Designation: F2788/F2788M – 21

An American National Standard

Standard Specification for Metric and Inch-sized Crosslinked Polyethylene (PEX) Pipe[1]

This standard is issued under the fixed designation F2788/F2788M; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope*

1.1 This specification covers crosslinked polyethylene (PEX) pipe that is outside diameter controlled in metric pipe sizes of DN 16 to DN 1000 (approximate outside diameters of 16 mm to 1005 mm) and inch pipe sizes NPS 3 to NPS 54 (approximate outside diameters of 3.5 in. to 54 in.), made in nominal pipe dimension ratios, and pressure rated for water at three temperatures (see Appendix X1). Included are requirements and test methods for material, workmanship, dimensions, burst pressure, hydrostatic sustained pressure, excessive temperature-pressure, environmental stress cracking, stabilizer functionality, bent-pipe hydrostatic pressure, oxidative stability in potable chlorinated water, degree of crosslinking, and minimum operating temperature. Requirements for pipe markings are also specified. The pipe covered by this specification is intended for pressure applications, such as, industrial and general-purpose pipelines, potable water pipelines, and fire–extinguishing pipelines

1.2 The text of this specification references notes, footnotes, and appendixes, which provide explanatory material. These notes and footnotes (excluding those in tables and figures) shall not be considered as requirements of the specification.

1.3 The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system are not necessarily exact equivalents; therefore, to ensure conformance with the standard, each system shall be used independently of the other, and values from the two systems shall not be combined.

1.4 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.5 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D618 Practice for Conditioning Plastics for Testing

D792 Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement

D1505 Test Method for Density of Plastics by the Density-Gradient Technique

D1598 Test Method for Time-to-Failure of Plastic Pipe Under Constant Internal Pressure

D1599 Test Method for Resistance to Short-Time Hydraulic Pressure of Plastic Pipe, Tubing, and Fittings

D1600 Terminology for Abbreviated Terms Relating to Plastics

D2122 Test Method for Determining Dimensions of Thermoplastic Pipe and Fittings

D2290 Test Method for Apparent Hoop Tensile Strength of Plastic or Reinforced Plastic Pipe

D2565 Practice for Xenon-Arc Exposure of Plastics Intended for Outdoor Applications

D2765 Test Methods for Determination of Gel Content and Swell Ratio of Crosslinked Ethylene Plastics

D2837 Test Method for Obtaining Hydrostatic Design Basis for Thermoplastic Pipe Materials or Pressure Design Basis for Thermoplastic Pipe Products

D3895 Test Method for Oxidative-Induction Time of Polyolefins by Differential Scanning Calorimetry

F412 Terminology Relating to Plastic Piping Systems

F1055 Specification for Electrofusion Type Polyethylene Fittings for Outside Diameter Controlled Polyethylene and Crosslinked Polyethylene (PEX) Pipe and Tubing

F2023 Test Method for Evaluating the Oxidative Resistance of Crosslinked Polyethylene (PEX) Pipe, Tubing and Systems to Hot Chlorinated Water

F2657 Test Method for Outdoor Weathering Exposure of Crosslinked Polyethylene (PEX) Tubing

[1] This specification is under the jurisdiction of ASTM Committee F17 on Plastic Piping Systems and is the direct responsibility of Subcommittee F17.26 on Olefin Based Pipe.

Current edition approved May 1, 2021. Published May 2021. Originally approved in 2009. Last previous edition approved in 2020 as F2788/F2788M–20. DOI: 10.1520/F2788_F2788M-21

[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

*A Summary of Changes section appears at the end of this standard

F2829/F2829M Specification for Metric- and Inch-Sized Fittings for Crosslinked Polyethylene (PEX) Pipe
F3373 Specification for Polyethylene (PE) Electrofusion Fittings for Outside Diameter Controlled Crosslinked Polyethylene (PEX) Pipe

2.2 *ANSI Standard:*[3]
B36.10 Standards Dimensions of Steel Pipe (IPS)

2.3 *Federal Standard:*[4]
FED-STD-123 Marking for Shipment (Civil Agencies)

2.4 *Military Standard:*[4]
MIL-STD-129 Marking for Shipment and Storage

2.5 *NSF Standard:*[5]
NSF/ANSI Standard 14 Plastic Piping System Components and Related Materials
NSF/ANSI Standard 61 Drinking Water System Components – Health Effects

2.6 *ISO Standards:*[6]
ISO 1167 Thermoplastics pipes, fittings and assemblies for the conveyance of fluids — Determination of the resistance to internal pressure — Part 1: General method
ISO 4427 Plastic piping systems - Polyethylene (PE) pipes and fittings for water supply
ISO 13477 Thermoplastics pipes for the conveyance of fluids — Determination of resistance to rapid crack propagation (RCP) — Small-scale steady-state test (S4 test)
ISO 13760 Plastics pipes for the conveyance of fluids under pressure — Miner's rule ~ Calculation method for cumulative damage
ISO 14531-1 Plastics pipes and fittings — Crosslinked polyethylene (PE-X) pipe systems for the conveyance of gaseous fuels — Metric series — Specifications — Part 1: Pipes
ISO 161-1 Thermoplastics pipes for the conveyance of fluids - Nominal outside diameters and nominal pressures - Part 1: Metric series

2.7 *PPI Standards:*[7]
PPI TR-3 Policies and Procedures for Developing Hydrostatic Design Basis (HDB), Pressure Design Basis (PDB), Strength Design Basis (SDB), and Minimum Required Strength (MRS) Ratings for Thermoplastic Piping Materials or Pipe
PPI TR-4 PPI Listing of Hydrostatic Design Basis (HDB), Strength Design Basis (SDB), Pressure Design Basis (PDB) and Minimum Required Strength (MRS) Ratings for Thermoplastic Piping Materials or Pipe
PEX Pipe Design Manual for Water, Oil, Gas & Industrial Applications

[3] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, http://www.ansi.org.

[4] DLA Document Services Building 4/D 700 Robbins Avenue Philadelphia, PA 19111-5094 http://quicksearch.dla.mil/

[5] Available from NSF International, P.O. Box 130140, 789 N. Dixboro Rd., Ann Arbor, MI 48113-0140, http://www.nsf.org.

[6] Available from International Organization for Standardization (ISO), 1, ch. de la Voie-Creuse, Case postale 56, CH-1211, Geneva 20, Switzerland, http://www.iso.ch.

[7] Available from Plastics Pipe Institute (PPI), 105 Decker Court, Suite 825, Irving, TX 75062, http://www.plasticpipe.org.

3. Terminology

3.1 *Definitions*—Definitions are in accordance with Terminology F412, and abbreviations are in accordance with Terminology D1600, unless otherwise specified. The abbreviation for crosslinked polyethylene is PEX. Plastic pipe denotes a particular diameter schedule of plastic pipe in which outside diameter of the pipe conforms with ISO 4427.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *design factor (DF), n*—a number between 0 and 1 that is multiplied by the hydrostatic design basis to determine the hydrostatic design stress for water.

3.2.2 *hydrostatic design stress (HDS)*—the estimated maximum tensile stress the material is capable of withstanding continuously with a high degree of certainty that failure of the pipe will not occur. This stress is circumferential when internal hydrostatic water pressure is applied. The HDS is equal to the hydrostatic design basis (HDB) multiplied by the design factor (DF) for water. For this standard, the design factor for water is equal to 0.50.

$$HDS = HDB \times DF \tag{1}$$

$$= HDB \times 0.50 \ (\textit{for this standard})$$

3.2.3 *hydrostatic design basis (HDB)*—one of a series of established stress values (specified in Test Method D2837) for a plastic compound obtained by categorizing the long-term hydrostatic strength determined in accordance with Test Method D2837.

3.2.3.1 *Discussion*—A listing of HDB and HDS values are contained in PPI publication PPI TR-4

3.2.4 *nominal diameter (DN), adj*—a designation for SI unit outside diameter controlled pipe sizes that generally comply with outside diameters specified in ISO 161-1.

3.2.5 *nominal pipe size (NPS), adj*—a designation for inch-pound unit outside diameter controlled pipe sizes that generally comply with outside diameters specified in ANSI B36.

3.2.6 *pressure rating (PR)*—the estimated maximum water pressure the pipe is capable of withstanding continuously with a high degree of certainty that failure of the pipe will not occur.

3.2.7 *relation between dimensions, hydrostatic design stress, and pressure rating*—the following expression, commonly known as the ISO equation[8] is used in this specification to relate dimensions, hydrostatic design stress, and pressure rating:

$$2S/P = (D_o/t) - 1 \ or \tag{2}$$

$$2S/P = R - I$$

S = hydrostatic design stress, psi (or MPa),
P = pressure rating, psi (or MPa),
D_o = average outside diameter, in. (or mm),
t = minimum wall thickness, in. (or mm), and
R = standard dimension ratio (SDR) or dimension ratio (DR)

3.2.8 *standard pipe material designation code*—The pipe material designation code shall consist of the abbreviation for

[8] ISO 161–1.

the type of plastic (PEX) followed by four Arabic digits that describe short-term properties in accordance with applicable ASTM standards and as shown in Table 1.

3.2.8.1 *Discussion*—The first digit is for chlorine resistance tested in accordance with Test Method F2023.

(1) A digit "0" indicates that the PEX pipe either has not been tested for chlorine resistance or that the PEX pipe does not meet the minimum requirement for chlorine resistance.

(2) A digit "1" indicates the PEX pipe has been tested and meets the requirement of 6.10 for minimum chlorine resistance at the end use condition of 25 % of the time at 140 °F (60 °C) and 75 % at 73 °F (23 °C).

(3) A digit "2" is reserved for future application.

(4) A digit "3" indicates that the PEX pipe has been tested and meets the requirement of 6.10 for minimum chlorine resistance at end use condition of 50 % of the time at 140 °F (60 °C) and 50 % of the time at 73 °F (23 °C).

(5) A digit "4" is reserved for future application.

(6) A digit "5" indicates that the PEX pipe has been tested and meets the requirement for minimum chlorine resistance at end use conditions of 100 % of the time at 140 °F (60 °C) .

3.2.8.2 *Discussion*—The second digit is reserved for demonstrated UV resistance of PEX material when tested in accordance with Test Method F2657. This digit may be any value as listed for the material in PPI TR-4. Completed testing to Test Method F2657 is not a requirement of this specification.

3.2.8.3 *Discussion*—The last two digits are the hydrostatic design stress for water at 73 °F (23 °C) in units of 100 psi with any decimal figures dropped. Where the hydrostatic design stress code contains less than two figures, a zero is used before the number. Thus, a complete material designation code for PEX pipe shall consist of the three letters "PEX" and four digits.

4. Pipe Classification

4.1 *General*—This specification covers PEX pipe materials having pressure ratings for water at 73 °F (23 °C) and an elevated temperature(s). The pressure ratings decrease as the temperature is increased.

4.2 *Standard Dimension Ratio (SDR)*—This specification covers PEX pipe in various standard dimension ratios and dimension ratios for nominal diameters 16 mm (½ in) and larger. The pressure ratings are uniform for all nominal pipe sizes with the same DR or SDR.

4.3 *Operating Temperature Range*—The minimum operating temperature shall be in accordance with 6.13. The maximum temperature for continuous operation shall be based on the highest temperature HDS in accordance with 5.2 and Table 2. The maximum temperature for intermittent operation shall require special design considerations and consultation with the pipe manufacturer and shall be consistent with the PPI "*PEX Pipe Design Manual for Water, Oil, Gas & Industrial Applications*."

5. Materials

5.1 *General*—Crosslinked polyethylene pipe, meeting the requirements of this specification, is primarily defined by means of three criteria, namely, *(1)* nominal density, *(2)* degree of crosslinking, and *(3)* long-term strength tests. There is a strong correlation between nominal density and results of short-term strength tests.

NOTE 1—PEX pipe intended for use in the transport of potable water should be evaluated and certified as safe for this purpose by a testing agency acceptable to the local health authority. The evaluation should be in accordance with requirements for chemical extraction, taste, and odor that are no less restrictive than those included in NSF/ANSI 14. The seal or mark of the laboratory making the evaluation should be included on the pipe.

5.2 *Basic Materials*—PEX pipe shall be made from polyethylene compounds which have been crosslinked by peroxides, azo compounds, or silane compounds in extrusion, or using an electron beam after extrusion, or by other means. Whatever means are used to crosslink the polyethylene and form pipe, the pipe shall meet the performance requirements of this specification. For the use temperatures that the pipe will be marked for, the materials, procedure for mixing, and the process for crosslinking shall result in a product with long term hydrostatic design stresses and pressure ratings as shown in Table 2, when determined in accordance with procedures no less restrictive than those of PPI TR-3[8]. See Appendix X1 for additional information on PPI hydrostatic stress ratings.

NOTE 2—Pipe produced by crosslinking by peroxides, azo compounds, or silane compounds in extrusion, or by electron beam after extrusion have met the requirements of this specification. There are several processes for producing crosslinked polyethylene pipe. Whatever process is used, the pipe produced must be established as meeting the requirements of this specification.

5.3 *Pipe Material Designation*—The pipe meeting the requirements of this specification shall be designated PEX.

5.4 *Color:*

5.4.1 If the color of the pipe is black, the formulation shall contain carbon black as a colorant, and the formulation shall meet the requirements of 5.5.

TABLE 1 Material Designation Code Cells

Property	Standard	0	1	2	3	4	5	6	7	8	9
Chlorine Resistance	F2023	Not tested or rated	75 % at 73 °F (23 °C) and 25 % at 140 °F (60 °C)	Reserved	50 % at 73 °F (23 °C) and 50 % at 140 °F (60 °C)	Reserved	100 % at 140 °F (60 °C)	...	...	...	...
Reserved for UV Weathering	...	...	...	...	...	...	...	...	...	...	...
HDS for water at 73 °F	...	...	...	...	...	...	...	630	...	800	...

TABLE 2 PEX Pipe Pressure Ratings Based on DR/SDR and Temperature

DR/SDR	Rated Temperature		Hydrostatic Design Stress		Pressure Rating for Water	
	°F	°C	psi	MPa	Psig	MPa
DR 6	73.4	(23)	630	(4.34)	250	(1.72)
	73.4	(23)	800	(5.51)	320	(2.21)
	180	(82.2)	400	(2.76)	160	(1.10)
	200	(93.3)	315	(2.17)	125	(0.86)
DR 7.4	73.4	(23)	630	(4.34)	200	(1.38)
	73.4	(23)	800	(5.51)	250	(1.72)
	180	(82.2)	400	(2.76)	125	(0.86)
	200	(93.3)	315	(2.17)	100	(0.69)
SDR 9	73.4	(23)	630	(4.34)	160	(1.10)
	73.4	(23)	800	(5.51)	200	(1.38)
	180	(82.2)	400	(2.76)	100	(0.69)
	200	(93.3)	315	(2.17)	80	(0.55)
SDR 11	73.4	(23)	630	(4.34)	125	(0.86)
	73.4	(23)	800	(5.51)	160	(1.10)
	180	(82.2)	400	(2.76)	80	(0.55)
	200	(93.3)	315	(2.17)	60	(0.41)
DR 13.6	73.4	(23)	630	(4.34)	100	(0.69)
	73.4	(23)	800	(5.51)	125	(0.86)
	180	(82.2)	400	(2.76)	63	(0.43)
	200	(93.3)	315	(2.17)	50	(0.35)
DR 16.2	73.4	(23)	630	(4.34)	82	(0.56)
	73.4	(23)	800	(5.51)	105	(0.72)
	180	(82.2)	400	(2.76)	52	(0.36)
	200	(93.3)	315	(2.17)	41	(0.28)
SDR 17	73.4	(23)	630	(4.34)	80	(0.55)
	73.4	(23)	800	(551)	100	(0.69)
	180	(82.2)	400	(2.76)	50	(0.35)
	200	(93.3	315	(2.17)	40	(0.28)

5.4.2 If black pipe has colored stripes, the color of the stripes shall conform to the APWA Uniform Color Code.

5.4.3 If the color of the pipe is non-black, the formulation shall contain a non-black pigment, and the formulation shall meet the requirements of 5.5. The color of the pipe shall conform to the APWA Uniform Color Code.

5.5 *UV Protection:*

5.5.1 The material formulation shall contain additives to protect the pipe from UV radiation. The pipe shall be marked with the maximum UV exposure time, based on the manufacturer's testing of UV exposed pipe in accordance with Test Method F2657, Practice D2565 or ISO 14531-1 Annex C. After PEX pipe has been weathered, it shall meet the thermal stability, 95 °C hydrostatic strength, and elongation at break requirements of ISO 14531-1 Table 8.

5.5.2 See Appendix X2 for UV labeling guidelines.

5.6 Potable Water Applications Material formulations intended for chlorinated potable water applications per 3.2.8 shall first be weathered in accordance with 5.5 using Test Method F2657, and then shall meet the requirements of 6.10.

6. Requirements

6.1 *Workmanship*—The pipe shall be homogeneous throughout and free of visible cracks, holes, foreign inclusions, or other defects. The pipe shall be as uniform as commercially practicable in color, opacity, density, and other physical properties.

6.2 *Out-of Roundness*—The maximum out-of roundness requirements, shown in Table 3 for pipe, apply to the average, measured diameter after rounding with a rounding tool recommended by the manufacturer.

TABLE 3 Outside Diameters and Tolerances for Metric-sized PEX Pipe

DN (Nominal Diameter)	Average Outside Diameter	Tolerances for Average Diameter	Maximum Out-of-Roundness
	mm	mm	mm
16	16.15	±0.15	1.2
20	20.15	±0.15	1.2
25	25.1	±0.15	1.2
32	32.15	±0.15	1.3
40	40.20	±0.20	1.4
50	50.20	±0.20	1.4
63	63.20	±0.20	1.5
75	75.25	±0.25	1.6
90	90.30	±0.30	1.8
110	110.35	±0.35	2.2
125	125.40	±0.40	2.5
140	140.45	±0.45	2.8
160	160.50	±0.50	3.2
180	180.55	±0.55	3.6
200	200.60	±0.60	4.0
225	225.70	±0.70	4.5
250	250.75	±0.75	5.0
280	280.85	±0.85	9.8
315	315.95	±0.95	11.1
355	356.10	±1.10	12.5
400	410.20	±1.20	14.0
450	451.35	±1.35	15.6
500	501.50	±1.50	17.5
560	561.70	±1.70	19.6
630	631.90	±1.90	22.1
710	713.20	±3.20	24.9
800	813.60	±3.60	28.0
900	904.05	±4.05	31.5
1000	1004.50	±4.50	35.0

6.3 *Dimensions and Tolerances:*

6.3.1 *Outside Diameters*—The outside diameters and tolerances shall be as shown in Table 3 for metric sizes or Table 4 for inch sizes, when measured in accordance with 7.4 and 7.4.1.

6.3.2 *Wall Thickness*—The wall thickness shall be as shown in Table 5 for metric sizes and Table 6 for inch sizes, when measured in accordance with 7.4 and 7.4.2. The tolerance for all wall thicknesses is plus 12 %.

NOTE 3—Pipe diameters less than 25 mm (1 in.) diameter have minimum wall thicknesses based on both hydrostatic and mechanical strength.

6.4 *Density*—When determined in accordance with 7.5, the crosslinked polyethylene pipe material shall have a minimum density of 0.926 Mg/m^3.

6.5 *Hydrostatic Sustained Pressure Strength*—When tested in accordance with 7.6 at 73 °F (23 °C) and 1300 psi (8.96 MPa) hoop stress, 180 °F (82 °C) and 770 psi (5.31 MPa) hoop stress, and 200 °F (93 °C) and 640 psi (4.40 MPa) hoop stress, the pipe shall not fail, in less than 1000 h. Test pressure, $P_{test\ pressure}$, shall be calculated in accordance with:

$$P_{(test\ pressure)} = 2 \times (hoop\ stress) / [(average\ OD/minimum\ wall) - 1]$$

6.6 *Hydrostatic Burst Pressure/Apparent Tensile Strength*—Pipe shall be tested for minimum burst pressure in accordance with 7.7 at 73 °F (23 °C) and 1900 psi (13.10 MPa) hoop stress, 180 °F (82 °C) and 850 psi (5.86 MPa) hoop stress, and 200 °F (93 °C) and 720 psi (4.96 MPa) hoop stress. The minimum burst pressure, $P_{burst\ pressure}$, for PEX pipe shall be determined in accordance with the formula:

$$P_{burst\ pressure} = 2\ (hoop\ stress) / [(average\ OD/minimum\ wall) - 1].$$

For pipe sizes NPS 4 and larger, the testing lab shall be allowed to replace the hydrostatic burst pressure test (Test Method D1599) by the apparent ring tensile strength test (Test Method D2290). The minimum apparent tensile strength at yield when determined in accordance with 7.13 shall be 2520 psi (17.4 MPa) for PEX pipe with an HDB of 1250 psi or 2900 psi (20.0 MPa) for PEX pipe with an HDB of 1600 psi.

6.7 *Environmental Stress Cracking*—There shall be no loss of pressure in the pipe, when tested in accordance with 7.8.

6.8 *Degree of Crosslinking:*

6.8.1 When tested in accordance with 7.9, the degree of crosslinking for PEX pipe material shall be within the range from 65 to 89 % inclusive. Depending on the process used, the following minimum percentage crosslinking values shall be achieved: 70 % by peroxides, 65 % by Azo compounds, 65 % by electron beam, or 65 % by silane compounds.

6.8.2 In addition, for pipe with a wall thickness greater than 0.5 in (12.7 mm), the degree of crosslinking shall be measured at four points separated by 90 degrees in the middle of the wall. For one of these points, measure at three points along the wall thickness – see Fig. 1. Collect shaving samples, about 0.004 in (0.10 mm) thick, by drilling a hole in the axial pipe direction with a ⅛ in (3 mm) drill to collect a 0.007 – 0.014 oz (0.2 – 0.4 gram) sample size.

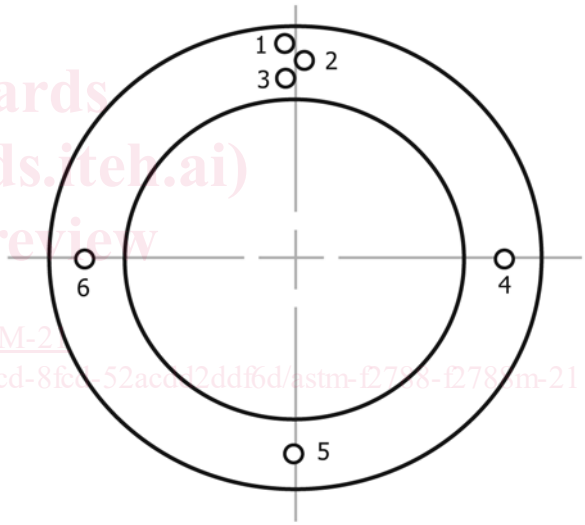


FIG. 1 Sample Location for Degree of Crosslink Test on Thick-wall Pipe

6.8.3 The degree of crosslinking over the entire wall thickness of all thick-wall pipe tested per 6.8.2 shall meet the minimum requirements specified in 6.8.1. The degree of crosslinking shall not vary outside the limits for the grade in question specified in 6.8.1 at any time at any part of the pipe.

6.9 *Stabilizer Functionality*—Stabilizer Functionality shall be tested in accordance with 7.10.

NOTE 4—For example PEX pipe marked with the material designation code PEX 1006 is a PEX pipe meeting the chlorine resistance requirement for 25 % of the time at 140 °F (60 °C) and 75 % of the time at 73 °F (23 °C) and having an HDS for water at 73 °F of 630 psi (HDB of 1250 psi) as follows:

TABLE 4 Outside Diameters and Tolerances for Inch-sized PEX Pipe

NPS (Nominal Pipe Size)	Average Outside Diameter	Tolerances for Average Diameter	Maximum Out-of-Roundness
	in.	in.	in.
3	3.500	0.016	0.07
4	4.500	0.020	0.09
5	5.563	0.025	0.11
6	6.625	0.030	0.13
8	8.625	0.039	0.17
10	10.750	0.048	0.22
12	12.750	0.057	0.26
14	14.000	0.063	0.28
16	16.000	0.072	0.40
18	18.000	0.081	0.54
20	20.000	0.090	0.60
22	22.000	0.099	0.66
24	24.000	0.108	0.72
26	26.000	0.117	0.78
28	28.000	0.126	0.98
30	30.000	0.135	1.05
32	32.000	0.144	1.12
34	34.000	0.153	1.19
36	36.000	0.162	1.26
42	42.000	0.189	1.47
48	48.000	0.216	1.68
54	54.000	0.243	1.89

TABLE 5 Wall Thickness and Tolerances for Metric-sized PEX Pipe

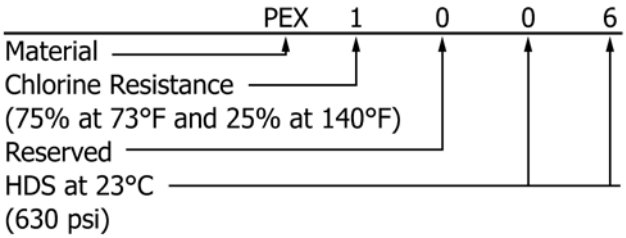
Minimum Wall Thickness (t), (mm) (Tolerance shall be plus 12 %)

	Pipe DR/SDR						
DN (Nominal Diameter)	DR 6	DR 7.4	SDR 9	SDR 11	DR 13.6	DR 16.2	SDR 17
16	3.0	2.3	2.0	...	...	...	...
20	3.4	3.0	2.3	2.0	...	...	...
25	4.2	3.5	3.0	2.3	2.0	...	...
32	5.4	4.4	3.6	3.0	2.4	2.0	2.0
40	6.7	5.5	4.5	3.7	3.0	2.5	2.4
50	8.3	6.9	5.6	4.6	3.7	3.1	3.0
63	10.5	8.6	7.1	5.8	4.7	3.9	3.8
75	12.5	10.3	8.4	6.8	5.6	4.6	4.5
90	15.0	12.3	10.1	8.2	6.7	5.6	5.4
110	18.3	15.1	12.3	10.0	8.1	6.8	6.6
125	20.8	17.1	14.0	11.4	9.2	7.7	7.4
140	23.3	19.2	15.7	12.7	10.3	8.7	8.3
160	26.6	21.9	17.9	14.6	11.8	9.9	9.5
180	29.9	24.6	20.1	16.4	13.3	11.1	10.7
200	33.2	27.4	22.4	18.2	14.7	12.4	11.9
225	37.4	30.8	25.2	20.5	16.6	13.9	13.4
250	41.5	34.2	27.9	22.7	18.4	15.5	14.8
280	46.5	38.3	31.3	25.4	20.6	17.3	16.6
315	52.3	43.1	35.2	28.6	23.2	19.5	18.7
355	59.0	48.5	39.7	32.2	26.1	21.9	21.1
400	...	54.7	44.7	36.3	29.4	24.7	23.7
450	...	61.5	50.3	40.9	33.1	27.8	26.7
500	...	...	55.8	45.4	36.8	30.9	29.7
560	...	...	62.5	50.8	41.2	34.6	33.2
630	...	...	70.3	57.2	46.3	38.9	37.4
710	...	...	79.3	64.5	52.2	43.9	42.1
800	...	...	89.3	72.6	58.8	49.4	47.4
900	...	...	...	81.7	66.2	56.6	53.3
1000	...	...	...	90.2	72.5	61.8	59.3

TABLE 6 Wall Thickness and Tolerances for Inch-sized PEX Pipe

Minimum Wall Thickness (t), (in.) (Tolerance shall be plus 12 %)

	Pipe DR/SDR							
NPS (Nominal Pipe Size)	DR 7.3	DR 8.3	SDR 9	SDR 11	DR 13.5	DR 15.5	SDR 17	SDR 21
3	0.479	0.422	0.389	0.318	0.259	0.226	0.206	0.167
4	0.616	0.542	0.500	0.409	0.333	0.290	0.265	0.214
5	0.762	0.670	0.618	0.506	0.412	0.359	0.327	0.265
6	0.908	0.798	0.736	0.602	0.491	0.427	0.390	0.315
8	1.182	1.039	0.958	0.784	0.639	0.556	0.507	0.411
10	1.473	1.295	1.194	0.977	0.796	0.694	0.632	0.512
12	1.747	1.536	1.417	1.159	0.944	0.823	0.750	0.607
14	1.918	1.687	1.556	1.273	1.037	0.903	0.824	0.667
16	2.192	1.928	1.778	1.455	1.185	1.032	0.941	0.762
18	2.466	2.169	2.000	1.636	1.333	1.161	1.059	0.857
20	...	2.409	2.222	1.818	1.481	1.290	1.176	0.952
22	...	...	2.444	2.000	1.630	1.419	1.294	1.048
24	...	...	2.667	2.182	1.778	1.548	1.412	1.143
26	...	...	...	2.364	1.926	1.677	1.529	1.238
28	...	...	...	2.545	2.074	1.806	1.647	1.333
30	...	...	...	2.727	2.222	1.935	1.765	1.429
32	...	...	...	2.909	2.370	2.065	1.882	1.524
34	...	...	...	3.091	2.519	2.194	2.000	1.619
36	...	...	...	3.273	2.667	2.323	2.118	1.714
42	...	...	...	...	...	2.710	2.471	2.000
48	...	...	...	...	...	3.097	2.824	2.286
54	...	...	...	...	...	...	3.176	2.571



6.10 *Oxidative Stability in Potable Chlorinated Water Applications*—PEX pipe intended for use in the transport of potable water shall have a minimum extrapolated time-to-time failure of 50 years when tested and evaluated in accordance with 7.11.

6.11 *Bent Pipe Hydrostatic Sustained Pressure Strength:*

6.11.1 *General*—PEX pipe, up to and including DN 25 shall meet the requirements 6.11.2 and 6.11.3.

NOTE 5—PEX pipe larger than DN 25 mm is typically installed as main distribution lines and is installed in straight runs. Fittings are used when a change in direction of 90° or greater and a bend radius of 6 times the outside diameter is needed. The test procedures in 6.11.2 and 6.11.3 are intended to evaluate PEX pipe installed in tight bend applications in accordance with the procedures in X3.2.4 and X3.2.5. This application applies to pipe up to and including 1 in nominal diameter only.

6.11.2 Hot-bent pipe, with a radius of 2.5 times the outside diameter and consisting of a continuous bend length inducing not less than 90° angle, shall meet the minimum hydrostatic sustained pressure strength requirements for 180 °F per 6.5 when tested in accordance with 7.6. The bend length and bend angle is kept throughout the testing period by rigid supports immediately outside the bend.

6.11.3 Cold-bent pipe, with a radius of 6 times the outside diameter and consisting of a continuous bend length inducing not less than 90° angle, shall meet the minimum hydrostatic sustained pressure strength requirements for 180 °F per 6.5 when tested in accordance with 7.6. The bend length and bend angle is kept throughout the testing period by rigid secures immediately outside the bend.

6.12 *Excessive Temperature and Pressure Capacity:*

6.12.1 *General*—PEX pipe sizes, up to and including DN 25, shall meet the requirements of 6.12.2. In the event of a residential water heating system malfunction, PEX pipe shall have adequate strength to accommodate short-term conditions, 48 h of 210 °F (99 °C). 150 psi (1034 kPa) until repairs can be made.

6.12.2 Pipe shall not fail as defined in Test Method D1598 in less than 30 days (720 h) when tested in accordance with 7.12.

6.13 *Minimum Operating Temperature:*

6.13.1 Pipe that is intended to be operated at temperatures from 0 °F (-18 °C) to -58 °F (-50 °C) shall have the minimum operating temperature determined by testing in accordance with 6.13.2 and, if applicable, 6.13.3.

6.13.1.1 Testing in accordance with 6.13.2 and 6.13.3 need only be performed for original pipe made from a specific compound. Re-testing is required for a compound change that also requires re-testing the long term hydrostatic strength of the new formulation.

NOTE 6—Changes in compound formulations are defined in PPI TR-3.

6.13.2 The minimum operating temperature shall be greater than the Small-Scale-SteadyState RCP critical temperature when determined in accordance with ISO 13477 at a constant hoop stress of 928 psi (6.4 MPa) for PEX with an HDB of 1250 psi, or 1160 psi (8.0 MPa) for PEX with an HDB of 1600 psi.

6.13.3 The squeeze-off testing discussed below is only for pipe sizes, wall thicknesses, squeeze procedures, and conditions deemed suitable for squeeze-off in service by the pipe manufacturer. The PEX pipe shall be conditioned to assure it is at the established minimum operating temperature, then squeezed-off at this temperature in accordance with ISO 14531-1 Annex D. Samples of pipe that have been subjected to squeeze-off shall then not fail when tested at 200 °F (93 °C) for 1000 h in accordance with Test Method D1598 at the hoop stress stated in Table 7.

6.14 *Fittings:*

6.14.1 Inch-sized fittings shall not be used for metric-sized pipe, and metric-sized fittings shall not be used for inch-sized pipe.

6.14.2 Fittings shall meet the requirements of Specification F2829/F2829M when used with PEX pipe that is manufactured to this specification.

6.14.3 For PEX pipe that is deemed suitable by the pipe manufacturer for joining to polyethylene (PE) electrofusion fittings, the pipe manufacturer shall qualify the PE electrofusion fitting by testing joints made between PE electrofusion fitting and PEX pipe meeting this specification, and assuring that these joints meet the performance requirements of the PE electrofusion fitting standard (Specification F1055 or F3373). The pipe manufacturer shall then mark the PEX pipe in accordance with 9.2.12.

7. Test Methods

7.1 *Conditioning*—Condition the specimens at 73 °F ± 4 °F (23 °C ± 2 °C) and 50 % ± 5 % relative humidity for not less than 40 h prior to testing in accordance with Procedure A of Practice D618, for those tests where conditioning is required and not otherwise specified.

7.2 *Test Conditions*—Conduct the test in the standard laboratory atmosphere of 73 °F ± 4 °F (23 °C ± 2 °C) and 50 % ± 5 % relative humidity, unless otherwise specified in the test methods or in this specification.

7.3 *Sampling*—A sufficient quantity of pipe, shall be selected and tested to determine conformance with this specification. In the case of no prior agreement, random samples selected by the testing laboratory shall be deemed adequate.

7.3.1 *Test Specimens*—Not less than 50 % of the test specimens required for any pressure test shall have at least a part of the marking in their central sections. The central section is that portion of pipe that is at least one pipe diameter away from an end closure.

7.4 *Dimensions and Tolerances*—Use any length of pipe to determine the dimensions. Measure dimensions in accordance with Test Method D2122.

7.4.1 *Outside Diameter*—Measure the outside diameter of the pipe in accordance with Test Method D2122. The referee