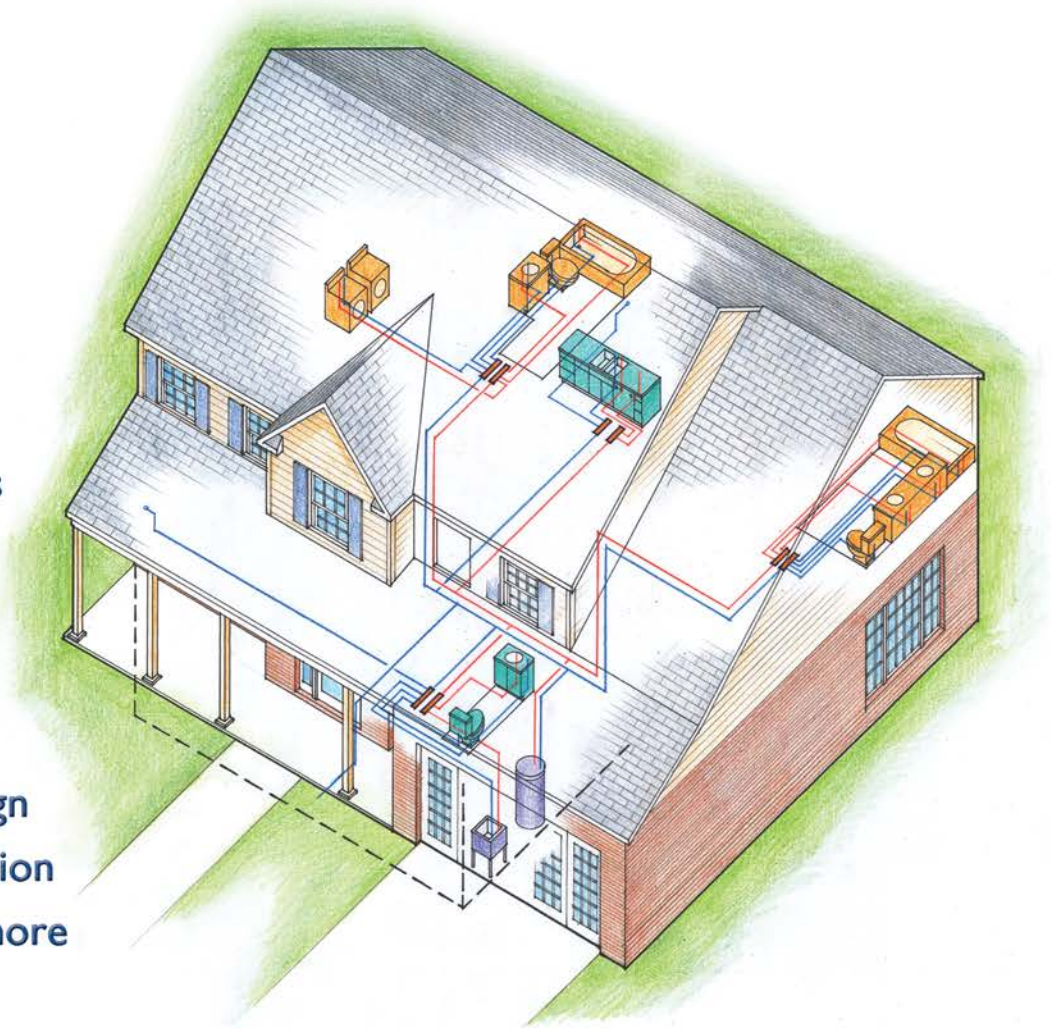
DESIGN GUIDE

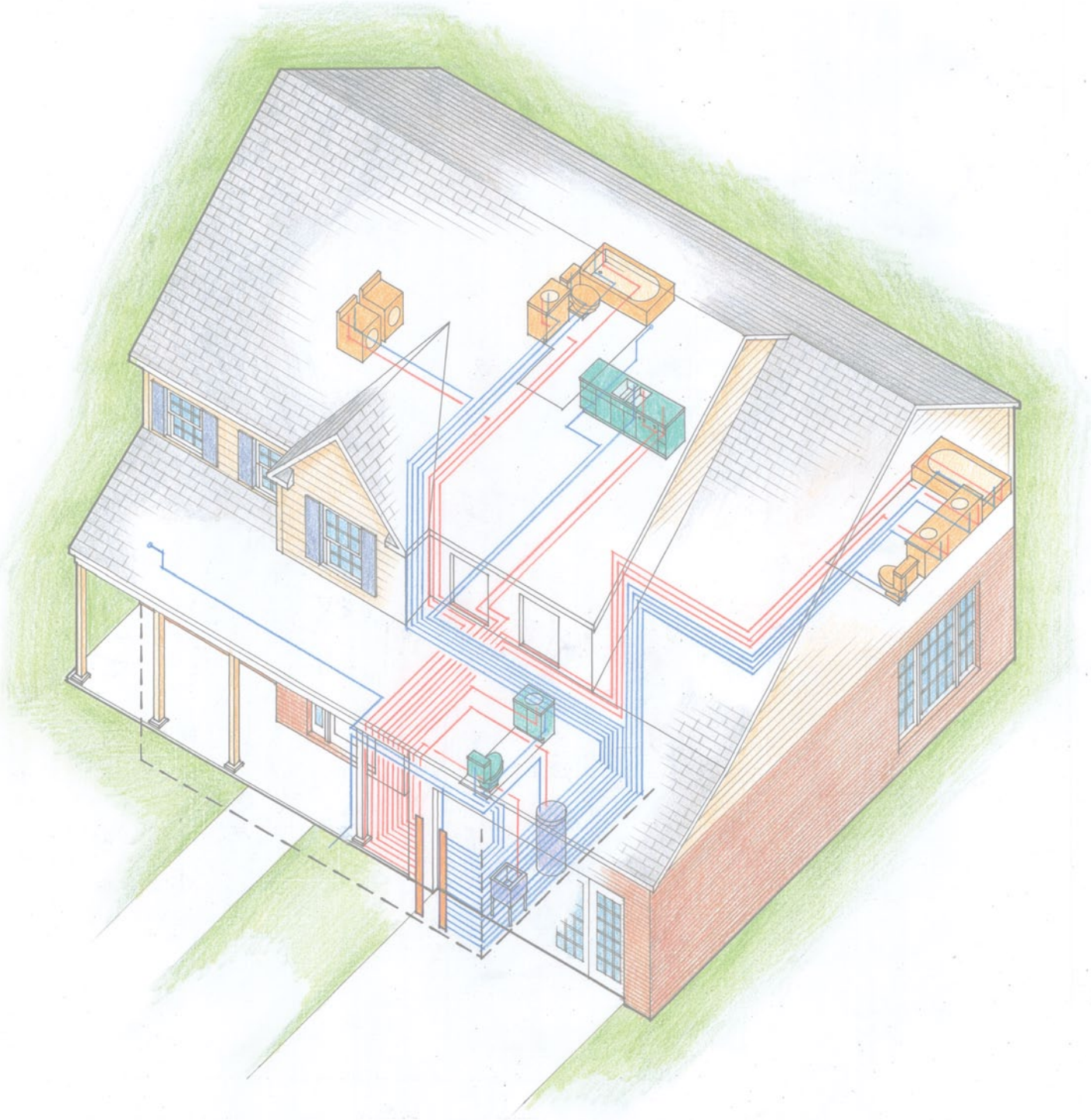
Residential PEX Water Supply Plumbing Systems

Second Edition



Applications
Advantages
Material Properties
Joining Methods
Code Acceptance
System Design
Installation
and more

PPFA Plastic Pipe and Fittings Association
ICC ES PMG
PLASTICS·PIPE·INSTITUTE™
Home Innovation RESEARCH LABS™



DESIGN GUIDE

Residential PEX Water Supply Plumbing Systems

Second Edition

Prepared for

Plastics Pipe Institute, Inc (PPI)
105 Decker Court
Suite 825
Irving, TX 75062
www.plasticpipe.org

and

Plastic Pipe and Fittings Association

Plastic Pipe and Fittings Association (PPFA)
800 Roosevelt Road, Bldg. C, Ste. 312
Glen Ellyn, IL 60137
www.ppfahome.org

Prepared by

Home Innovation Research Labs
(formerly the NAHB Research Center, Inc.)
400 Prince George's Boulevard
Upper Marlboro, MD 20774
www.HomeInnovation.com

November 2013

This document was developed as the result of a consensus process involving the Plastic Pipe Institute, the Plastic and Plastic Pipe and Fitting Association, and representatives from numerous piping and fitting manufacturers. It was prepared by the Home Innovation Research Labs.

Acknowledgements

We would like to thank the following principal contributors to this Guide:

NIBCO, Inc.
Elkhart, Indiana

Tom Coe

Plastic Pipe and Fittings Association
Glen Ellyn, Illinois

Richard Church, Mike Cudahy

Plastics Pipe Institute
Irving, Texas

Randy Knapp

REHAU, Inc.
Leesburg, Virginia

Lance MacNevin

Uponor
Apple Valley, Minnesota

Kate Olinger, Mike Rivers

Viega, LLC
Wichita, Kansas

Gary Morgan, Christina Smith

Watts
Springfield, Missouri

Chris Haldiman

Zurn Plumbing Products Group
Commerce, Texas

Gary Runyan

ICC – ES
Whittier, California

Maribel Campos

NSF International
Ann Arbor, Michigan

Nasrin Kashefi

Home Innovation Research Labs
Upper Marlboro, Maryland

Joseph Wiehagen

Disclaimer

Neither the Home Innovation Research Labs, Inc., the Plastics Pipe Institute, the Plastic Pipe and Fitting Association, the U.S. Department of Housing and Urban Development, nor any person acting in its behalf, makes any warranty, express or implied, with respect to the use of any information, apparatus, method, or process disclosed in this publication or that such use may not infringe privately owned rights, or assumes any liabilities with respect to the use of, or for damages resulting from the use of, any information, apparatus, method, or process disclosed in this publication, or is responsible for statements made or opinions expressed by individual authors.

For Further Information:

Please consult the following websites for the latest version of this publication. Print on demand version available through ICC ES only.

Plastics Pipe Institute
http://www.plasticpipe.org/

Plastic Pipe and Fittings Association
http://www.ppfahome.org/

Home Innovation Research Labs
http://www.HomeInnovation.com

ICC Evaluation Service, LLC
www.icc-es.org

Table of Contents

List of Figures

List of Tables

4 CODE ACCEPTANCE

PEX plumbing systems are recognized in all major building model codes and are commonly used for hot- and cold-water distribution applications, water service lines, fire protection and radiant floor heating systems. The following is a summary of relevant model code requirements which specifically pertain to PEX and plastic pipe and fittings used for domestic water supply.

> The user must determine which codes are applicable to his/her specific project, and also must ensure compliance with all local, state, and federal codes, regulations, and standards. Codes are constantly reviewed and updated. PEX water supply piping has been adopted in the model codes since 1993.

International Residential Code (IRC-2012)

P2605.1 General. PEX tubing shall be supported at distances not to exceed those indicated in Table 2605.1. For PEX, maximum horizontal support spacing is 32 inches, and maximum vertical support spacing is 10 feet (mid-story guide for sizes 2 inches and smaller). Piping shall be supported to ensure alignment and prevent sagging, and allow movement associated with the expansion and contraction of PEX tubing. Hangers and anchors shall be of sufficient strength to support piping and weight of its contents.

P2609.3 Plastic Pipe, Fittings, and Components. All plastic pipe, fittings, and components shall be third-party certified as conforming to NSF 14.

P2903.7 Size of Water-Service Mains, Branch Mains and Risers. The size of each water distribution system shall be determined according to design methods conforming to acceptable engineering practice, such as those methods in Appendix P (IRC 2012) and shall be approved by code official.

P2903.8 Gridded and Parallel Water-Distribution System Manifolds. Hot and cold parallel water-distribution system manifolds with individual distribution lines to each fixture or fixture fitting shall be sized and installed in accordance with Sections P2903.8.1 through P2903.8.6.

- **P2903.8.1 Sizing of Manifolds.** Manifolds shall be sized in accordance with Table P2903.8.1. Total gallons per minute is the demand for all outlets.
- **P2903.8.2 Minimum Size.** The maximum developed length of individual distribution lines shall be 60 feet (18.2 m) with 40 psi minimum at water meter in order to utilize 3/8" tubing for individual distribution lines. Fixtures shall be supplied with the tubing size specified by manufacturer. If water heater is fed from the end of a cold water manifold, the manifold shall be one size larger than the water heater feed.
- **P2903.8.3 Orientation.** Manifolds shall be permitted to be installed in a horizontal or vertical position.
- **P2903.8.4 Support and Protection.** Plastic piping bundles shall be secured in accordance with manufacturer's installation instructions and supported in accordance Section P2605. Bundles that have a change in direction equal to or greater than 45 degrees shall be protected from chaffing at the point of contact with framing members by sleeving or wrapping.
- **P2903.8.5 Valving.** Installed fixture valves shall be located at either the fixture or manifold. If installed at manifold, valves shall be labled indicating the fixture served.

P2903.9.4 Valve Requirements. Valves shall be approved and compatible with the type of piping material installed in the system. Valves intended to supply drinking water shall meet the requirements of NSF 61.

P2904 Dwelling Unit Fire Sprinkler Systems, P2904.1 General. Residential fire sprinkler systems shall be designed and installed in accordance with NFPA 13D. A multi-purpose fire sprinkler system shall supply domestic water to both fire sprinklers and plumbing fixtures.

P2904.2 Sprinklers. Sprinklers shall be new listed residential sprinklers and installed in accordance with manufacturer's installation instructions and in compliance with P2904.2.1 thru P2904.2.4.

P2904.3 Sprinkler Piping System. Sprinkler piping shall be supported in accordance with the requirements for cold water distribution piping. For multi-purpose piping systems, the sprinkler piping shall connect to and be a part of the cold water distribution piping system.

- **P2904.3.1 Non-metallic pipe and tubing, P2904.3.1.1 Non-metallic Pipe protection.** Non-metallic pipe and tubing, such as PEX, shall be listed for use in residential fire sprinkler systems. PEX tubing shall be protected from exposure to the living space by a layer of not less than 3/8 inch thick gypsum wallboard, ½ inch thick plywood or other material having a 15 minute fire rating.

P2904.4 Determining System Design Flow. The flow for sizing the sprinkler piping system shall be based on the flow rating of each sprinkler in accordance with Section P2904.4.1 and the calculation in accordance with Section P2904.4.2.

P2904.5 Water Supply. The water supply shall provide the required not less than the required design flow rate for sprinklers in accordance with Section P2904.4.2 at a pressure not less than that used to comply with Section P2904.6

P2904.6 Pipe Sizing. Sprinkler piping shall be sized for the flow required by Section P2904.4.2. Flow required to supply plumbing fixtures is not required to be added to the sprinkler design flow.

P2905.4 Water Service Pipe. Water service pipe shall conform to NSF 61 and one of the standards listed in Table P2905.4

P2905.5 Water-Distribution Pipe. Water distribution piping within the building shall conform to NSF 61 and one of the standards listed in Table P2905.4.

P2905.9 Plastic Pipe Joints. Joints in PEX tubing shall be made with approved fittings.

- **P2905.9.1.4 Cross-Linked Polyethylene Plastic (PEX).** Joints between PEX plastic tubing and fittings shall comply with Section P2905.9.1.4.1 or Section P2905.1.4.2.
- **P2905.9.1.4.2 Mechanical Joints.** Mechanical joints shall be installed in accordance with manufacturer's instructions. Fittings for PEX plastic tubing as described in ASTM F 1807, ASTM F 1960, ASTM F 2080, ASTM F2098, ASTM F2434 and ASTM F 2159, shall be installed in accordance with manufacturer's instructions. PEX tubing shall be factory marked with applicable fitting standards.

P2905.17 Joints Between Different Materials. Joints shall be installed in accordance with the manufacturer's instructions.

- **P2905.17.2 Plastic Pipe or Tubing to Other Pipe Materials.** Joints between different typesof plastic pipe or between plastic pipe and other piping material shall be made with an approved adapter fitting.

International Plumbing Code (IPC 2012)

601.3 Existing Piping Used for Grounding. Existing metallic water service piping used for electoral grounding shall not be replaced with nonmetallic pipe or tubing until other approved means of grounding is provided.

603.1 Size of Water Service Pipe. The water service pipe shall be sized to supply water to the structure in quantities and at the pressures required in this code. The water service pipe shall be not less than ¾ inch in diameter.

604.3 Water Distribution System Design Criteria. Pipe sizes shall be selected under conditions of peak demand and shall be no less than the minimum flow shown in Table 604.3

- **604.10.1 Manifold Sizing.** Hot and cold water manifolds shall be sized in accordance with Table 604.10.1. The total gallons per minute is the demand of all outlets supplied.

605.3 Water Service Pipe. Water service pipe shall conform to NSF 61 and to one of the standards listed in Table 605.3 (ASTM F 876, ATM F 877, AWWA C904 and CSA-B137.5).

605.4 Water Distribution Pipe. Water distribution pipe shall conform to NSF 61 and to one of the standards listed in Table 605.4 (ASTM F876, ASTM F 877, and CSA-B137.5).

605.5 Fittings. Pipe fittings shall be approved for installation with the piping material installed and shall conform to one of the standards listed in Table 605.5. Pipe fittings utilized in water supply systems shall also comply with NSF 61.

605.17 Cross-Linked Polyethylene Plastic. Joints between cross-linked polyethylene plastic tubing or fittings shall comply with Sections 605.17.1 and 605.17.2.

- **605.17.2 Mechanical Joints.** Mechanical joints shall be installed in accordance with manufacturer's instructions. Fittings for PEX tubing shall comply with the applicable standards listed in Table 605.5.

605.24 Joints Between Different Materials. Joints shall be installed in accordance with the manufacturer's instructions.

- **605.24.2 Plastic Pipe or Tubing to Other Piping Material.** Joints between different grades of plastic pipe or between plastic pipe and other piping material shall be made with an approved adapter fitting.

International Mechanical Code (IMC 2012)

305 Piping Support. Pipe hangers and supports shall have sufficient strength to withstand all anticipated static and specified dynamic loading conditions associated with the intended use. Pipe hangers and supports in direct contact with piping shall be of approved materials that are compatible with the piping and will not promote galvanic action.

305.4 Interval of Support. Piping shall be supported at distances not exceeding the spacing specified in Table 305.4 or in accordance with MSS SP-69; Horizontal spacing for PEX is 32 inches and 10 feet with mid-story guide for vertical support.

1201 General. Potable cold and hot water distribution systems shall be installed in accordance with the International Plumbing Code (IPC).

International Energy Conservation Code (IECC 2012)

R403.4.1 Circulating Hot Water Systems. Circulating hot water systems shall be provided with an automatic or readily accessible manual switch that can turn off the hot water circulating pump when the system is not in use.

R403.4.2 Hot Water Pipe Insulation. Insulation for hot water pipe with a minimum thermal resistance (R-value) of R-3 shall be applied to the following:

1. Piping larger than ¾ inch nominal diameter
2. Piping serving more than one dwelling unit
3. Piping from water heater to kitchen outlets
4. Piping located outseid the conditioned space
5. Piping from the water heater to a distribution manifold

6. Piping located under a floor slab

7. Buried pipe

8. Supply and return piping in a recirculation system other than demand recirulation systems

9. Piping with run lengths greater than the maximum run lengths for the nominal pipe diameter given in Table R403.4.2[8].

TABLE R403.4.2 MAXIMUM RUN LENGTH (feet)[a]				
Nominal Pipe Diameter of Largest Diameter Pipe in the Run (inch)	3/8	1/2	3/4	> 3/4
Maximum Run Length	30	20	10	5

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

[a] Total length of all piping from the distribution manifold or the recirculation loop to a point of use.

Uniform Plumbing Code (UPC-2012)

312.0 Protection of Piping.

312.9 Steel Nail Plates. PEX piping penetrating framing members to within 1 inch of the exposed framing shall be protected by steel nail plates not less than No. 18 gauge in thickness.

313.0 Hangers and Supports.

313.1 Suspended Piping. Suspended piping shall be supported at intervals not to exceed those shown in Table 313.1.

313.2 Piping Support. Piping shall be supported in a manner as to maintain its alignment and prevent sagging.

604.0 Materials.

604.1 Pipe, Tube, and Fittings. PEX pipe, tube, fittings used in potable water systems intended to supply drinking water shall be in accordance with the requirements in NSF 61. PEX materials for building water piping and building supply piping shall comply with the PEX standards referenced in Table 604.1

604. 9 Plastic Materials (Exception). Where a grounding system acceptable to the Authority Having Jurisdiction is installed, inspected, and approved, metallic pipe shall be permitted to be replaced with PEX pipe. Plastic materials for building supply piping outside underground shall have a blue insulated copper tracer wire or other approved conductor installed adjacent to the PEX pipe. Access shall be provided to the tracer wire or the tracer wire shall terminate aboveground at each end of the nonmetallic piping. The tracer wire size shall be not less than 18 AWG and the insulation type shall be suitable for direct burial.

604.13 Water Heater Connectors. PEX shall not be installed within the first 18 inches (457 mm) of piping connected to a water heater.

[8] IECC 2012.

605.10 PEX Tubing and Joints. PEX tubing and fitting joining methods shall be installed in accordance with the manufacturer's instructions and shall comply with Section 605.10.1 and Section 605.10.2.

- **605.10.1 Fittings.** Fittings for PEX tubing shall comply with the applicable standards referenced in Table 604.1. PEX tubing in accordance with ASTM F 876 shall be marked with the applicable standard designation for the fittings specified for use with the tubing.
- **605.10.2 Mechanical Joints.** Mechanical joints shall be installed in accordance with manufacturer's installation instructions.

605.17.2 Plastic Pipe to Other Materials. Where connecting PEX pipe to other types of piping, approved types of adapter or transition fittings designed for the specific transition intended shall be used.

Green Plumbing & Mechanical Code Supplement (IAPMO 2010)

502.1 Gray Water Systems. Refer to the provisions in Chapter 5 for construction, alteration and repair of gray water systems.

602.0 Service Hot Water – Low-Rise Residential Buildings, 602.1 General. The service water heating system for single-family houses, multi-family structures of three stories or fewer above grade and modular houses shall be in accordance with Section 602.2 through Section 602.5.

602.3 Recirculation Systems. Circulating hot water systems shall be arranged so that circulating pump(s) can be turned off when hot water system is not in operation. Circualtaion pump shall not operate continuously, be controlled by a timer or have a pump initiated by water temperature. Circulation pump shall initiate operation shortly before hot water is desired at a fixture. Systems with multiple recirculation zones shall be balanced to uniformly distribute hot water or operate with a pump for each zone.

602.5 Insulation. Hot water supply and return piping shall be thermally insulated. Wall thickness of insulation shall be equal to the diameter of pipe up to 2 inches and no less than 2 inches for piping larger than 2 inches. The conductivity of insulation shall be less than or equal to 0.28 [Btu*in/(h*sqft*°F)]. See Section 602.5 for further clarification and exceptions.

602.7.1 Central Core/Zone. Central core and zone plumbing system hot water distribution line volume to each qualified fixture shall not exceed a volume of 32 ounces.

602.7.2 Central Manifold. Central manifold, parallel piping or parallel hot-water plumbing systems, including the supply line from hot water source to the manifold, the internal volume of manifold and the lines to each qualified fixture shall not exceed a volume of 32 ounces.

602.7.3 Recirculation Loop. Residential hot water recirculation systems are limited to those that utilize on-demand activation of the circulating pump.

National Standard Plumbing Code (NSPC 2009)

3.4.1. Plastic Piping. Plastic piping materials used for the conveyance of potable water shall comply with NSF 14 and be marked accordingly.

3.4.2. Water Service Piping. Water service piping to the point of entrance into the building shall be of materials listed in Table 3.4, and shall be water pressure rated for not less than 160 psig at 73°F. Table 3.4: PEX Plastic Water Distribution Systems (ASTM F 877 with ASTM F 1807, F 1960, or F 2098 Fittings)

3.4.3. Water Distribution Piping. Water piping for distribution of hot and cold water within buildings shall be of materials listed in Table 3.4, and shall be water pressure rated for not less than 100 psig at 180°F and 160 psig at 73°F. Plastic piping used for hot water distribution shall be installed in accordance with requirements of Section 10.15.8.

3.4.4 Fittings. Fittings for water supply piping shall be compatible with the pipe material used.

8.7 Support of Plastic Pipe. Horizontal support spacing shall be based pipe schedule, wall thickness, pipe size, operating conditions and any concentrated loads. Vertical pipe shall be supported at each story and intermediate supports shall be provided to maintain alignment and stability. All piping shall be supported at changes of direction or elevation. Supports shall allow for free movement while not distorting, compressing or cutting the pipe. Provisions shall be made for expansion and contraction of the piping

10.5.9 Protection from Fire Systems. Backflow preventers shall not be required in multi-purpose or network residential sprinkler systems that supply both plumbing fixtures and residential fire sprinklers in accordance with NFPA 13D. The piping in such systems shall be approved for potable water.

10.15.8 Plastic Piping. Plastic piping used for hot-water distribution shall conform to the requirements of Section 3.4 and Table 3.4. Piping shall be water pressure rated for not less than 100 psi at 180°F. NOTE: The working pressure rating for certain approved plastic piping materials varies depending on pipe size, pipe schedule, and methods of joining. Plastic pipe or tube shall not be used downstream from instantaneous water heaters, immersion water heaters or other heaters not having approved temperature safety devices. Piping within 6 inches of flue or vent connectors shall be approved metallic pipe or tube. Normal operating pressure in water distribution piping systems utilizing approved plastic pipe or tube for hot-water distribution shall not be more than 80 psi.

National Plumbing Code of Canada (NPCC 2010)

2.3.4.4.1 Support for Vertical Piping. PEX piping shall be supported at its base and at floor level of alternate stories.

2.3.4.5. Support for Horizontal Piping.

1. Horizontal piping that is inside a building shall be braced to prevent swaying, buckling and to control the effects of thrusts.
2. Horizontal piping shall be supported as stated in Table 2.3.4.5; PEX = 0.8m
4. Where PEX plastic pipe is installed, hangers shall not compress, cut or abrade the pipe.

2.3.4.6 Support for Underground Horizontal Piping

1. Horizontal piping that is underground shall be supported on a base that is firm and continuous under the entire run of pipe.
2. Horizontal piping installed underground that is not supported as described in Sentence (1) may be installed using hangers fixed to a foundation or structural slab provided that the hangers are capable of maintaining alignment, and supporting the weight of pipe and its contents.

2.3.6.5 Air Pressure Tests

1. Air pressure tests shall be conducted in accordance with the manufacturer's instructions for each piping material to a minimum test pressure of 35 kPa and 15 minutes without a drop in pressure.

2.6.1.1 Design

1. Every fixture supplied with separate hot and cold water controls shall have the hot water control on the left and the cold on the right.
2. In a hot water distribution system of a developed length of more than 30 m or supplying more than 4 stories, the water temperature shall be maintained by recirculation or a self-regulating heat tracing system.

2.6.3.2 Design, Fabrication & Installation

1. Every water distribution system shall be designed to provide peak demand flow when the flow pressures at the supply openings conform to the plumbing supply fitting manufacturer's specifications and NPCC 2010 Division B.
2. Potable water systems shall be designed, fabricated and installed in accordance with good engineering practice, such as that described in the ASHRAE Handbooks and ASPE Data Books
3. In one- and two-family dwelling units and manufactured homes, multi-purpose systems that combine potable water systems and residential fire sprinkler systems shall be designed, fabricated and installed in accordance with NFPA 13D, "Installation of Sprinkler Systems in One- and Two-Family Dwellings and Manufactured Homes."

GLOSSARY

ASTM: American Society for Testing and Materials

Corrosion: deterioration in metals caused by oxidation or chemical action

Crosslinked polyethylene: a polyethylene material which has undergone a change in molecular structure using a chemical or a physical process whereby the polymer chains are chemically linked. Crosslinking of polyethylene into PEX for pipes results in improved properties such as elevated temperature strength and performance, chemical resistance, and resistance to slow crack growth.

Elasticity: a measure of material stiffness or the ability of the material to stretch or deform temporarily under a load

Fitting: a device or connection that allows the PEX pipe to change direction or size, such as a tee, elbow, or coupling

Fixture: a device or appliance at the end of a water supply distribution pipe line. Example: lavatory, water closet, tub/shower, dishwasher

IAPMO: International Association of Plumbing and Mechanical Officials

ICC: International Code Council

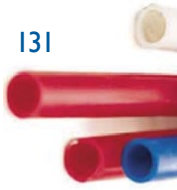
IPC: International Plumbing Code

IRC: International Residential Code

Joint: the connection of the PEX pipe to a fitting, fixture, or manifold

Manifold: a device having a series of ports that are used to connect distribution lines for several fixtures

NSPC: National Standard Plumbing Code



Outlet: see fixture

Parallel: a plumbing design that utilizes a central manifold and distribution piping to each hot and cold water fixture

pH: a scale ranging from 0 to 14 that ranks how acidic or alkaline a liquid is; water with a pH below 7 is considered acidic and water with a pH above 7 is considered alkaline

PPFA: Plastic Pipe and Fittings Association

PPI: Plastics Pipe Institute

Scaling: process of mineral buildup on the interior of a pipe

Test fixture: the tub-shower unit farthest from the water source that was instrumented to measure flow rate, flowing pressure, and mixed water temperature in the lab tests

Thermoplastic: having the property of becoming soft when heated and hard when cooled

Thermoset: having the property of becoming permanently hard and rigid when heated or cured

Trunk and branch: a plumbing design that has a large main line that feeds smaller pipes to each fixture

Ultraviolet: high energy light waves found in sunlight that lead to the degradation of many plastics and materials (UV)

UPC: Uniform Plumbing Code

Wait time: the time it takes for hot water to be delivered to the Test Fixture; delivery time

Water hammer: a banging noise heard in a water pipe following an abrupt alteration of the flow with resultant pressure surges

Zone: a plumbing system that uses trunk lines from the water source to small manifolds at grouped fixtures, such as a bathroom; can be flow-through or closed end