from a fixed point to a corner, or in the case of an expansion loop, from a fixed point to a fixed point.

LB is the flexible arm in inches.

C is the material constant (12 for PEX).

D is the outside diameter of the tubing.

ΔL is the thermal-expansion length in inches.

Example:

Wirsbo AQUAPEX tubing with an outside diameter of 1.625 inches is installed running a length of 50 feet. The hot water it carries is 160ºF/71.1ºC and the ambient temperature is 60ºF/15.6ºC. Calculate the length of the flexible arm. PEX tubing will expand at a rate of 1.1 inches per 100 feet per 10ºF/12.2ºC temperature rise.

LB = C x SQRT(D x ΔL)

LB = 12 x SQRT(1.625 inches x (1.1 inches*10/(100 feet/L)))

LB = 12 x SQRT(1.625 inches x 5.5 inches)

LB = 12 x 2.99 inches

LB = 35.8 inches

The required arm length is 36 inches to prevent excessive stress on the fittings and support clamps.

Expansion Loop

The same equation applies for an expansion loop. However, the arm length (LB) must be divided into three sections using the following formula:

LB = 5L1

Example:

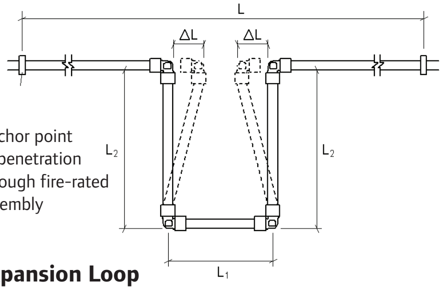
5L1 = 36 inches

L1 = 36/5

L1 = 7.2 inches

L2 = 2 L1

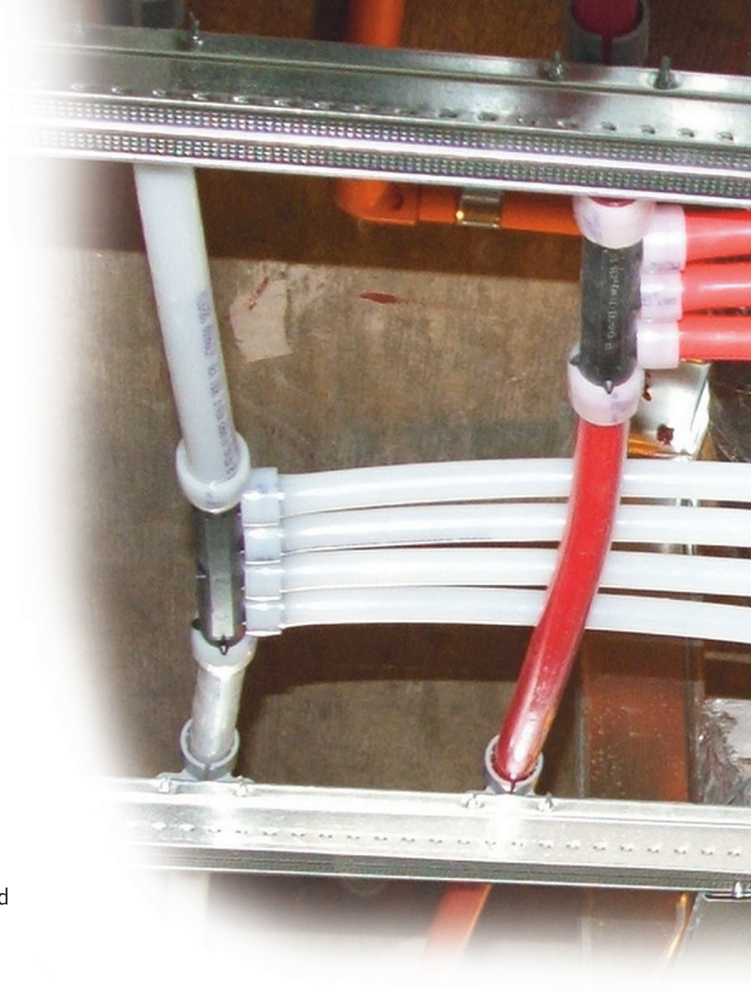
L2 = 14.4 inches



Expansion Loop

2" Wirsbo AQUAPEX® Tubing Expansion Joint Kit

Uponor offers a 2" Wirsbo AQUAPEX® Tubing Expansion Joint Kit (F8052000). The kit includes a pre-formed loop made from a piece of 2" Wirsbo AQUAPEX tubing, two 2" ProPEX® Brass Elbows (Q4712000) and four 2" ProPEX Rings (Q4682000).



Section 11 — Installation Methods

Background

In late 2005 and early 2006, the National Association of Home Builders (NAHB) Research Center conducted a systematic series of laboratory tests and case studies to support the creation of a Residential PEX Water Supply Plumbing Systems Design Guide. The tests examined the performance of three system designs — trunk and branch, home-run and remote manifold — under a range of pressure and simultaneous flow conditions. At the same time, layouts and material takeoffs were created for four common house types to compare and contrast the material cost and actual pipe routing.

Purpose of Laboratory Testing

To quantify the differences between the PEX system designs for the design guide, the three system designs were tested at the NAHB Research Center laboratory to provide a similar set of conditions under which the systems are installed and operated. Actual residential plumbing fixtures, piping layouts with fittings and elevation changes were incorporated in the test setup. This provided a consistent comparison between system designs, as well as an indication of the minimum-performance characteristics of each system.

The testing performed as a basis for this report adds comparative flow, pressure and time-to-hot water data for the recirculation system in Uponor Logic.

Test System Design

In the original tests, a test system was constructed for each type of plumbing design. A primary test fixture, represented by a tub/shower unit, was installed and instrumented to measure flow rate and flow pressure on the hot and cold lines, as well as outlet water temperature. This shower test fixture was the furthest fixture, located 100 feet from the hot-water tank. It represents the "worst-case" characteristics of the full system. In the subsequent set of tests evaluated for this report, an Uponor Logic system design with a hot-water circulation loop was incorporated into the original test setup.

The characteristics of Uponor Logic with circulation loop design include:

- Supply line (³⁄₄-inch) from the hot-water tank to flow-through remote manifolds
- Remote manifolds located no more than 10 feet from the outlets
- A return line from the furthest remote manifold to the cold-water inlet of the hot-water tank
- A circulation pump located on the return line near the tank
- A momentary switch that activates the circulation pump

Figure 11-1 diagrams the layout of Uponor Logic as installed at the NAHB Research Center. Uponor Logic is similar to the remote manifold system design in the original testing, with the exception of the fixtures located no more than 10 feet from the remote manifold in Uponor Logic. (The fixtures in the original remote manifold design were located no more than 20 feet from the remote manifold.)

Uponor Logic was installed with three 90-degree elbows in each of the hot- and cold-water ¾-inch supply lines to the furthest remote manifold to be consistent with typical current practice and with

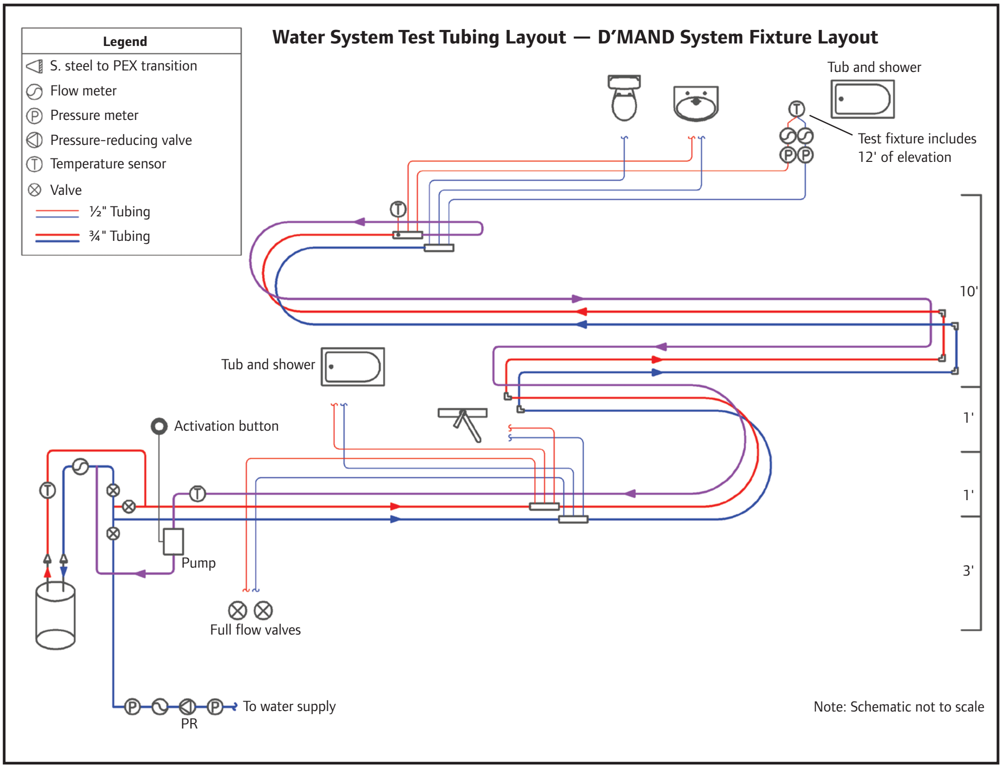


Figure 11-1: Uponor Logic With Circulation Loop Layout

previous tests of remote manifold systems. The furthest fixture is located 100 feet from the hot-water tank, with 90 feet of ¾" Wirsbo AQUAPEX tubing to the remote manifold and 10 feet of ½ -inch tubing to the outlet from the remote manifold. All plumbing tubing and manifolds were supplied by Uponor, Inc. The fitting system used the ProPEX system with a ProPEX ring. The remote manifolds used were the EP three- and four-port manifolds with ¾-inch inlets and flow throughs and ½-inch outlets. All original tests were performed with the standard PEX crimp system with insert fittings (ASTM F877 and F1807) and all tubing and fittings were from other manufacturers.

Test Procedure

In the original test set, two sets of tests were performed for each plumbing design. One test recorded pressure and flow data at the test fixture. A second set of tests measured the length of time it took for hot water to reach the test fixture. This second test was started after both the cold-and hot-water piping were stabilized to the incoming cold-water temperature.[1] For Uponor Logic, the original test setup was modified to include operation of the recirculation pump at various times before or during the test-fixture operation.

The pressure and flow rate at the furthest operating fixture (a shower) was measured while operating alone and then with simultaneous flows from each of the other fixtures and finally with all the fixtures operating simultaneously. The flow and pressure performance data of Uponor Logic can be compared directly to the original test systems data for the trunk and branch, remote manifold and home-run system designs. Performance parameters measured for this test set included:

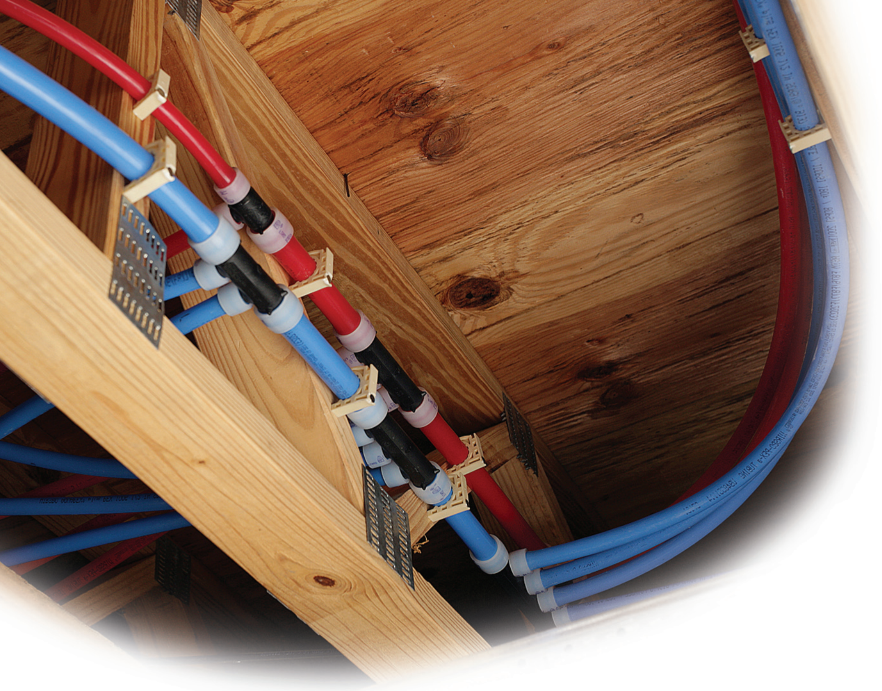
- Pressure at the main cold-water supply
- Pressure at the farthest test fixture (shower), both hot and cold
- Flow rate at the farthest test fixture (shower), both hot and cold
- Flow rate at the cold-water supply to the system
- Flow rate through the hot-water tank

The time-to-hot water tests for the structured plumbing design vary depending on the operation of the recirculation pump. Four tests were conducted to fully characterize the operation of the recirculation pump. The four tests measure the time-to-hot water for the shower to reach 100°F/37.8°C and 110°F/43.3°C from an initial water temperature of 53°F/11.7°C in the hot-water pipe.[2] The water heater delivery temperature was set to approximately 130°F/54.4°C. Performance parameters for this test set include:

- Shower flow with no operation of the recirculation pump
- Shower flow with simultaneous operation of the recirculation pump
- Fifteen-second operation of the recirculation pump prior to shower flow
- Two-minute operation of the recirculation pump prior to shower flow

[1] Refer to www.toolbase.org for an NAHB Research Center Technote on the test-system design and test results.

[2] The original test set flowed cold water in the hot-water tubing until it achieved a 53°F/11.7°C temperature in the tubing. Hot water was then circulated into the tubing and the time to achieve the test set temperatures of 100°F/37.8°C and 110°F/43.4°C were measured.



Prior to each test the hot-water pipe was cooled to 53ºF/11.7ºC before activating either the shower or the recirculation pump. Performance parameters measured for this test set include:

- Flow rate at the furthest test fixture (shower), both hot and cold
- Flow rate at the cold-water supply to the system
- Flow rate through the hot-water tank
- Temperature at the furthest test fixture (shower), both hot and cold
- Temperature at the hot-water tank supply
- Temperature at the furthest remote manifold
- Temperature at the recirculation pump
- Electric power of the pump (indicating runtime of the pump)

In addition to these test sets, a third test set was incorporated to evaluate the operation of the circulation pump specifically. The test setup incorporated a series of pump activations without any fixture flow to evaluate the run time of the pump following various cool-down periods of the tubing. The first activation of the pump was initiated after the tubing was cooled to 53ºF/11.7ºC. Subsequent activations were based only on the amount of time since the previous activation. The steps included:

- Cool pipe to 53ºF/11.7ºC, then activate the pump
- Wait 30 minutes, then activate the pump
- Wait 60 minutes, then activate the pump
- Wait 90 minutes, then activate the pump

The specific parameters measured for this test set include:

- Flow rate of circulation pump
- Temperature at the farthest remote manifold
- Temperature at the pump
- Electric power of the pump (indicating runtime of the pump)

Remote Manifold 100-foot Flow and Pressure Test, Average Data								
Remote Manifold 100 Feet	System	Cold Water	Hot Water	Main	Test Shower Fixture			
Fixture Flow	Flow	Flow	Flow	Pressure	Hot Flow	Hot Pres.	Cold Flow	Cold Pres.
Source Pressure	gpm	gpm	gpm	psi	gpm	psi	gpm	psi
40 psi	0.0	0.0	0.0	40.1	0.0	34.0	0.0	35.3
TF	1.7	0.3	1.4	31.3	1.5	22.8	0.2	26.3
TF+Lav	2.9	1.1	1.7	29.3	1.4	20.4	0.2	23.9
TF+WC	4.5	3.2	1.3	28.1	1.4	20.1	0.2	19.9
TF+Kit	3.0	1.1	1.8	30.3	1.5	21.6	0.2	25.2
TF+Sh2	3.7	1.3	2.4	29.8	1.4	20.4	0.2	24.7
TF+Sh2+Kit	4.7	2.0	2.6	28.0	1.3	18.5	0.2	22.7
TF+Sh2+Kit+Lav	5.7	2.9	2.8	27.3	1.3	17.3	0.2	21.3
TF+Sh2+Kit+Lav+WC	7.9	4.8	3.1	25.4	1.2	15.3	0.1	16.2
60 psi	0.0	0.0	0.0	60.0	0.0	54.2	0.0	55.1
TF	2.4	0.4	2.0	51.8	2.1	41.5	0.3	46.7
TF+Lav	3.9	1.6	2.3	48.3	1.9	37.4	0.2	42.5
TF+WC	6.1	4.2	1.8	46.5	1.9	36.7	0.3	36.1
TF+Kit	4.0	1.5	2.5	50.3	2.0	39.4	0.3	45.1
TF+Sh2	4.9	1.6	3.3	49.0	1.9	37.5	0.2	43.7
TF+Sh2+Kit	6.3	2.6	3.7	46.2	1.8	34.2	0.2	40.5
TF+Sh2+Kit+Lav	7.7	3.8	3.9	44.7	1.8	31.9	0.2	37.8
TF+Sh2+Kit+Lav+WC	10.5	6.2	4.3	40.7	1.6	27.1	0.2	28.6
80 psi	0.0	0.0	0.0	79.8	0.0	74.3	0.0	75.2
TF	2.8	0.5	2.3	72.8	2.4	61.5	0.3	67.9
TF+Lav	4.8	1.8	2.9	69.6	2.3	56.9	0.3	63.6
TF+WC	7.4	5.2	2.2	65.7	2.3	54.6	0.3	53.3
TF+Kit	4.7	1.6	3.0	70.4	2.3	58.6	0.3	65.2
TF+Sh2	5.2	1.6	3.6	70.6	2.3	57.8	0.3	65.4
TF+Sh2+Kit	7.0	2.7	4.2	67.4	2.2	53.3	0.3	61.9
TF+Sh2+Kit+Lav	8.7	4.2	4.5	64.4	2.2	49.4	0.3	57.1
TF+Sh2+Kit+Lav+WC	12.3	7.3	5.0	59.3	2.0	42.3	0.2	44.3
Nomenclature: TF = test fixture, shower open full, Lav = lavatory, both hot and cold on full, WC = water closet flush, Kit = kitchen at mid-point of single lever, Sh2 = second shower operating full open								

Table 11-1: Flow and Pressure Test Results for the Remote Manifold Design

Flow and Pressure Test Results

The results of the original test flow and pressure tests for the remote manifold are shown in **Table 11-1** to compare with Uponor Logic results as shown in **Table 11-2** on **page 88**. At each of the source pressures of 40, 60 and 80 psi, the test fixture (TF) — the shower operating at full flow — was operating alone and then with each of the other fixtures as indicated.

Figure 11-2 (see **page 89**) charts specific data from **Tables 11-1** and **11-2**, comparing the test-fixture hot-water flow at various pressures and with simultaneous flows from other fixtures. All flow measurements are at the furthest shower fixture. Refer to the tables for the nomenclature for each of the

Uponor Logic 100-foot Flow and Pressure Test, Average Data								
Uponor Logic 100 Feet	**System**	**Cold Water**	**Hot Water**	**Main**	**Test Shower Fixture**			
Fixture Flow	**Flow**	**Flow**	**Flow**	**Pressure**	**Hot Flow**	**Hot Pres.**	**Cold Flow**	**Cold Pres.**
Source Pressure	gpm	gpm	gpm	psi	gpm	psi	gpm	psi
40 psi	0.0	0.0	0.0	41.4	0.0	35.4	0.0	36.6
TF	1.7	0.4	1.3	30.0	1.5	22.1	0.2	25.1
TF+Lav	2.6	1.1	1.6	27.2	1.3	19.0	0.1	21.9
TF+WC	4.5	3.3	1.2	26.0	1.3	18.4	0.2	18.2
TF+Kit	2.9	1.1	1.8	28.3	1.4	20.3	0.2	23.4
TF+Sh2	3.6	1.1	2.4	28.9	1.4	20.3	0.1	23.9
TF+Sh2+Kit	4.5	1.8	2.7	26.0	1.3	17.2	0.1	20.9
TF+Sh2+Kit+Lav	5.4	2.6	2.8	25.5	1.2	16.4	0.1	19.8
TF+Sh2+Kit+Lav+WC	7.7	4.6	3.1	23.6	1.1	14.1	0.1	14.9
60 psi	0.0	0.0	0.0	58.8	0.0	53.0	0.0	54.0
TF	2.4	0.4	2.1	52.7	2.1	43.0	0.2	47.8
TF+Lav	3.9	1.5	2.4	47.9	2.0	37.8	0.2	42.2
TF+WC	6.1	4.3	1.8	44.8	1.9	35.5	0.2	34.9
TF+Kit	3.9	1.4	2.5	48.1	2.0	38.5	0.2	43.1
TF+Sh2	4.9	1.5	3.4	49.0	2.0	38.2	0.3	43.8
TF+Sh2+Kit	6.1	2.5	3.6	44.2	1.8	33.2	0.2	38.8
TF+Sh2+Kit+Lav	7.5	3.7	3.8	42.8	1.8	31.3	0.2	36.3
TF+Sh2+Kit+Lav+WC	10.5	6.3	4.2	38.8	1.6	26.0	0.2	27.2
80 psi	2.8	0.4	2.4	73.9	2.4	63.5	0.3	69.1
TF	2.9	0.5	2.4	74.4	2.4	64.3	0.3	69.6
TF+Lav	4.7	1.8	2.9	68.6	2.3	57.2	0.3	62.6
TF+WC	7.6	5.3	2.2	64.4	2.3	54.4	0.3	51.7
TF+Kit	4.7	1.7	3.0	68.8	2.3	58.1	0.3	63.8
TF+Sh2	5.3	1.6	3.7	71.2	2.3	59.4	0.3	66.0
TF+Sh2+Kit	6.9	2.5	4.4	65.4	2.2	52.4	0.3	59.9
TF+Sh2+Kit+Lav	8.6	4.1	4.5	63.0	2.2	49.2	0.3	56.1
TF+Sh2+Kit+Lav+WC	12.5	7.4	5.1	58.4	2.1	42.4	0.3	44.4
Nomenclature: TF = test fixture, shower open full, Lav = lavatory, both hot and cold on full, WC = water closet flush, Kit = kitchen at mid-point of single lever, Sh2 = second shower operating full open								

Table 11-2: Flow and Pressure Results for Uponor Logic

fixtures. Small differences in flow rates in **Figure 11-2** (see **page 89**) are a result of small differences in source pressure as indicated in **Figure 11-3** (see **page 90**).

The flow and pressure test results indicate that Uponor Logic performance is almost identical to the remote manifold test results as would be expected given the similarity in system layouts. Only minor differences in flow rates, less than 10% at 40 psi static, and less than 2% at higher pressures, are recorded between the remote manifold and Uponor Logic.

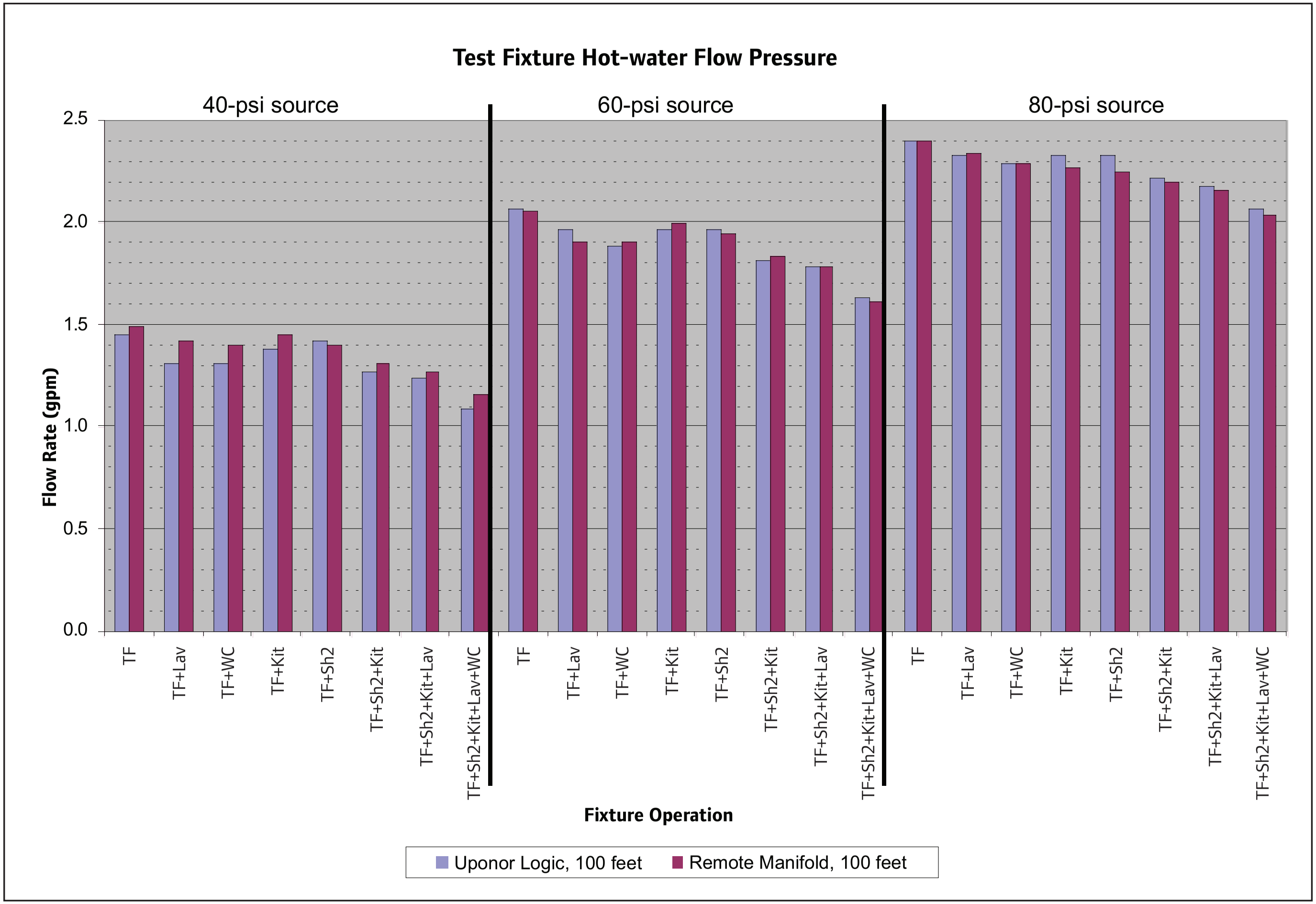


Figure 11-2: Flow-rate Comparison for Uponor Logic and Remote-manifold System Designs

Section 11 — Installation Methods

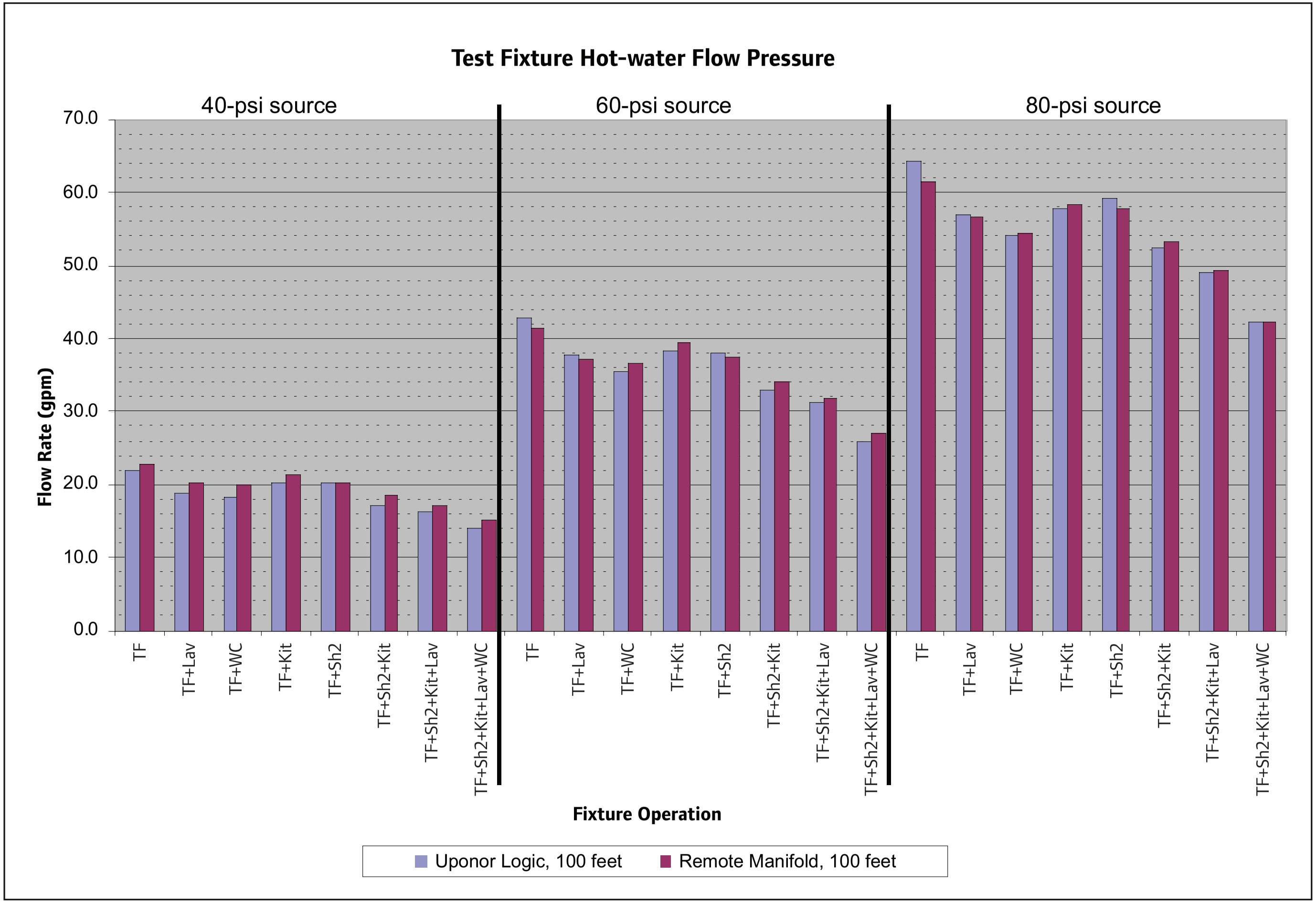


Figure 11-3: Flow-pressure Comparison for Uponor Logic and Remote-manifold Designs

Time-to-hot Water Test Results

A second set of tests was performed to characterize the time-to-hot water for Uponor Logic with various operations of the circulation pump. The circulation pump is designed to be activated using a momentary switch. Once activated, the pump circulates water in the hot-water tubing through the remote manifolds back to the cold-water inlet side of the water heater. (Refer to **Figure 11-1** on **page 84**.)

The operating time of the circulation pump is based on the pump-controller characteristics incorporated within the pump. The internal circuitry of the pump measures a temperature difference at the pump from the time it is activated to when the temperature sensor registers approximately a 20ºF/6.7ºC rise. The pump then deactivates automatically.

Four tests were used to compare the time-to-hot water with different circulation pump-activation times. The first test is with no pump activation and can be compared with the original test of the remote manifold system. All time-to-hot water tests were performed at 60-psi inlet pressure and 100 feet to the furthest fixture. Since the tests were performed in the summer months with cold-water inlet temperatures about 20ºF/6.7ºC above that of the original tests, a chiller was used to lower the water temperature to that of the original tests, approximately 53ºF/11.7ºC. The chilled water was circulated through the hot-water tubing to the remote manifold and through the circulation loop tubing. A limited amount of mixed chilled water was circulated through the 10-foot length of tubing and through the shower fixture, a minor difference in the test setup from the original set of tests that circulated cold water through all the tubing and the shower fixture.

The four tests that encompassed the time-to-hot water characteristics include:

- No operation of the recirculation pump
- Activation of the recirculation pump simultaneous with the shower operation
- Activation of the recirculation pump 15 seconds prior to the shower operation
- Activation of the recirculation pump two minutes prior to the shower operation

The results of the time-to hot water can be compared with previous testing performed on PEX plumbing systems each with 100 feet to the furthest test fixture (a shower) in three different configurations — trunk and branch, home-run and remote manifold. Since the remote manifold system previously tested and Uponor Logic are similar it is expected that those results would be similar when the recirculation pump is not activated. **Figure 11-4** on **page 92** charts the summary results for this test set.

The chart data is based on a normalized calculation of the time-to-hot water with normalization factors of fixture hot-water flow rate and hot-water tank delivery temperature. As expected, Uponor Logic performs similarly to the remote manifold system when the circulation pump is not activated. The wait time after activation of the circulation pump effects the wait time for hot water at the fixture.

A more detailed analysis of the time-to-hot water is shown in **Figures 11-5** to **11-12** on **pages 93-100**. These graphical representations indicate the temperatures at different points in

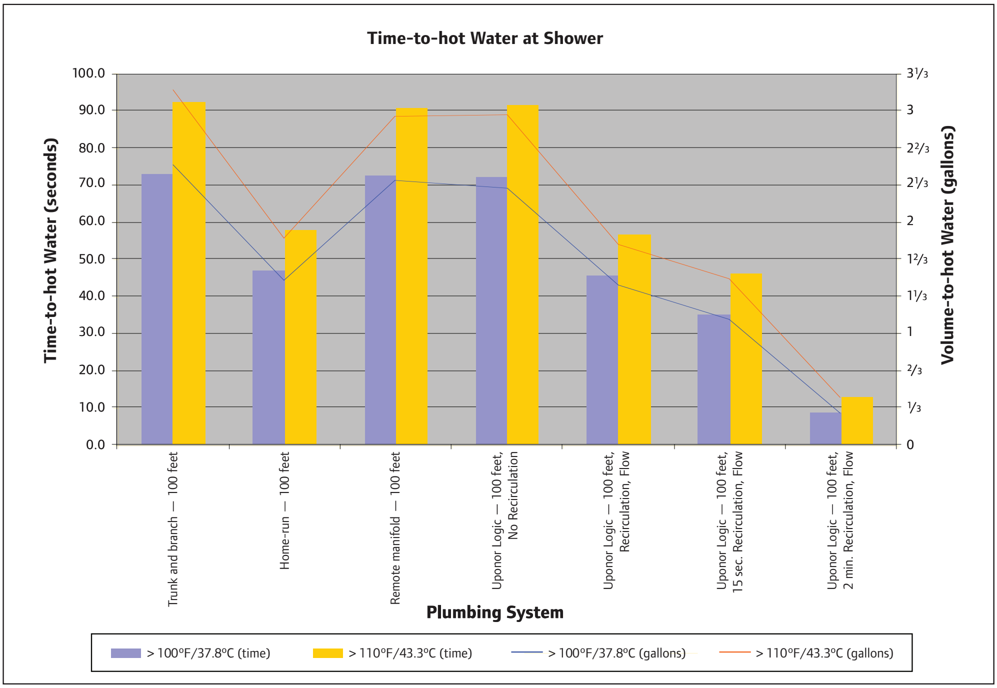


Figure 11-4: Summary Data for Time- and Volume-to-hot Water for Various PEX System Designs for a Fixture Located 100 Feet From the hot-water Tank

the system as the recirculation pump is activated prior to operation of the shower fixture. Two tests were performed for each of the four different pump circulation setups.

The data indicates an approximate 18°F/ -7.8°C temperature rise at the circulation pump before it automatically shuts off. The length of time for the pump operation is dependent on the flow rate — when the shower is activated in close proximity to the pump activation, the pump will operate for about two minutes, whereas if no fixtures are in use the pump will operate for less than 90 seconds.

In addition, the two-minute circulation pump operation prior to fixture flow shows that the remote manifold (located 10 feet from the fixture) reached 110°F/43.3°C in about 60 seconds, indicating that a minimum wait time after pump activation is a minimum of 60 seconds when the fixture is located no more than 100 feet from the hot-water tank. This testing applies only to the smaller 100-watt pump.

Another test set was performed to evaluate the operation of the circulation pump after various rest periods when no water was used at the fixtures. The rest periods between operations of the pump was varied from 30 minutes to 90 minutes. **Figure 11-13** on **page 101** graphs the results, which are consistent between rest periods. **Figure 11-14** on **page 102** extracts one of the rest periods to show a more detailed view of the temperature change at the remote manifold and the circulation pump.

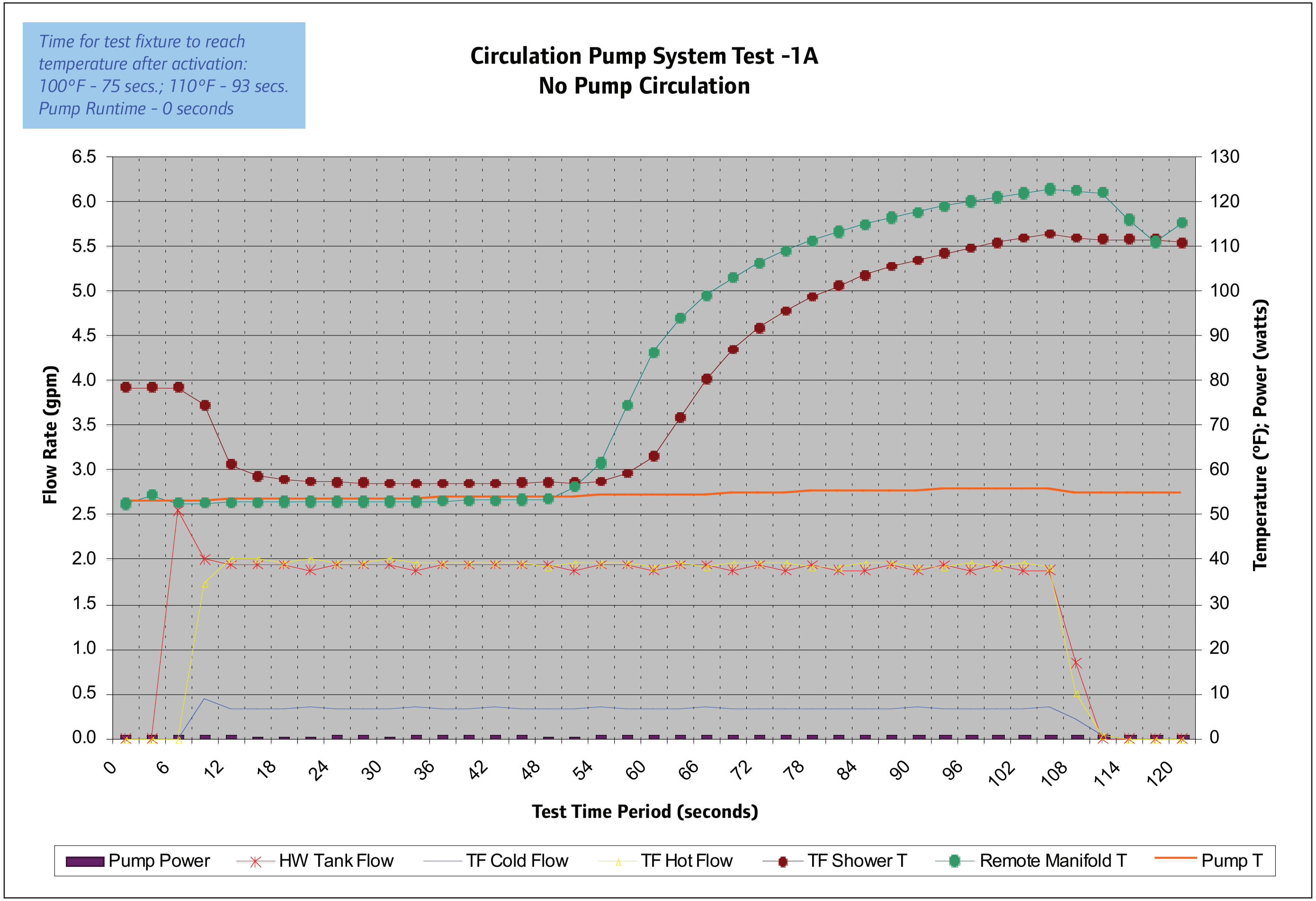


Figure 11-5: Recirculation System Test 1A

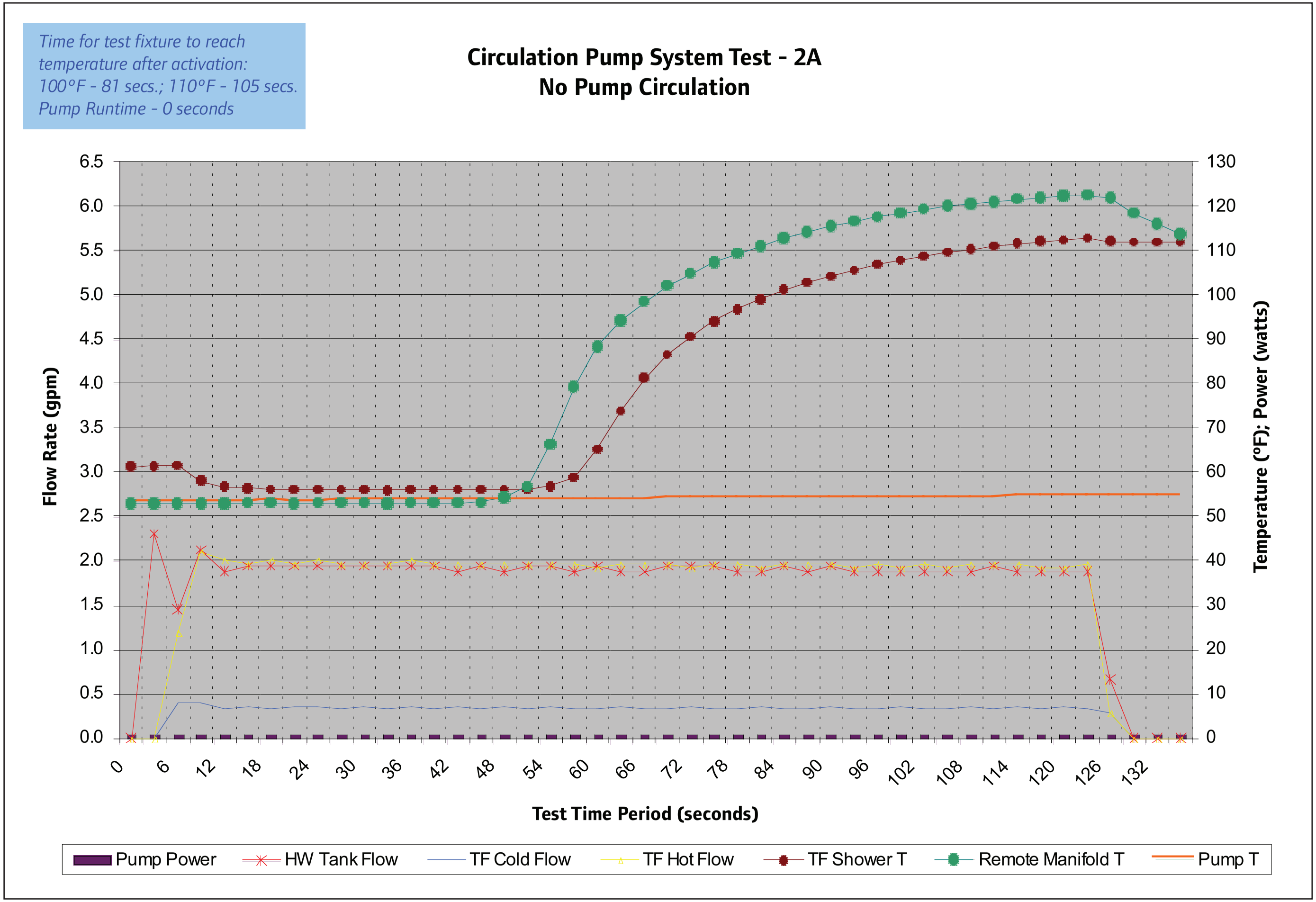


Figure 11-6: Recirculation System Test 2A

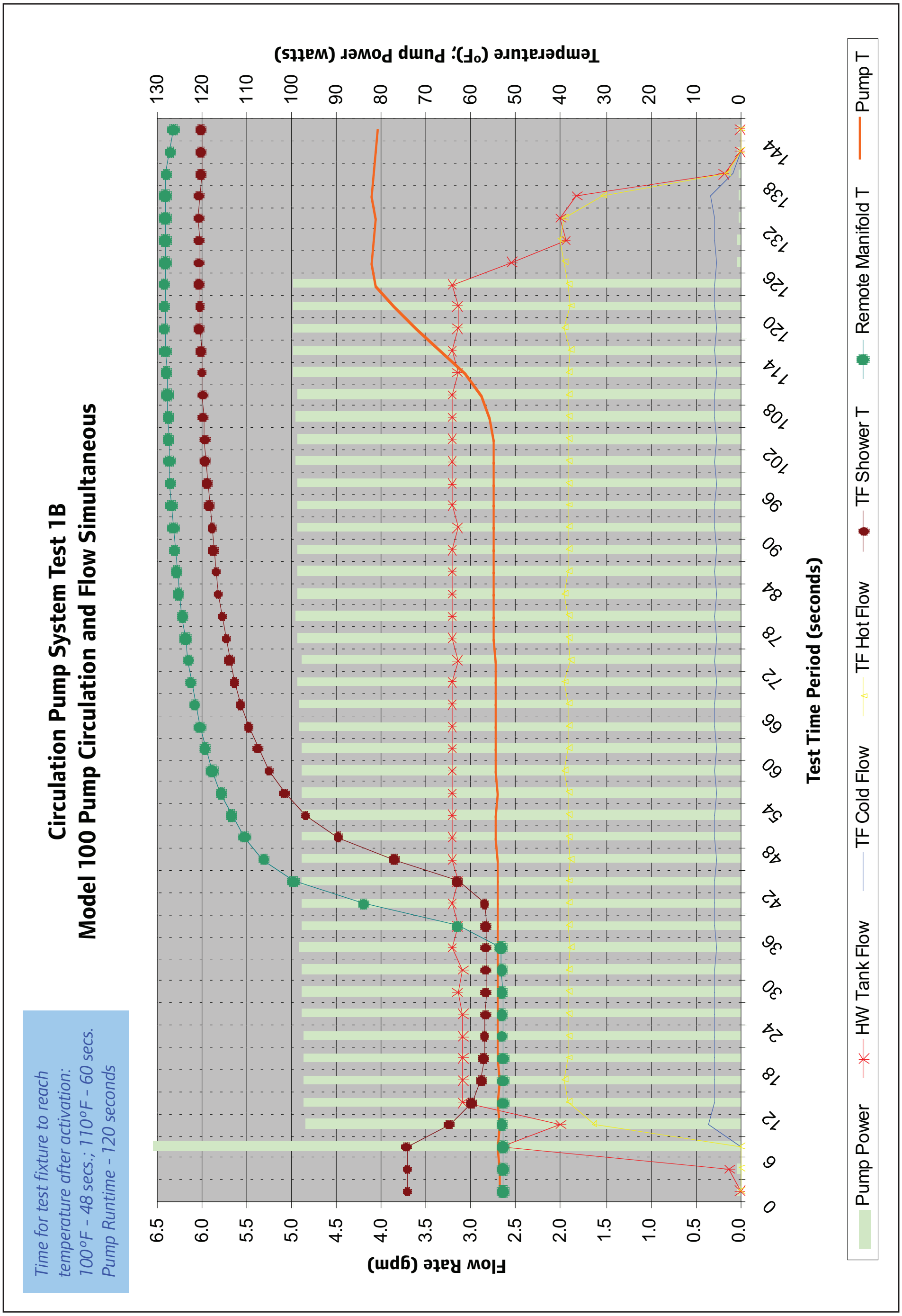


Figure 11-7: Recirculation System Test 1B

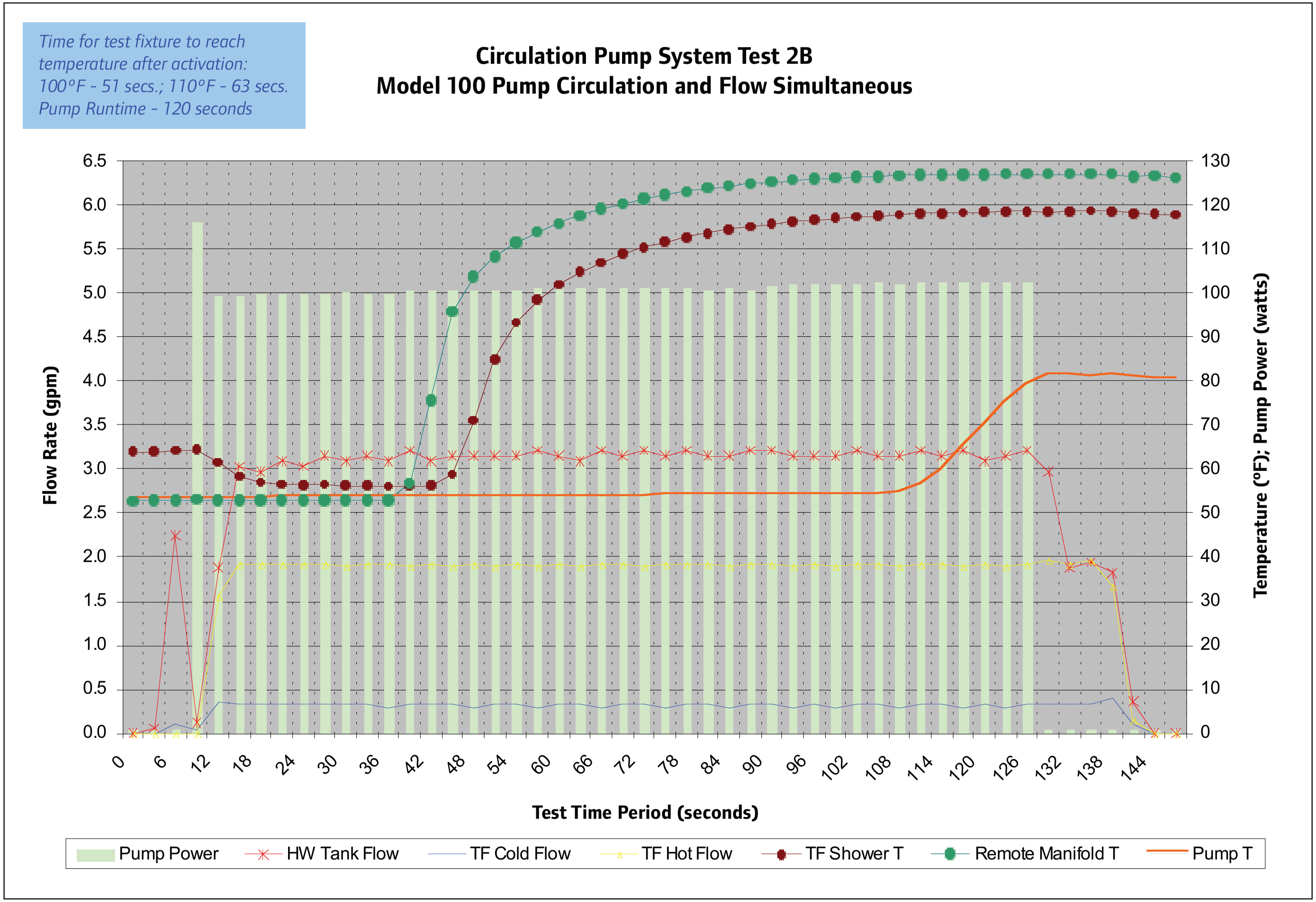


Figure 11-8: Recirculation System Test 2B

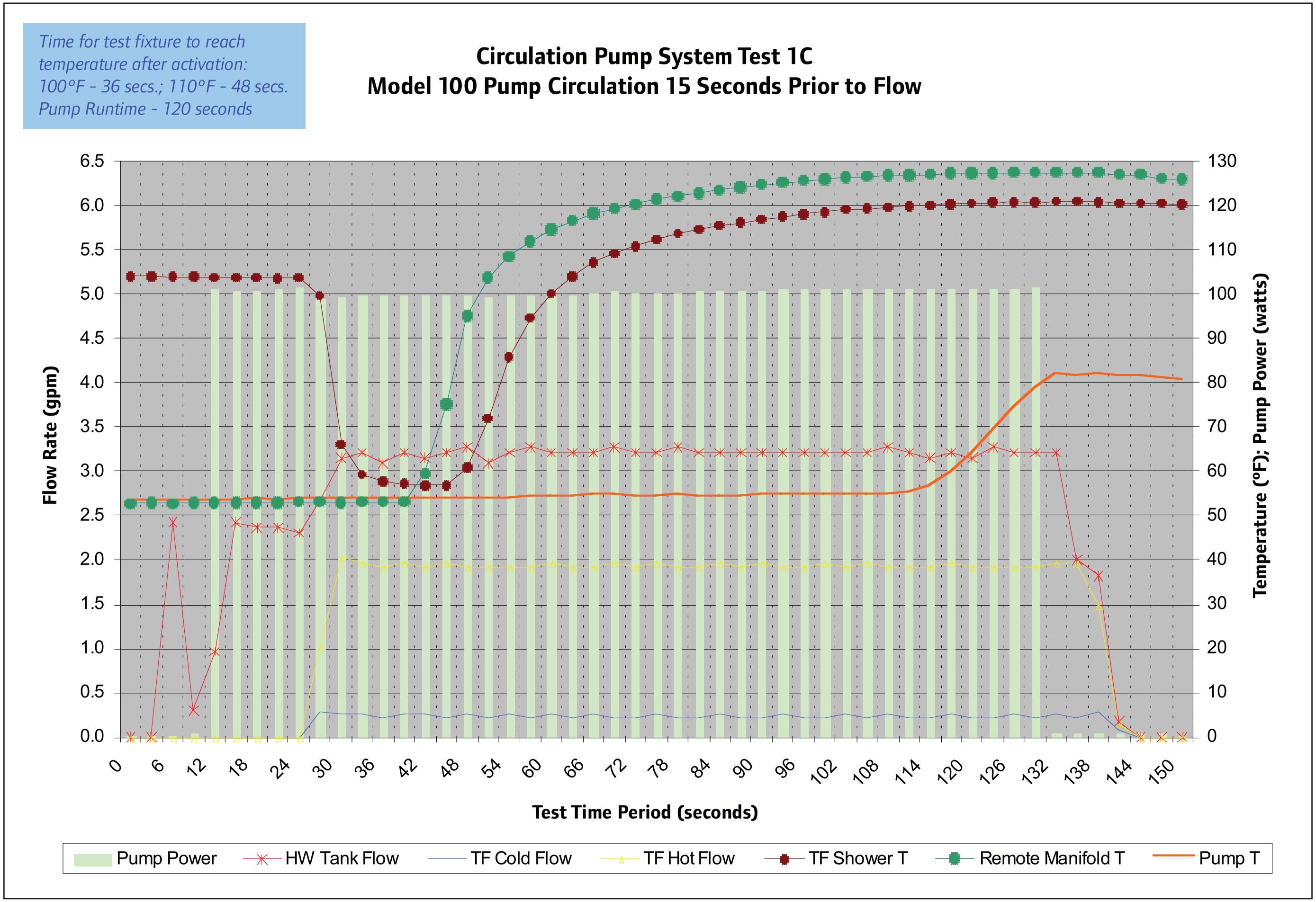


Figure 11-9: Recirculation System Test 1C

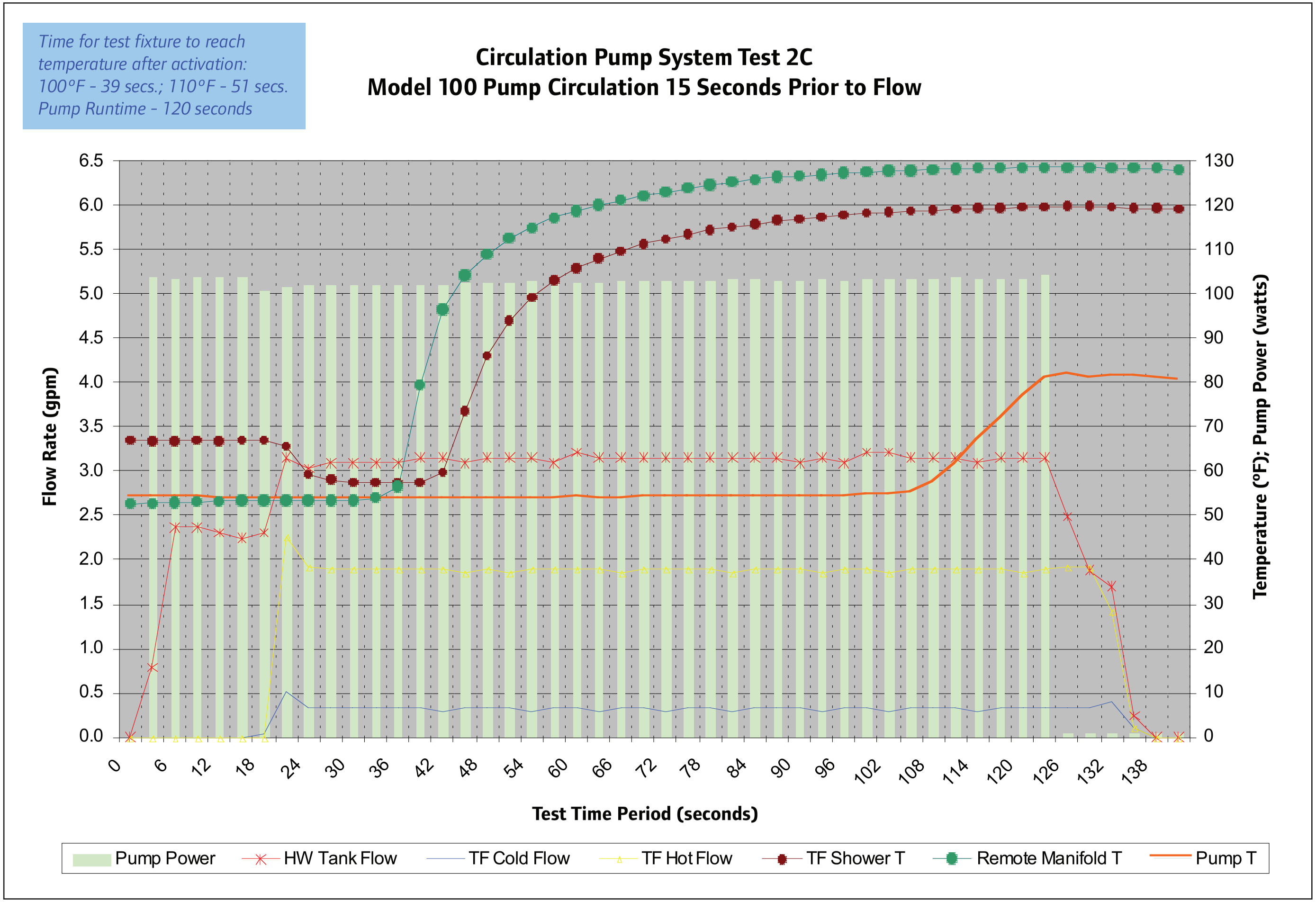


Figure 11-10: Recirculation System Test 2C

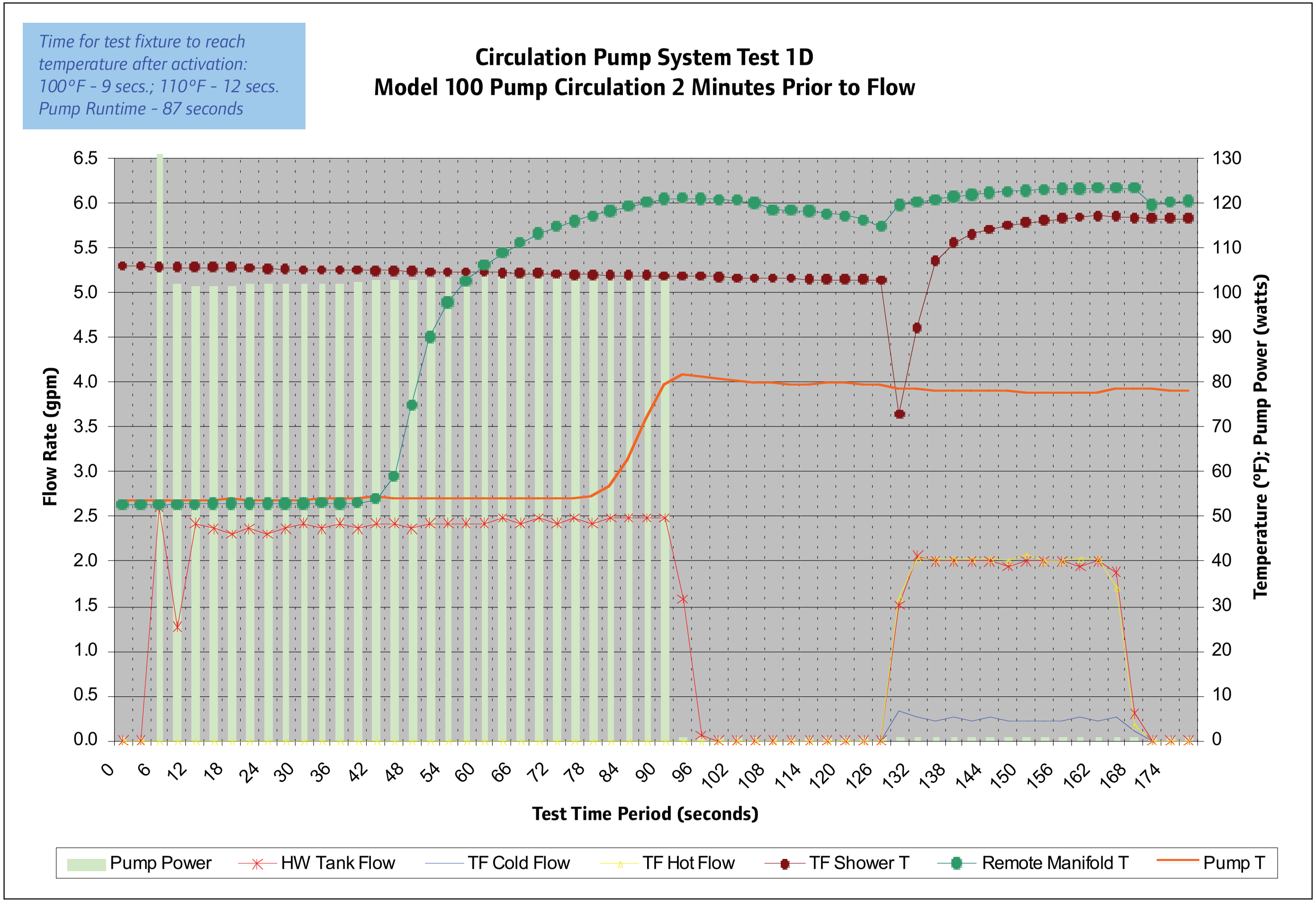


Figure 11-11: Recirculation System Test 1D

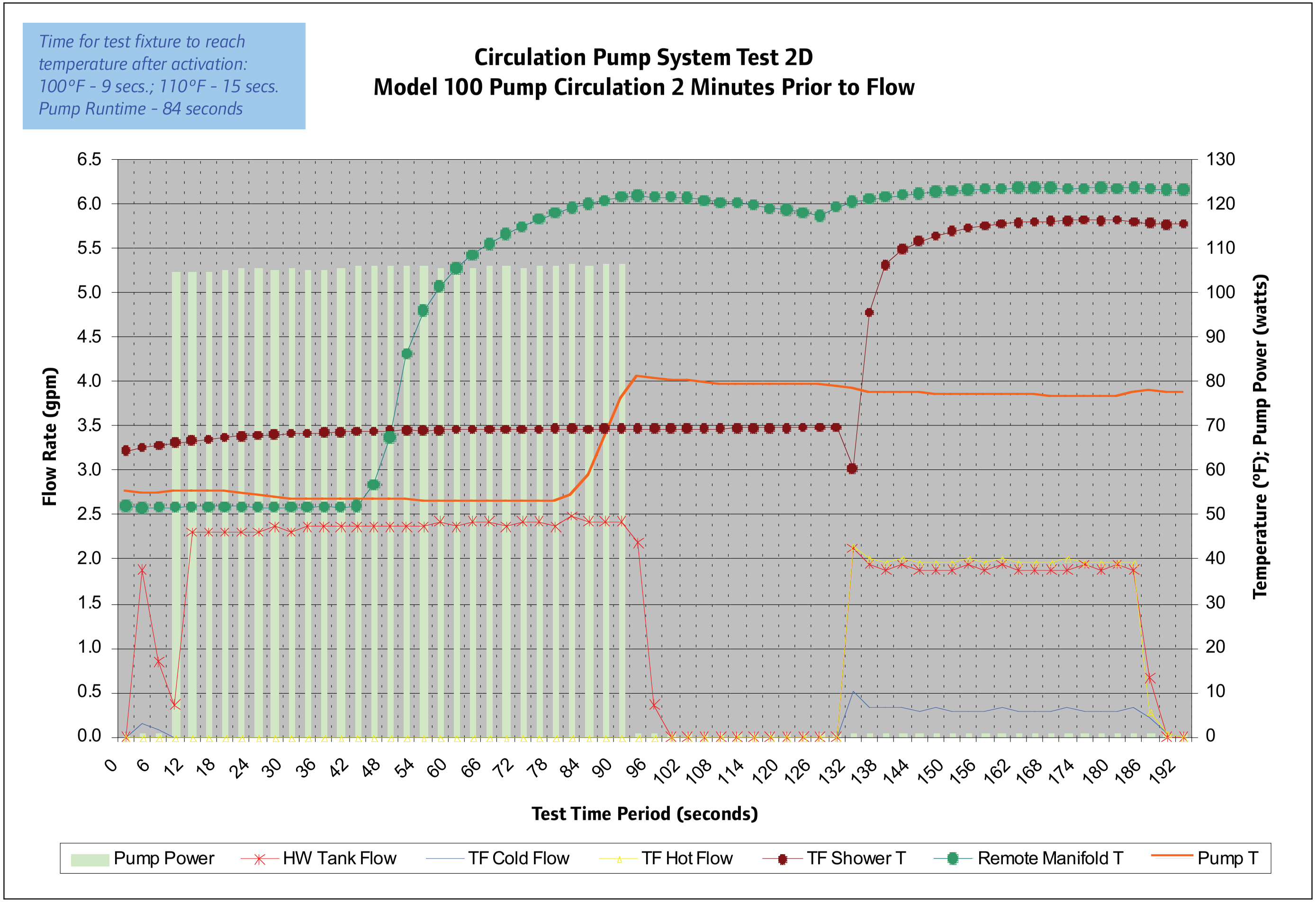


Figure 11-12: Recirculation System Test 2D

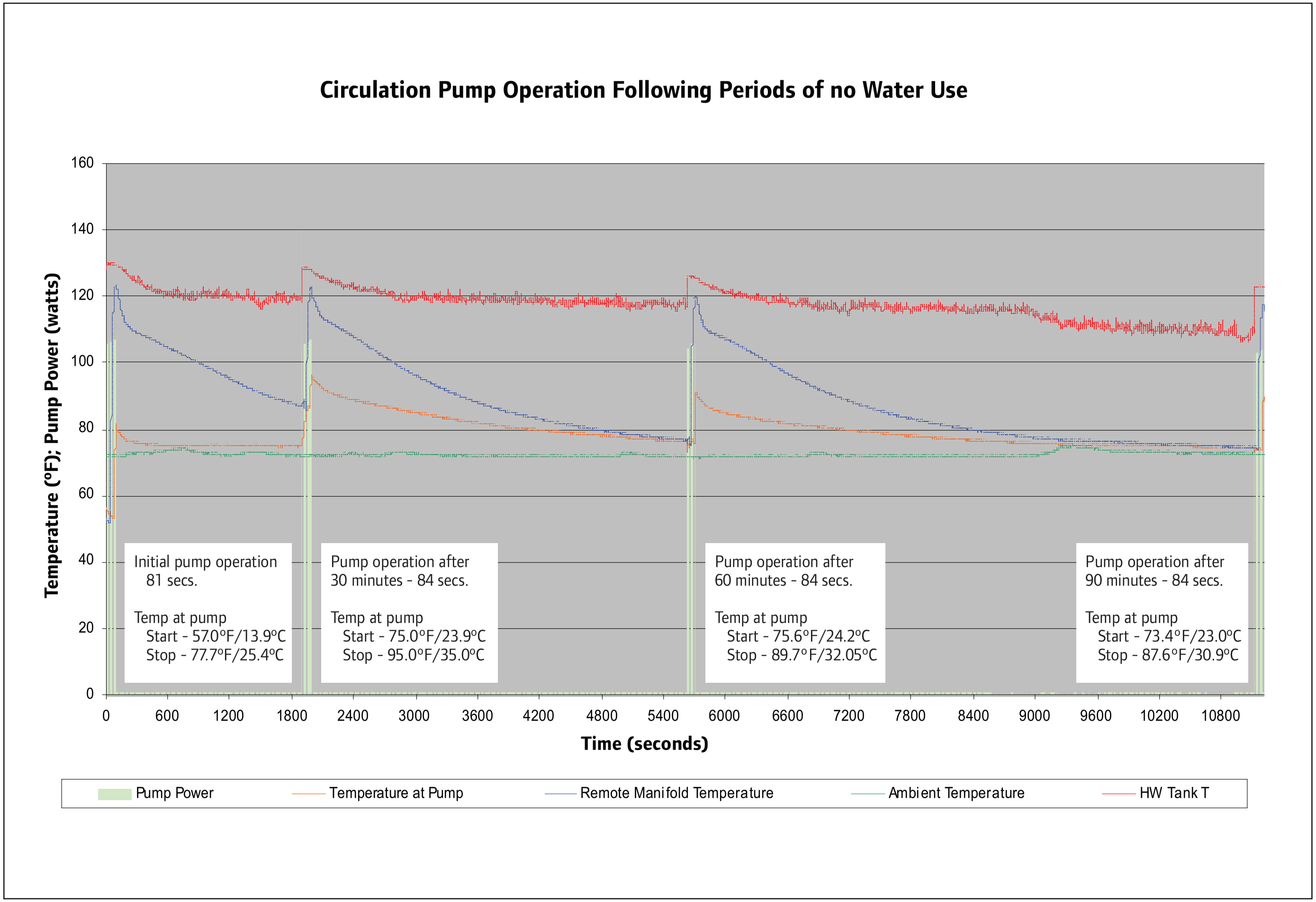


Figure 11-13: Sequential Operations of the Circulation Pump

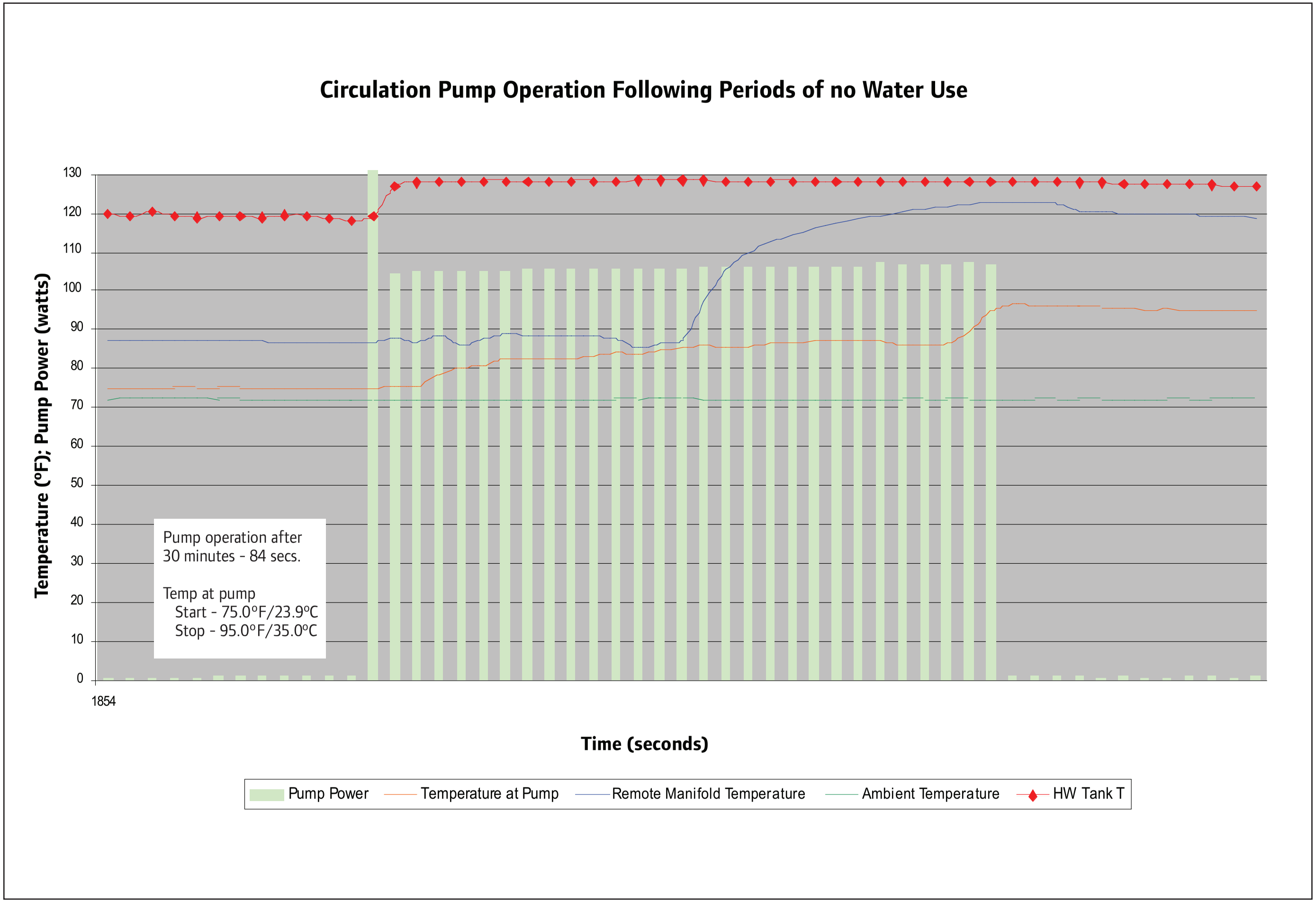


Figure 11-14: Snapshot of Circulation Pump Operation Following 30-minute Rest From the Previous Operation

Examples of Uponor Logic

As with the design guide, Uponor Logic was developed for three different house types — a two-story single-family house with 2.5 baths; a townhouse with two stacked baths; and a single-family ranch-house. A fourth house design — a condominium floor plan — was not developed since the typical hot-water supply is from a central water-heating system that does not lend itself to use of individual hot-water circulation systems.

The example layouts shown in **Figures 11-15** to **11-17** on **pages 104** to **106** indicate Uponor Logic with the circulation loop tubing and pump at the water heater.

Based on each of the Uponor Logic designs, a fitting count and pipe length table was developed. The tubing lengths and fitting counts are similar to those developed originally for the design guide for the remote-manifold system design but with the addition of the circulation loop. **Table 11-3** lists the Uponor Logic fitting count and tubing lengths for each house layout. For comparison, **Table 11-4** lists the originally tested remote-manifold design fitting count and tubing lengths for each house layout.

System	Length of cold pipe			Length of hot pipe			Return pipe	Fittings		Joints		Manifolds
	1"	3/4"	1/2"	1"	3/4"	1/2"	3/4"	Tees	Elbows	Fixtures	Piping	Remote
Colonial	27'	93'	152'	0'	93'	107'	72'	8	15	26	95	7
Ranch	25'	59'	196'	0'	59'	159'	66'	8	4	21	61	4
Townhouse	0'	67'	100'	0'	30'	44'	38'	7	7	15	52	2

Table 11-3: Uponor Logic Fitting Count and Tubing Length With Recirculation Loop

System	Length of cold pipe			Length of hot pipe			Fittings		Joints		Manifolds
	1"	3/4"	1/2"	1"	3/4"	1/2"	Tees	Elbows	Fixtures	Piping	Remote
Colonial	27'	93'	152'	0'	93'	107'	8	13	27	83	7
Ranch	25'	59'	196'	0'	59'	159'	8	4	23	53	4
Townhouse	0'	67'	100'	0'	30'	44'	5	7	17	42	2

Table 11-4: Remote-manifold Plumbing System Fitting Count and Tubing Length

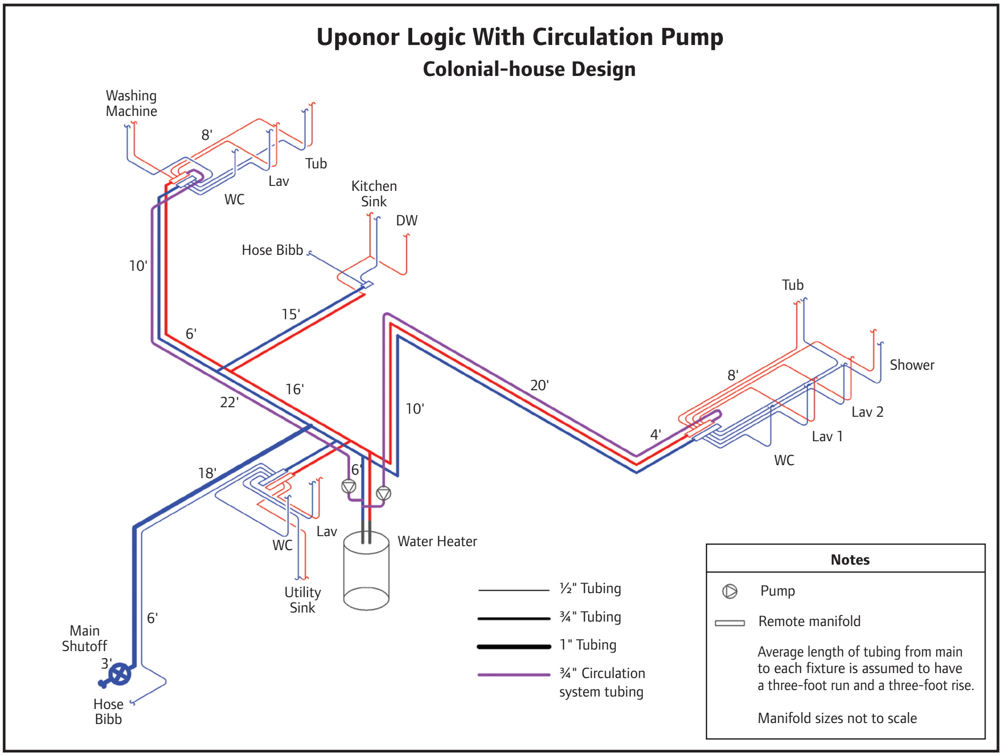


Figure 11-15: Uponor Logic for a Typical Colonial-house Plan

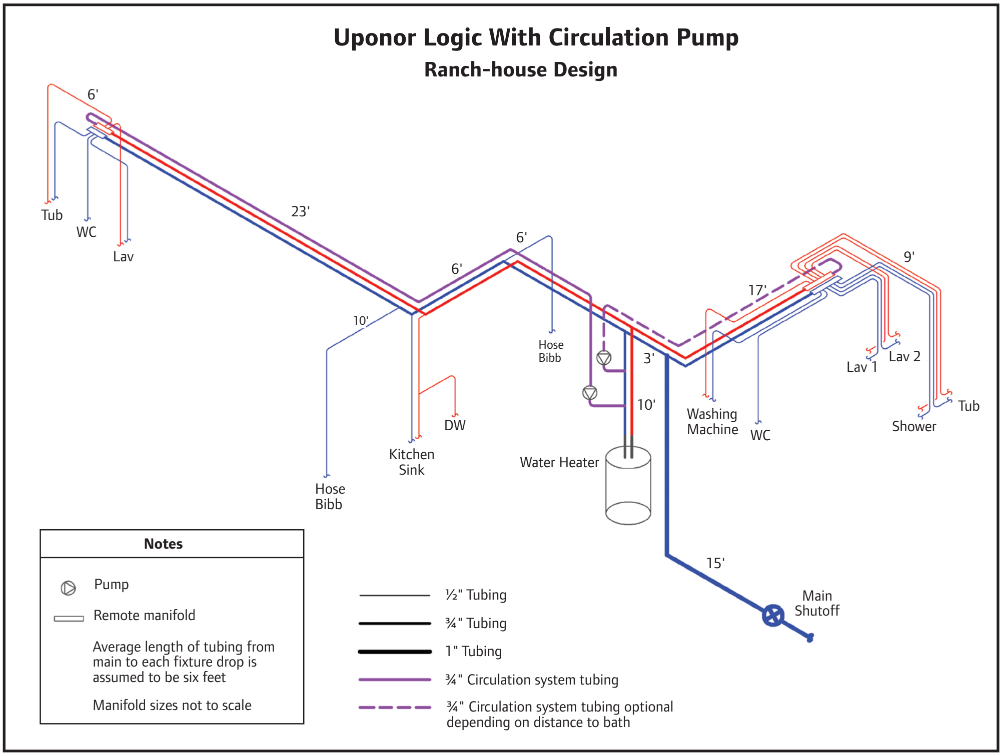


Figure 11-16: Uponor Logic for a Typical Ranch-house Plan

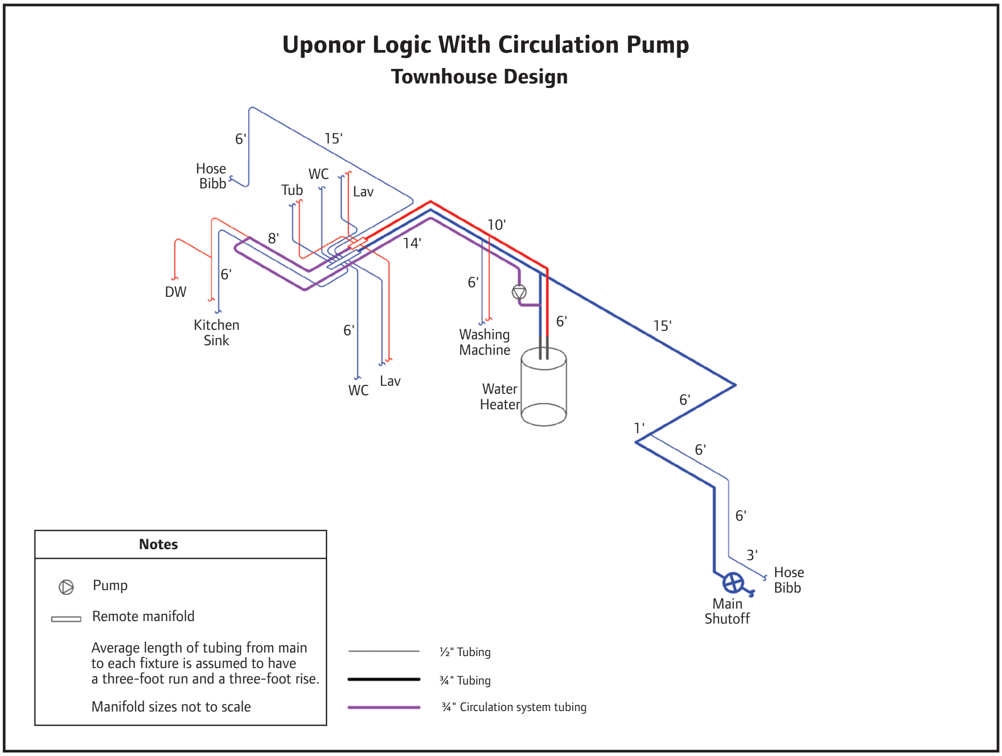


Figure 11-17: Uponor Logic for a Typical Townhouse Plan

Summary

Uponor Logic that includes a remote manifold within 10 feet of the fixtures and a circulation pump that is connected between the remote manifold and the hot-water tank was tested for flow and pressure characteristics and time-to-hot water characteristics. When compared to previous testing of a remote-manifold system design, the flow and pressure characteristics are nearly identical.

While the time-to hot water for Uponor Logic is very similar to that of the remote-manifold system tested originally, the time-to-hot water characteristics are markedly different for Uponor Logic with a circulation pump. However, as expected, the timing of the circulation-pump activation is critical to reducing the hot-water delivery time to a minimum. When the circulation pump is activated simultaneously with the fixture flow, the hot-water delivery time is similar to that of the home-run system design tested originally. There is a slight reduction in wait time when the circulation pump is activated 15 seconds prior to the fixture flow. There is a large reduction in wait time when the pump is activated two minutes prior to fixture flow. The data also indicates that an approximate one-minute delay after pump activation prior to fixture operation would be sufficient for fixtures up to 100 feet to circulate hot water to the remote manifold and reduce the wait time for hot water to a minimum.

Uponor Logic for various house layouts has been developed. A count of the fittings and tubing lengths associated with each layout was also developed for comparison with other PEX system designs provided in the design guide. Differences in the components required for the system installation for Uponor Logic are primarily due to the additional use of ¾-inch tubing for the return line(s) to the water heater and the additional fittings.

Addendum Report — Hot-water Recirculation System With Uponor Logic

This report summarizes test results for Uponor Logic installed using the Model 200 circulation pump, which replaced the Model 100 circulation pump used in the original test set. Testing with the Model 200 pump included the time-to hot water tests using the similar test setup used with the Model 100 pump. The four tests that encompassed the time-to-hot water characteristics include:

- No operation of the circulation pump
- Activation of the circulation pump simultaneous with the shower operation
- Activation of the circulation pump 15 seconds prior to the shower operation
- Activation of the circulation pump two minutes prior to the shower operation

Basic comparative performance characteristics between a system installed with the Model 100 circulation pump and the same system installed with the Model 200 circulation pump are shown in **Table 11-5** on **page 109**. Each row in the table indicates one activation of the pump. The unshaded rows are activations of the pump where the shower test fixture operated simultaneously. The shaded rows indicate operation of the pump without simultaneous fixture flow. The dark-shaded rows for the Model 100 pump are tests where the initial water temperature was higher than for other tests.

Installed with Uponor Logic, the pumps include 90 feet of Wirsbo AQUAPEX tubing from the water heater to the most remote manifold and 90 feet back to the water heater. The average pump power for the Model 100 is about 103 watts; for the Model 200, about 216 watts. The Model 200 pump used roughly 34% more energy with an average increase in flow rate of 61%.

The Model 200 pump delivered hot water to the remote manifold on average 30 seconds, or about one-third faster than the Model 100 pump. Generally, the Model 200 pump delivered hot water to the manifold in just under one minute where the Model 100 pump delivered hot water in about one and a half minutes. With simultaneous flows — for example, the shower is activated at the same time as the pump — the difference is more pronounced with hot water delivered to the manifold in about half the time using the Model 200 pump from the Model 100 pump. The additional pump energy was less than 15% with simultaneous flow of the shower and pump.

Using data from previous test and including this test set of the Model 200 pump, the time-to-hot water comparison, as shown in **Figure 11-18** on **page 110**, indicates that the primary benefit of the Model 200 pump occurs when there are simultaneous flows of a faucet along with activation of the pump.

The individual test results collected for this report are shown in **Figures 11-19** to **11-30** on **pages 111-122.**

Pump Type	Pump Average Flow Rate (gpm)	Off Delta T at pump (°F)	Pump Operation (seconds)	Pump Minimum Temp. (°F)	Pump Maximum Temp. (°F)	Pump Delta T per Operation (°F/sec)	Pump Energy (watts per hour)
Model 100	1.25	27.5	117	53.5	81.0	0.235	3.20
Model 100	1.39	25.3	117	53.5	78.8	0.216	3.27
Model 100	1.23	25.9	117	53.4	79.3	0.222	3.29
Model 100	1.38	27.4	123	53.6	81.0	0.234	3.52
Model 100	2.42	25.7	84	53.3	79.0	0.305	2.41
Model 100	2.37	23.1	84	52.9	76.0	0.275	2.47
Model 100	2.37	23.9	84	50.6	74.5	0.285	2.48
Model 100	2.35	24.4	84	53.3	77.7	0.290	2.49
Model 100	2.47	19.2	84	75.8	95.0	0.229	2.48
Model 100	2.44	16.3	87	73.4	89.7	0.187	2.53
Model 100	2.43	14.3	87	73.3	87.6	0.164	2.49
Model 200	2.74	35.0	63	54.1	89.1	0.556	3.80
Model 200	2.74	34.9	63	54.6	89.5	0.554	3.77
Model 200	2.95	33.1	66	51.7	84.8	0.501	3.95
Model 200	2.96	33.8	66	50.7	84.5	0.512	3.93
Model 200	2.75	27.0	60	54.0	81.0	0.451	3.58
Model 200	3.02	30.0	63	52.3	82.3	0.476	3.74
Model 200	2.73	33.3	63	56.2	89.5	0.529	3.68
Model 200	2.76	30.9	60	53.6	84.5	0.515	3.55
Model 200	3.89	31.3	54	55.6	86.9	0.580	3.29
Model 200	3.90	33.1	54	51.2	84.2	0.612	3.32
Model 200	3.83	35.6	57	52.1	87.7	0.625	3.48
Model 200	3.88	27.6	54	53.7	81.3	0.511	3.19

Table 11-5: Models 100 and 200 Circulation Pumps Performance Characteristics

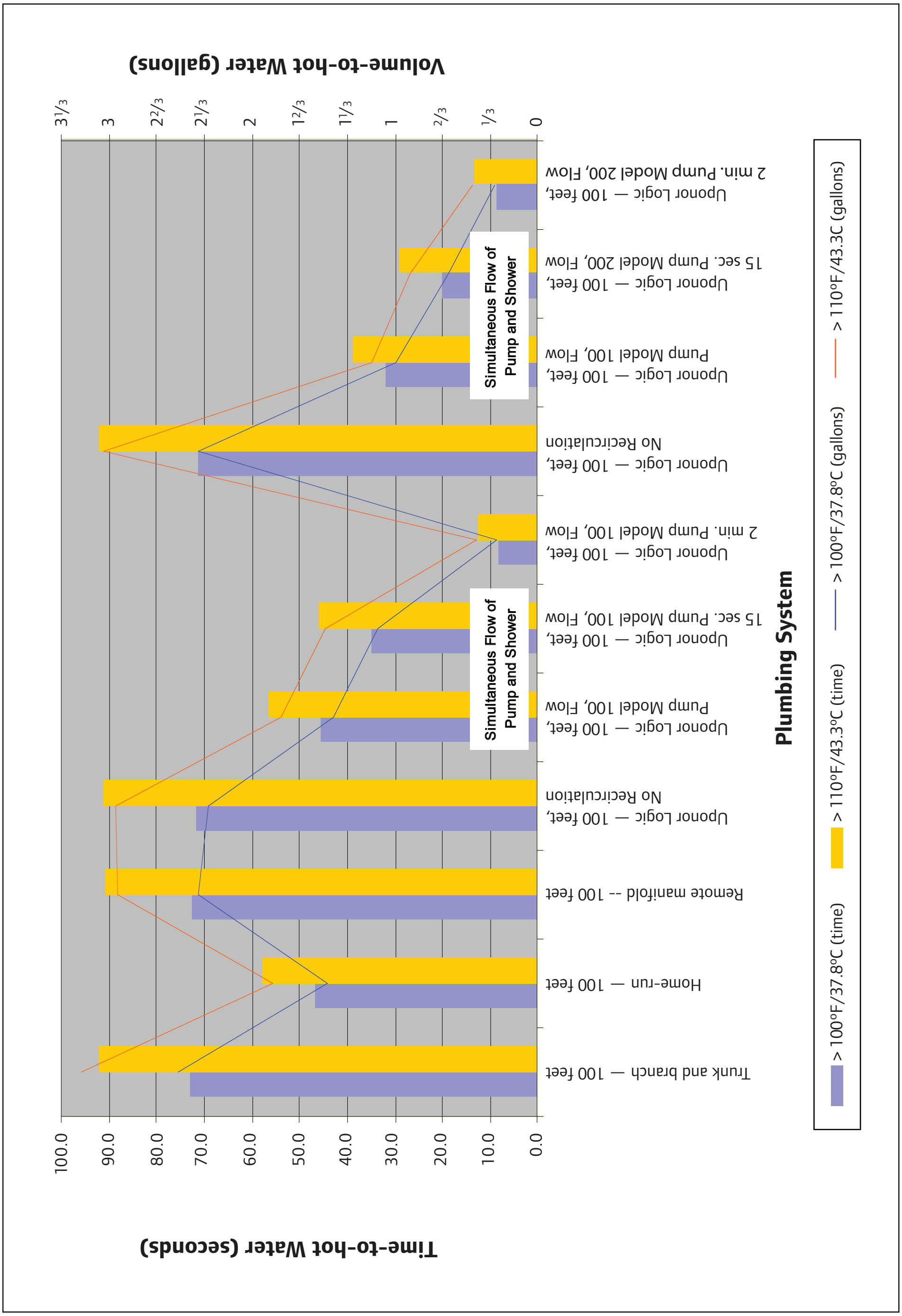


Figure 11-18: Comparison of Time-to-hot Water at Shower

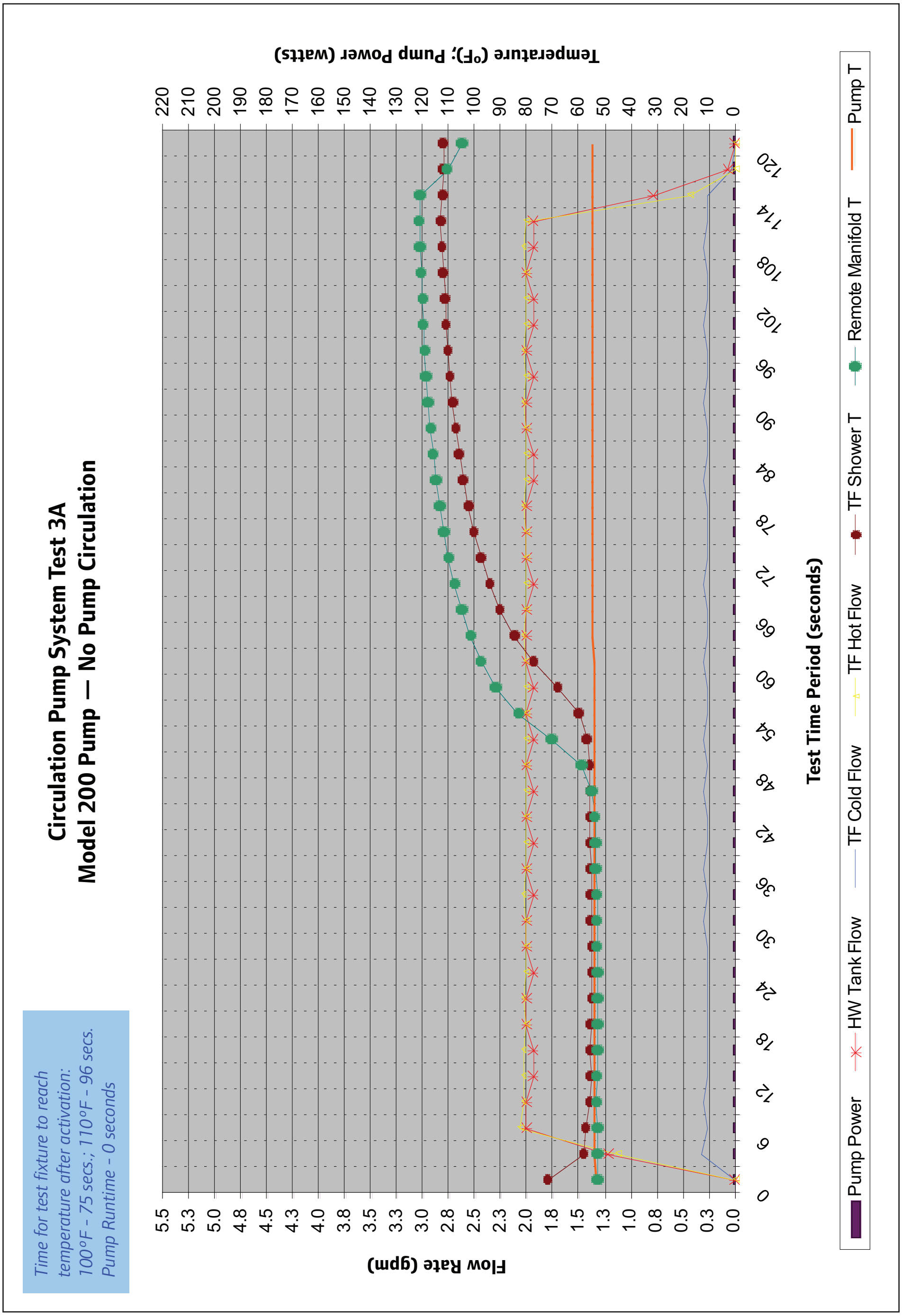


Figure 11-19: Recirculation System Test 3A

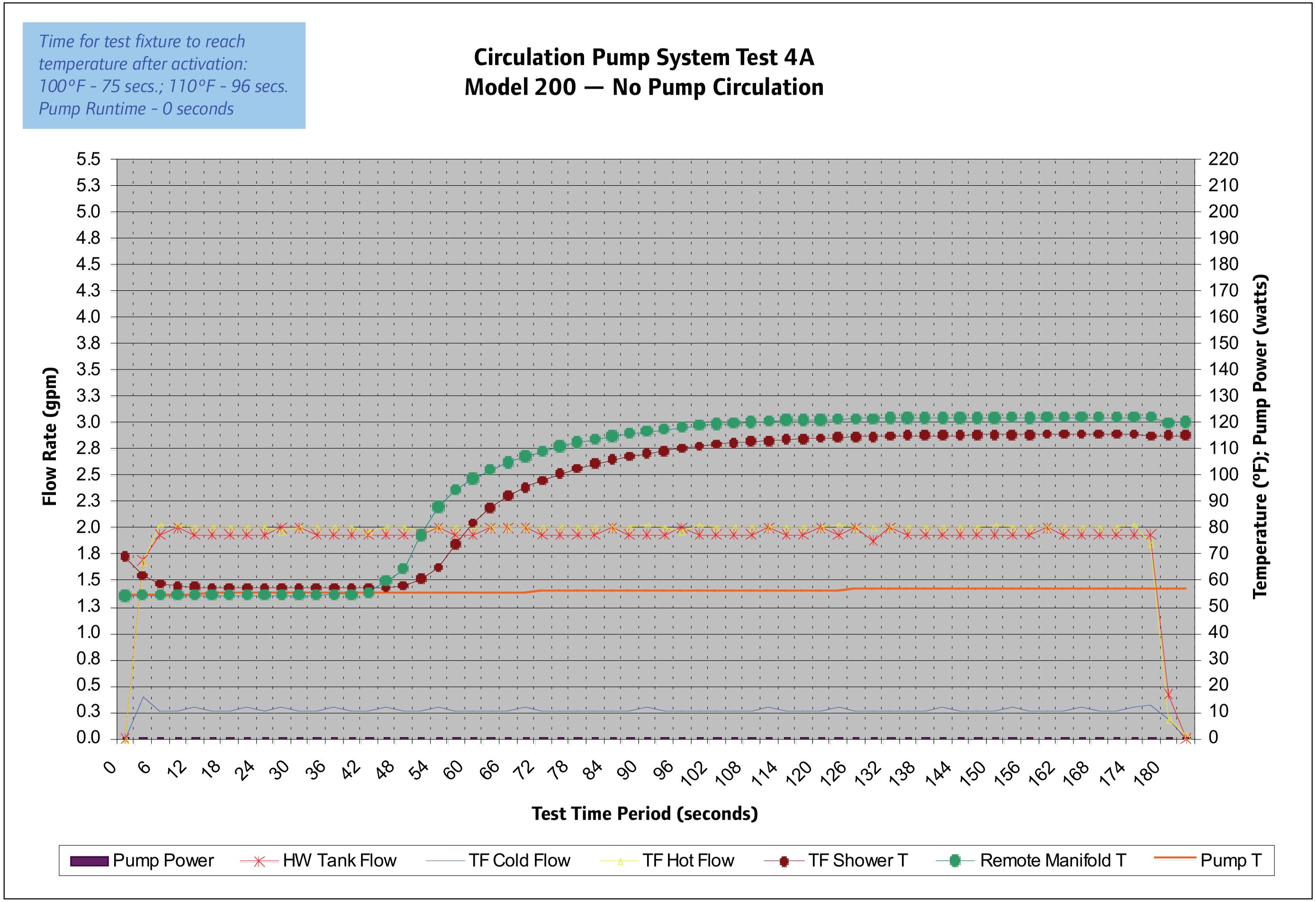


Figure 11-20 : Recirculation System Test 4A

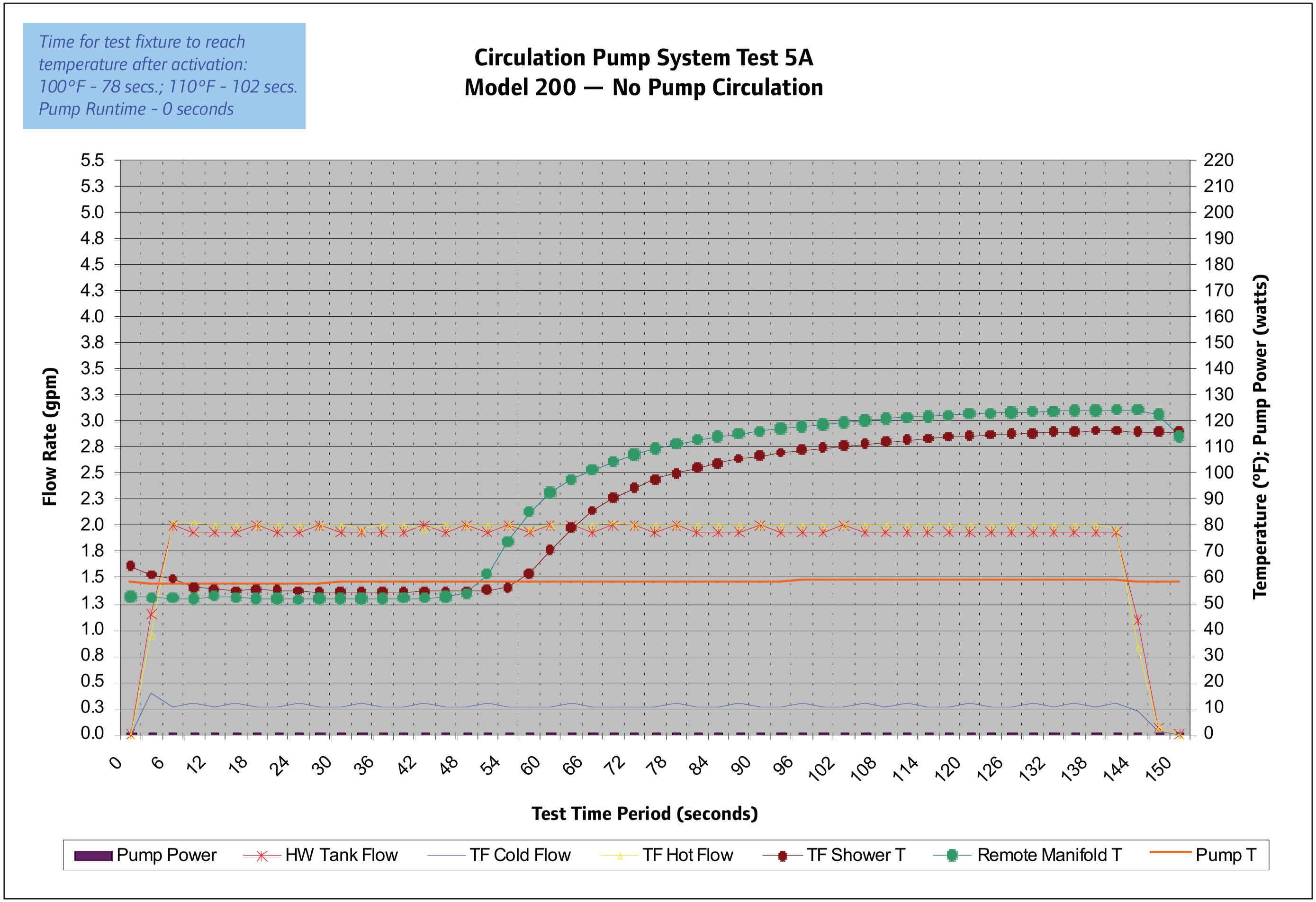


Figure 11-21: Recirculation System Test 5A

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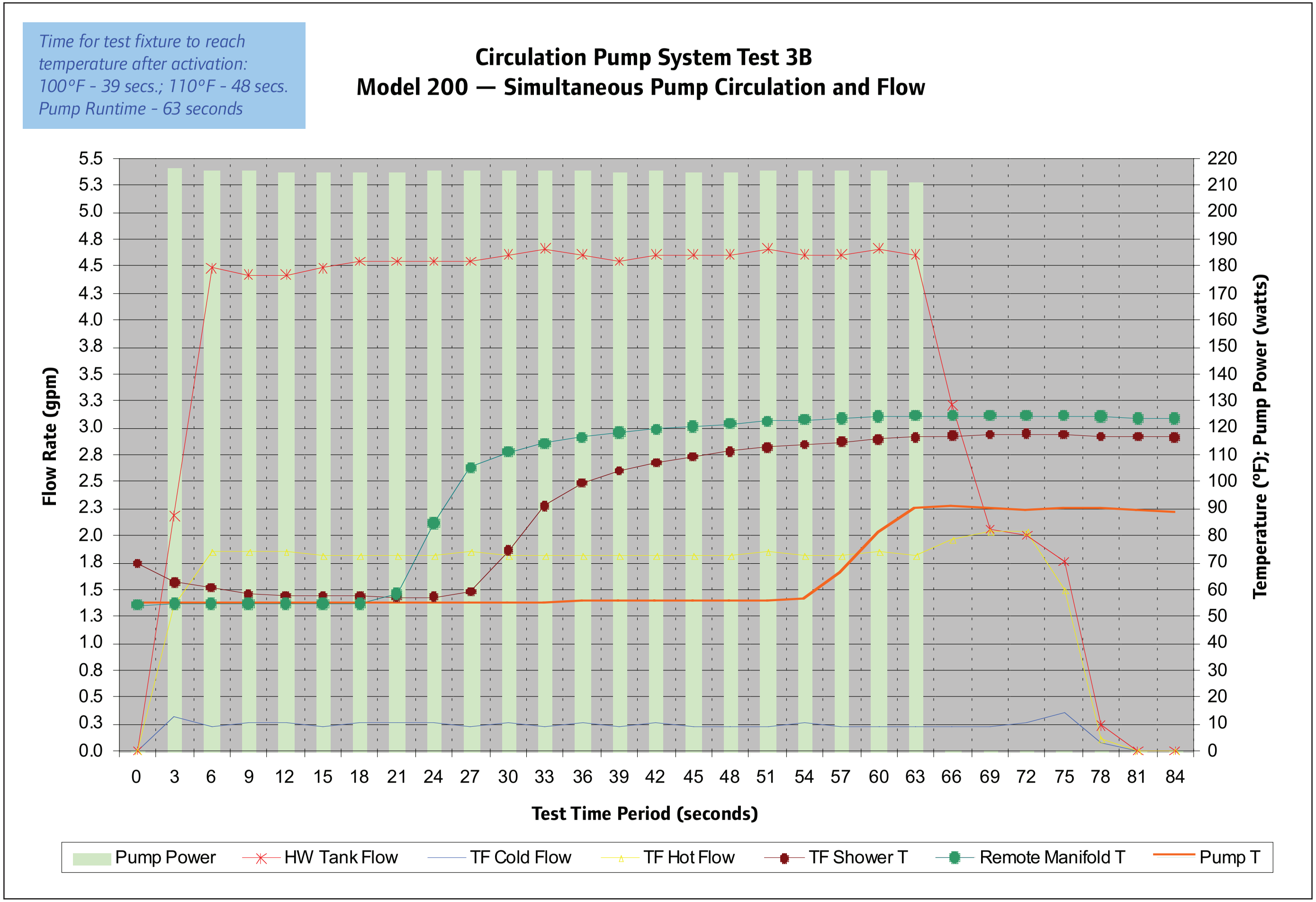

Figure 11-22: Recirculation System Test 3B

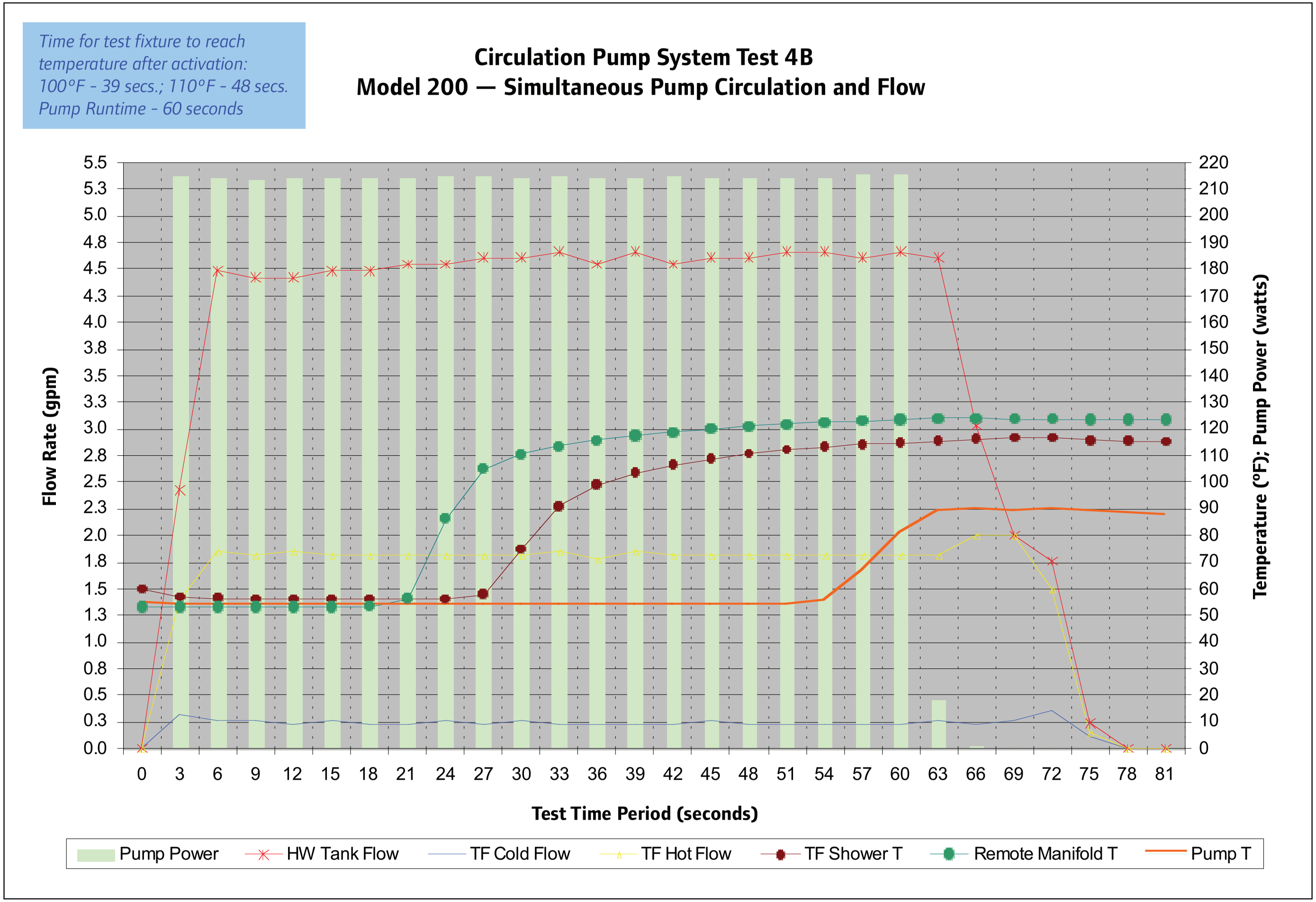

Figure 11-23: Recirculation System Test 4B

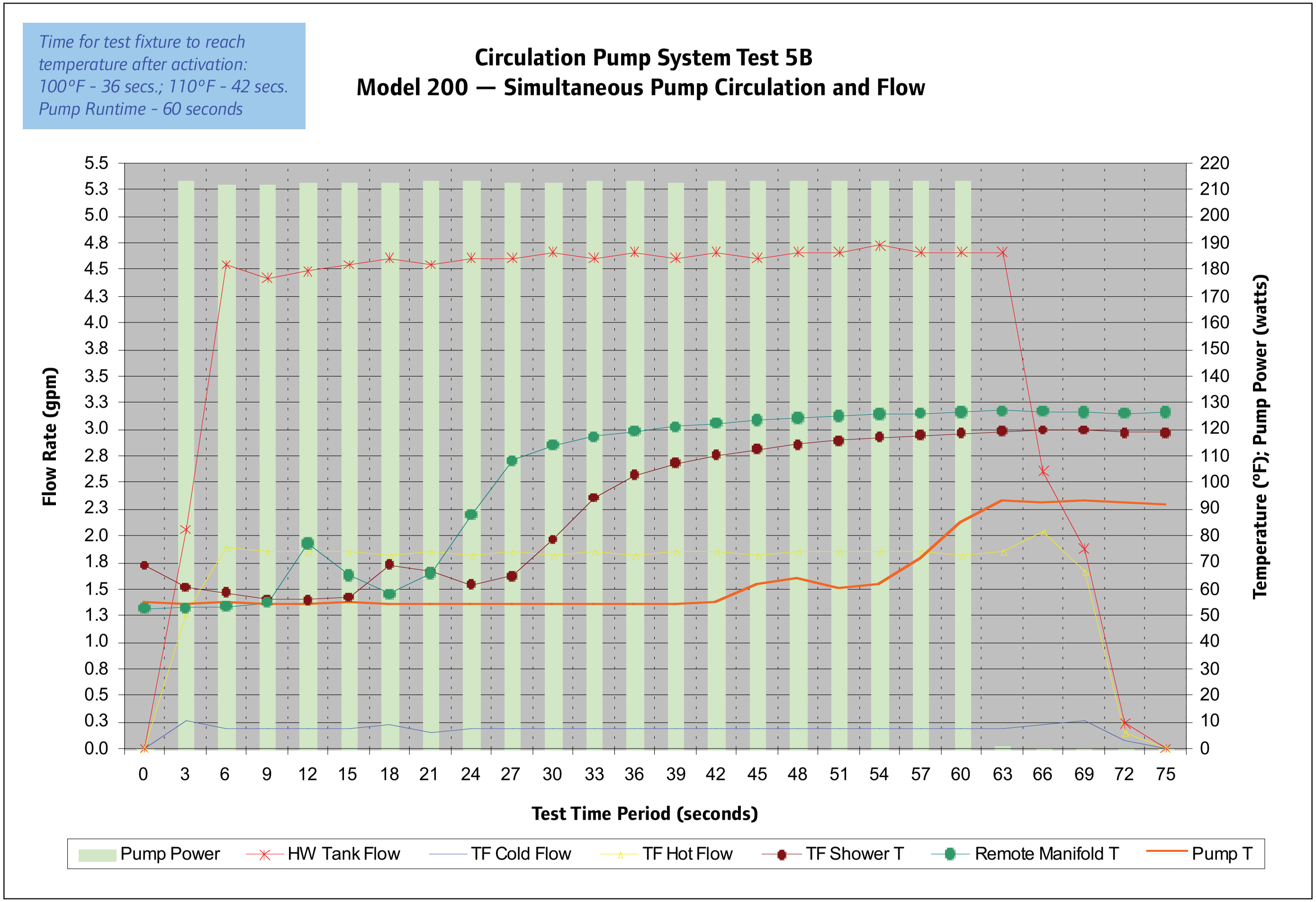

Figure 11-24: Recirculation System Test 5B

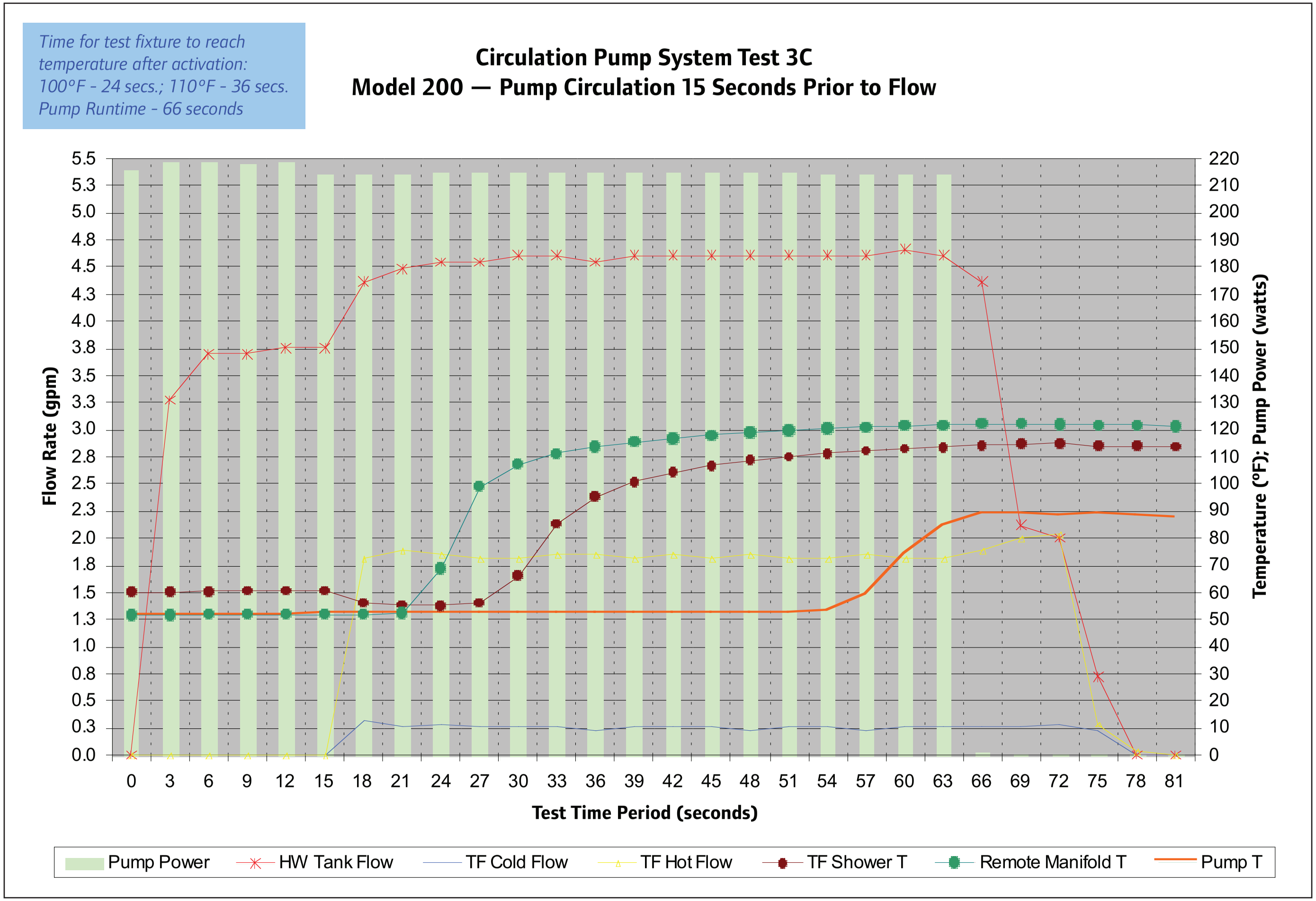

Figure 11-25: Recirculation System Test 3C

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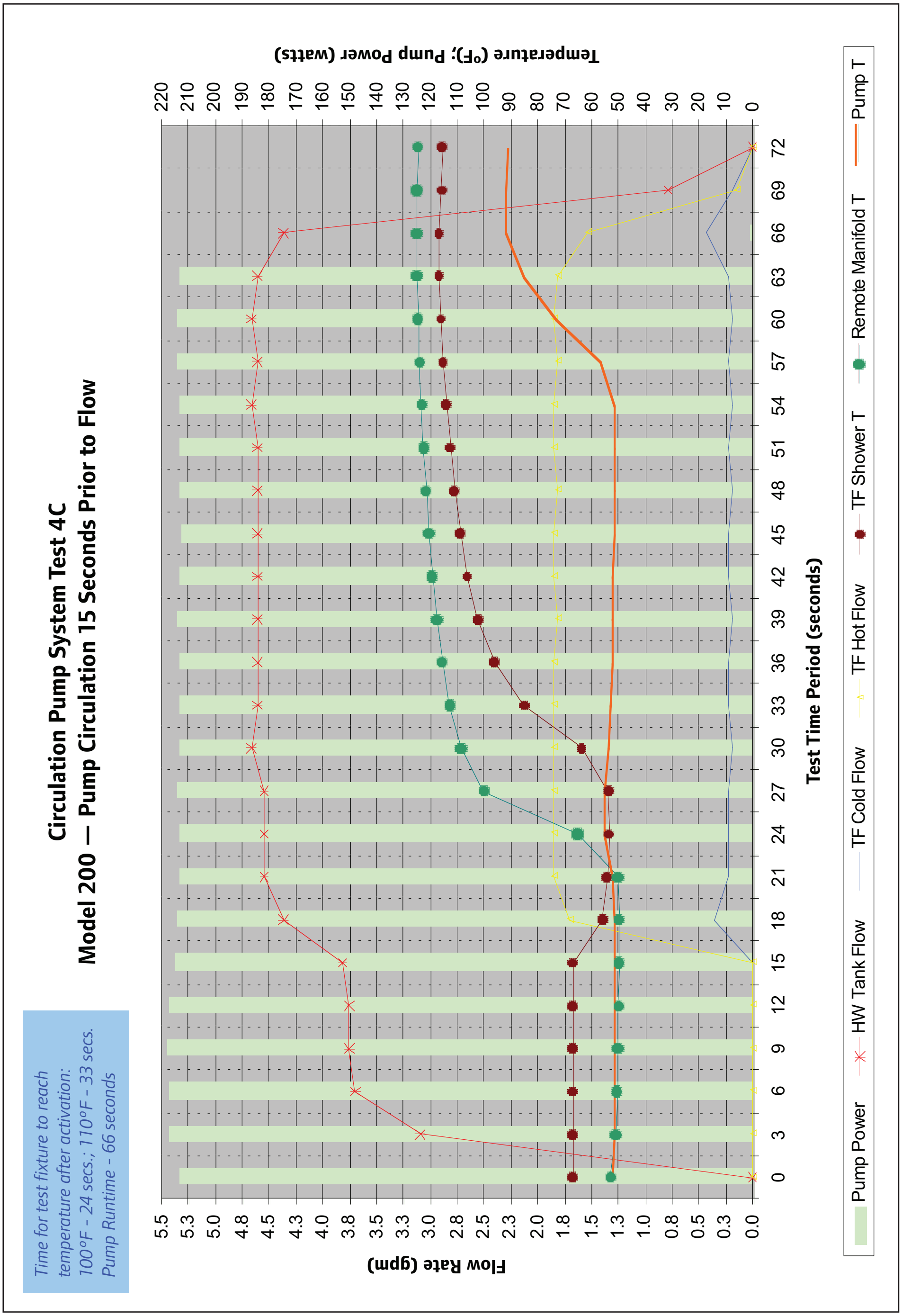

Figure 11-26: Recirculation System Test 4C

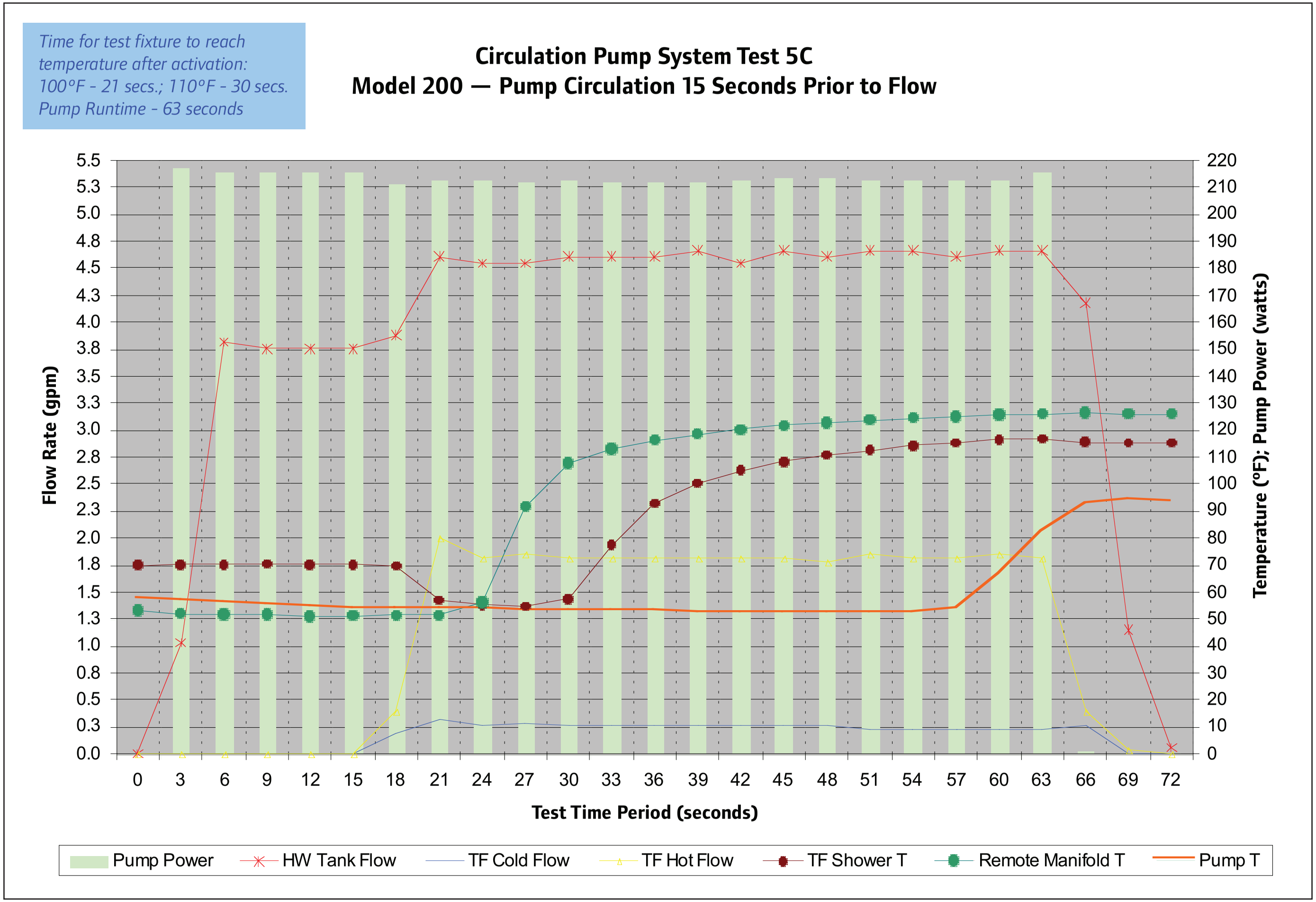

Figure 11-27: Recirculation System Test 5C

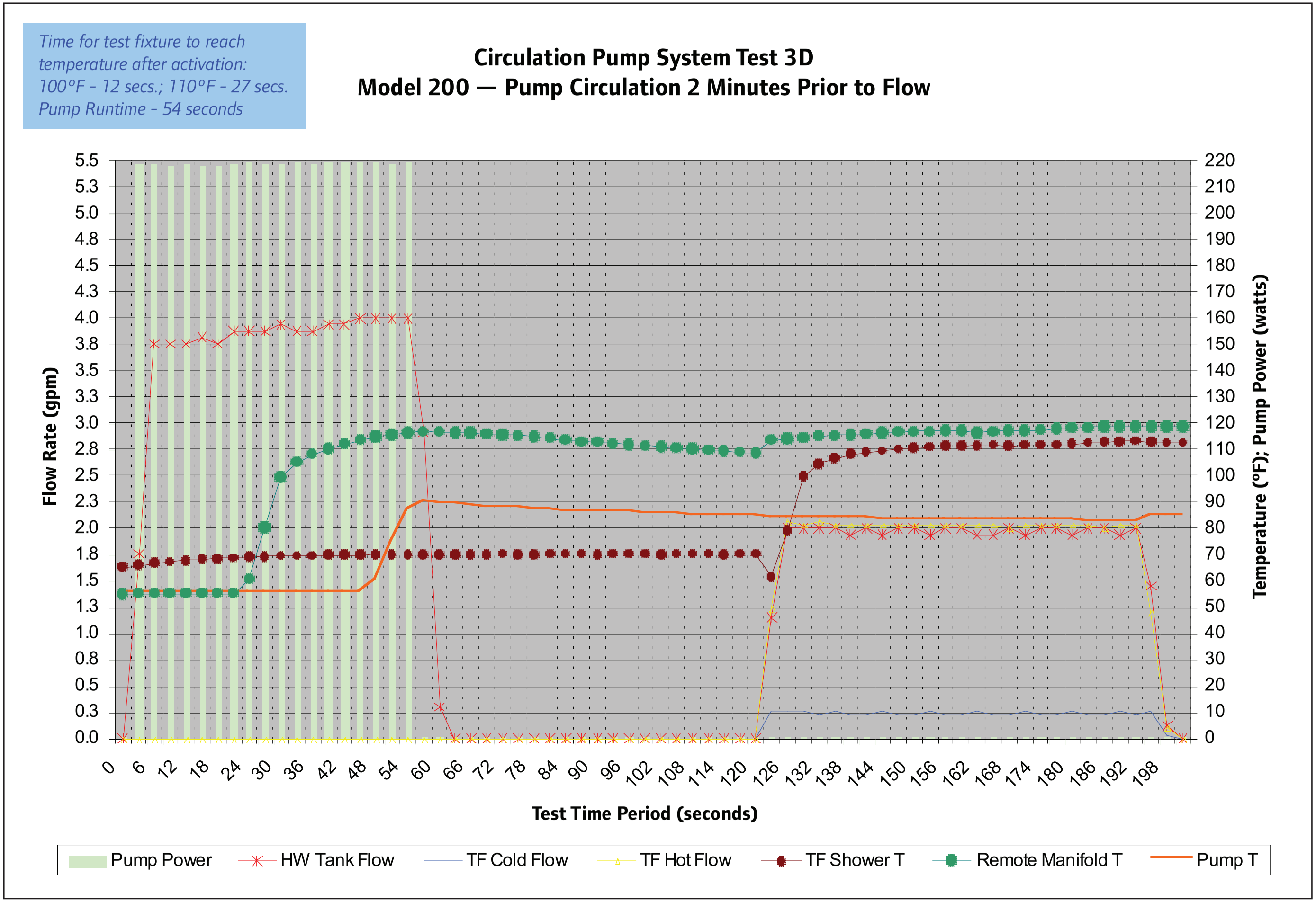

Figure 11-28: Recirculation System Test 3D

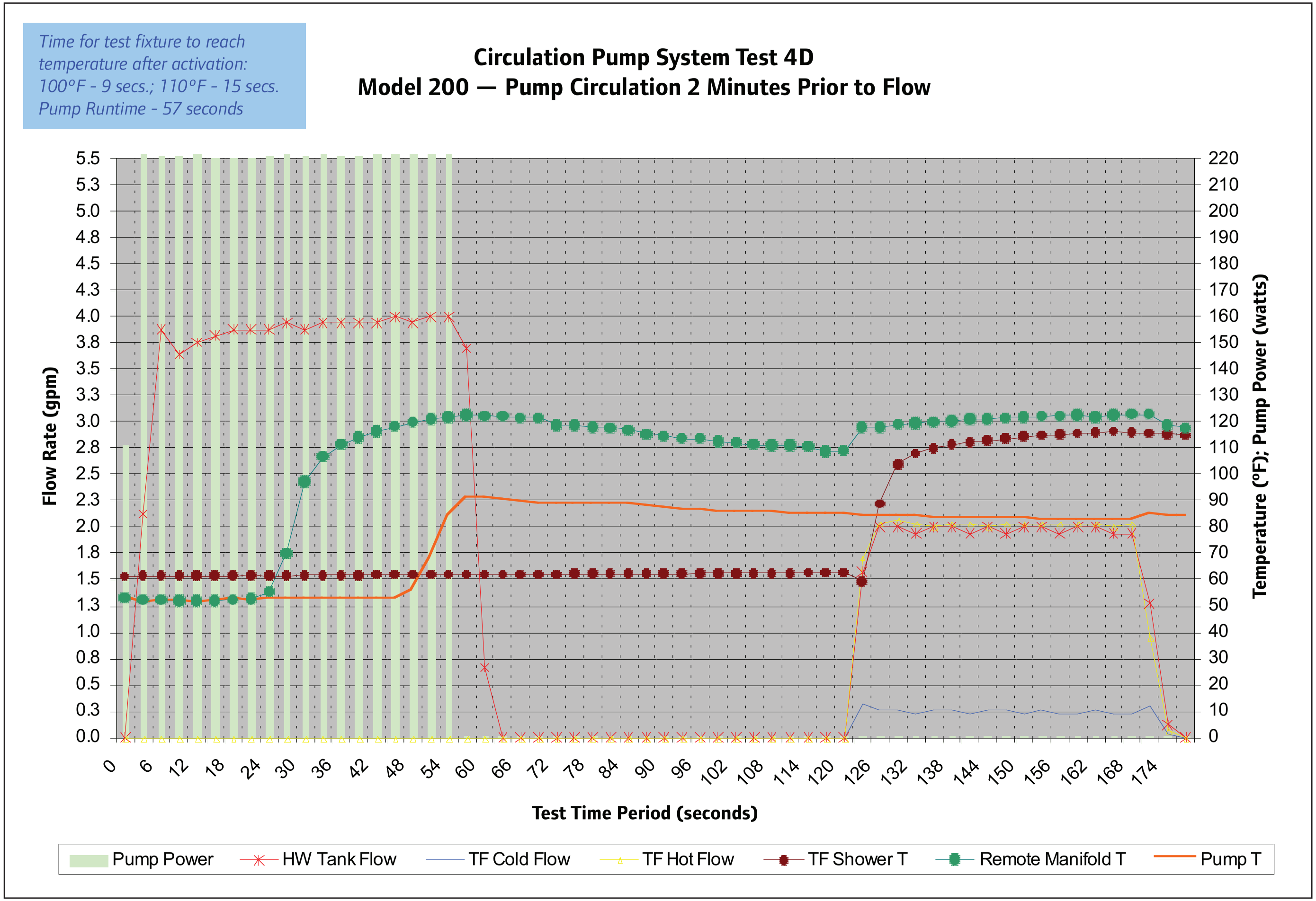

Figure 11-29: Recirculation System Test 4D

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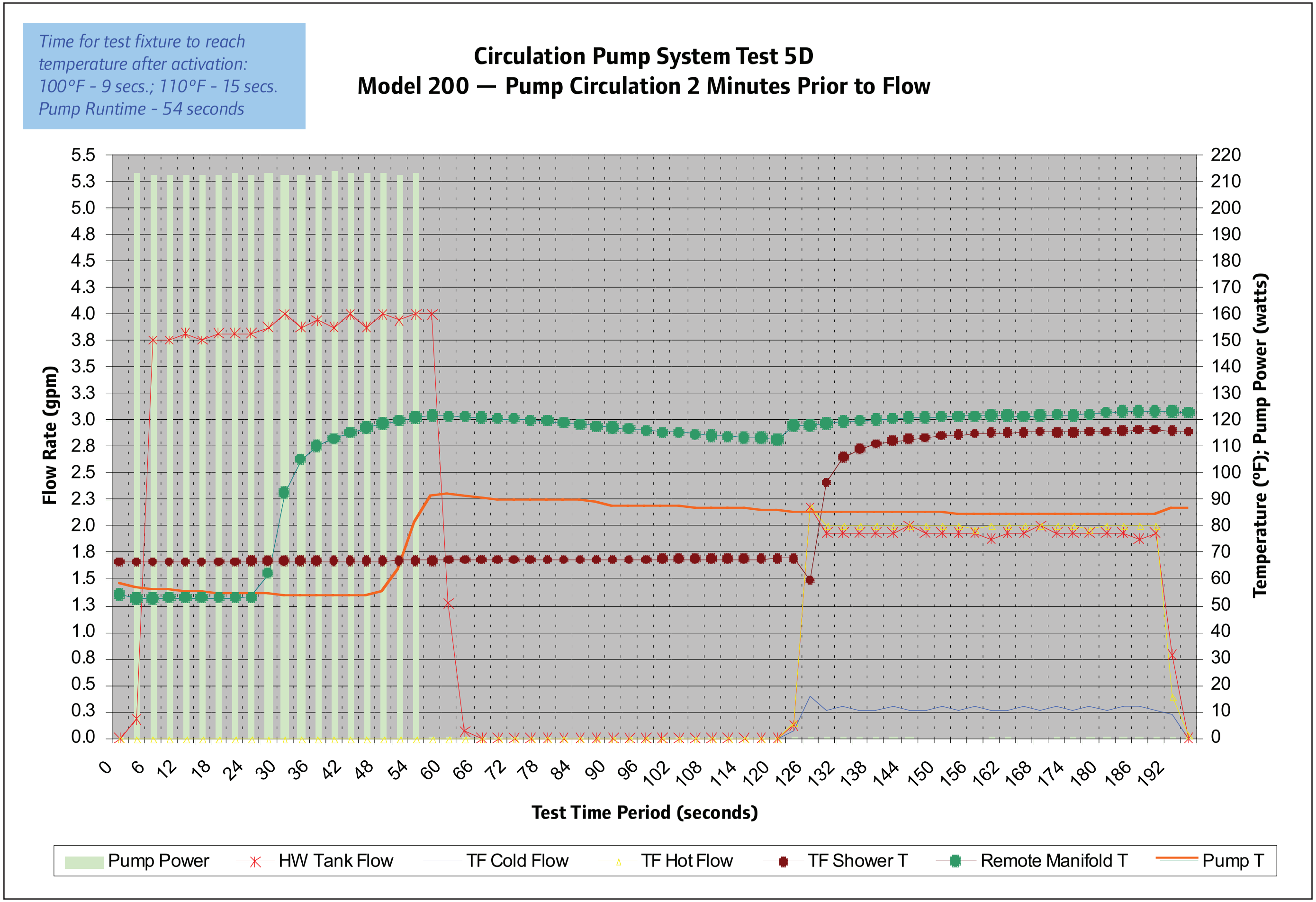


Figure 11-30: Recirculation System Test 5D

Section 12 —

Water Service

Requirements

Wirsbo AQUAPEX tubing and associated fittings meet the requirements of American Water Works Association (AWWA) C904, which is the standard for water-service applications of PEX tubing.

Handling and Repairs

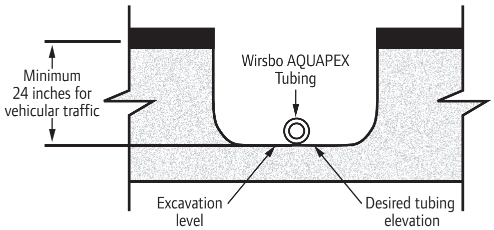
Although Wirsbo AQUAPEX tubing is highly resistant to kinking and abrasion, take care while handling and installing the tubing to prevent damage and possible failure of the tubing. If damage occurs during installation, the area should be cut out and repaired before backfilling.

To reform kinked tubing, see **Section 1** on **page 18**. If damaged beyond the tubing's thermal-memory capacity, use a ProPEX Repair Coupling. Do not reuse or reclaim EP fittings.

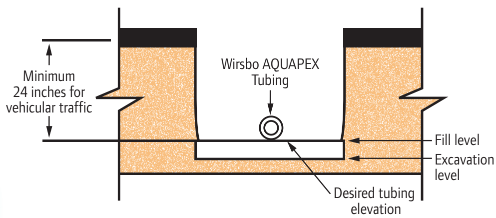
Trench-bottom Preparation

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

Good-soil Conditions — If the trench is cut smoothly, install the tubing directly on the prepared bottom. The bottom must be flat with no hollows, lumps or rocks.



Poor-soil Conditions — In 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.



Installation

Install Wirsbo AQUAPEX tubing underground in a manner that ensures external loads will not subsequently cause a decrease in the vertical dimension of the cross section of the tubing that exceeds 5% of the outside diameter. Install Wirsbo AQUAPEX tubing 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 Wirsbo AQUAPEX tubing is approximately 1.1 inch per 10ºF/12.2ºC temperature change for every 100 feet of tubing.

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

Caution: Do not install Wirsbo AQUAPEX tubing 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 tubing. Where such conditions are suspected, perform a chemical analysis of the soil or groundwater to ascertain the acceptability of Wirsbo AQUAPEX tubing for the specific installation. Check local codes for additional requirements.

Joining Methods and Fittings

Use ProPEX or approved compression fittings to connect tubing to itself or to the corporation and curb stops. Check with Uponor or the fitting manufacturer for application suitability and proper-usage instructions.

For applications requiring direct burial, Uponor offers dezincification-resistant brass ProPEX fittings for large-dimension Wirsbo AQUAPEX tubing.

When using compression fittings with Wirsbo AQUAPEX tubing, a stiffener is required on the inside of the tubing at the connection.

Tubing Embedment

Proper soil selection, placement and compaction are essential in the area around the tubing. Backfill the tubing with sand or gravel of ¾-inch maximum particle size.

Compact the initial backfill around the tubing to provide adequate tubing support and prevent settlement. It is particularly important to adequately compact the soil around the tap connection. It is recommended to pressurize the tubing prior to backfilling to reveal any damage. In heavy vehicular traffic areas, compact backfill to 90% 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 tubing. Compact the backfill from the subgrade to a level per local code that will cover the tubing four to six inches to provide protection around the tubing and to prevent settlement that puts stress on the fittings and the tubing.

For additional information about the proper installation practices of PEX tubing in water-service applications, refer to AWWA C904.

Water-system Disinfection

Wirsbo AQUAPEX tubing should be disinfected in accordance with AWWA C651-86, Standard for Disinfecting Water Mains, or local codes.

Important: To prevent reduced service life of system components, disinfection solutions should not stand in the system longer than 24 hours. Flush the system with potable water after disinfection.

Section 13 —
Sound Intensity

Copper to PEX

When considering the change in sound intensity when switching from copper to PEX tubing, 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, $\Lambda^2 p = (1/c^2) (M^2 p / M t^2)$ and some simplifying assumptions (e.g., point source of sound), the relationship for intensity can be derived with the following form:

$I = pv$

Where I is the sound intensity, p is the sound pressure and v is the particle velocity.

The main sources of sound in a water-delivery system are cavitation surface roughness and water hammer.

Cavitation is generally a design issue, so the question is which material will absorb more of the sound. Typical polymers will absorb sound in the range of 10 dB/cm, whereas metals are on the order of 0.1-1.0 dB/cm. For a similar thickness of material, the PEX tubing would reduce the noise level approximately 10 times that of copper.

Surface roughness is very low for any plastic tubing and would be for new copper as well. There should not be a significant difference from one material to the other in this respect.

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 tubing, the dimension ratio (D/t) of PEX tubing is approximately seven, while for copper (Type K) it is approximately 11.

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

PEX tubing – 1,520 ft./second

Copper tubing – 4,240 ft./second

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 tubing, $I = 31{,}000\ (v)$

For copper tubing, $I = 242{,}000\ (v)$

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

Section 14 —
Glossary

Crosslinking — A chemical process that changes the molecular structure of a polymer material by linking otherwise independent hydrocarbon chains. Crosslinking creates a three-dimensional network of hydrocarbons. The end product is insoluble and cannot melt.

Engel Method — A peroxide-based method of manufacturing crosslinked polyethylene (PEX) tubing. Engel-method PEX is crosslinked during the extrusion process while the raw polyethylene is above its crystal melting temperature, creating an even, consistent three-dimensional network of joined hydrocarbons.

Extrusion — A method used for the continuous formation of tubing from polymer materials.

Fire-resistant Construction — Type of construction that requires the building elements, components or assembly to have a specified fire-resistant rating.

Fire-resistant Rating — The length of time a building element, component or assembly maintains the ability to confine a fire, continues to perform a given structural function or both when tested in accordance with ASTM E119 or ULC S101.

Hot-water Recirculation — System that automatically circulates the hot water from the hot-water outlet side of the water heater back to the return side of the water heater, allowing for less wait time for hot water at the fixture.

Linear Expansion (thermal) — Refers to the physical material characteristic of a body which causes it to expand in the presence of heat. It is known as heat expansion. Linear expansion creates a force within the product which, if held back by huge compressive strengths such as concrete, will transmit itself as an internal stress. Unlike other tubing products, PEX is highly resistant to stresses caused by linear expansion.

PE — Abbreviation for polyethylene

PEX — Abbreviation for crosslinked polyethylene

Pressure Loss — The loss of fluid pressure between any two points in a flow-conducting system expressed in pounds per square inch (psi). The loss of pressure is caused by friction against the tubing walls and is further influenced by the tubing size, length and texture of the inside wall of the tubing, fittings, valves and other components. Pressure loss is also influenced by the temperature and viscosity of the fluid.

Section 15 —

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Uponor, Inc.
5925 148th Street West
Apple Valley, MN 55124 USA
Phone: (800) 321-4739
Fax: (952) 891-2008
www.uponor-usa.com

Uponor Ltd.
655 Park Street
Regina, SK S4N 5N1 CANADA
Phone: (888) 994-7726
Fax: (800) 638-9517
www.uponor.ca

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