



Standard Specification for Crosslinked Polyethylene (PEX) Pipe for Gas Distribution Applications¹

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1. Scope*

1.1 This specification covers outside diameter controlled, metric-sized and inch-sized black or yellow crosslinked polyethylene (PEX) pipe, made in pipe dimension ratios ranging from 6 to 17, and pressure rated for gas distribution. Included are requirements and test methods for material, workmanship, dimensions, burst pressure, hydrostatic sustained pressure, stabilizer functionality, bent-pipe hydrostatic pressure, degree of crosslinking, chemical resistance, minimum operating temperature and squeeze-off. Requirements for pipe markings are also given. The pipe covered by this specification is intended for buried gas distribution and gas transmission pressure piping applications.

1.2 This specification also includes requirements for joints made between PEX pipe and polyethylene electrofusion fittings (specified in Specification F3373). Fittings to be used with PEX pipe manufactured to this specification are in Specification F2829/F2829M. Installation considerations are in X3.2.

NOTE 1—Inch-sized fittings should not be used for metric-sized pipe, and metric-sized fittings should not be used for inch-sized pipe.

1.3 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.

1.4 *Units*—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.

1.5 *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 appro-*

priate safety and health practices and determine the applicability of regulatory limitations prior to use.

1.6 *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

- D543 Practices for Evaluating the Resistance of Plastics to Chemical Reagents
- 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
- D1603 Test Method for Carbon Black Content in Olefin 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

¹ This specification is under the jurisdiction of ASTM Committee F17 on Plastic Piping Systems and is the direct responsibility of Subcommittee F17.60 on Gas.

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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.

- D4218** Test Method for Determination of Carbon Black Content in Polyethylene Compounds by the Muffle-Furnace Technique
- D5596** Test Method for Microscopic Evaluation of the Dispersion of Carbon Black in Polyolefin Geosynthetics
- F412** Terminology Relating to Plastic Piping Systems
- F876** Specification for Crosslinked Polyethylene (PEX) Tubing
- F1041** Guide for Squeeze-Off of Polyolefin Gas Pressure Pipe and Tubing
- F1563** Specification for Tools to Squeeze-off Polyethylene (PE) Gas Pipe or Tubing
- F1948** Specification for Metallic Mechanical Fittings for Use on Outside Diameter Controlled Thermoplastic Gas Distribution Pipe and Tubing
- F2657** Test Method for Outdoor Weathering Exposure of Crosslinked Polyethylene (PEX) Tubing
- F2829/F2829M** Specification for Metric- and Inch-Sized Fittings for Crosslinked Polyethylene (PEX) Pipe
- F2897** Specification for Tracking and Traceability Encoding System of Natural Gas Distribution Components (Pipe, Tubing, Fittings, Valves, and Appurtenances)
- F3373** Specification for Polyethylene (PE) Electrofusion Fittings for Outside Diameter Controlled Crosslinked Polyethylene (PEX) Pipe
- 2.2 Federal Standard:**³
- FED-STD-123** Marking for Shipment (Civil Agencies)
- 2.3 Military Standard:**³
- MIL-STD-129** Marking for Shipment and Storage
- 2.4 ISO Standards:**⁴
- ISO 1167** Thermoplastics pipes, fittings and assemblies for the conveyance of fluids — Determination of the resistance to internal pressure — Part 1: General method
- 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 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 14531-2** Plastics pipes and fittings — Crosslinked polyethylene (PE-X) pipe systems for the conveyance of gaseous fuels — Metric series — Specifications — Part 2: Fittings for heat-fusion jointing
- ISO 14531-3** Plastics pipes and fittings — Crosslinked polyethylene (PE-X) pipe systems for the conveyance of gaseous fuels — Metric series — Specifications — Part 3: Fittings for mechanical jointing (including PE-X/metal transitions)
- ISO 18553** Method for the assessment of the degree of pigment or carbon black dispersion in polyolefin pipes, fittings and compounds.

2.5 PPI Standards:⁵

- 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. 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 that is outside diameter controlled.

3.2 Definitions of Terms Specific to This Standard:

3.2.1 crosslinked polyethylene, n—a polyethylene material that has undergone a change in molecular structure using a chemical or a physical process whereby the polymer chains are chemically linked.

3.2.2 PEX pipe material designation code—The PEX pipe material designation code shall consist of the abbreviation for crosslinked polyethylene (PEX) followed by four Arabic digits as shown in **Table 1**, and as defined in Terminology **F412** for PEX pipe materials.

4. Pipe Classification

4.1 General—This specification covers PEX pipe that is pressure rated based on HDB at 73 °F [23 °C] and 200 °F [93 °C]. Pressure ratings for temperatures between 73 °F [23 °C] and 200 °F [93 °C] are determined by temperature interpolation in accordance with PPI TR-3.

4.2 Classification—PEX pipes are classified by their PEX pipe material designation codes as shown in **Table 1**.

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 HDB in accordance with **5.2** and **Table 1**. The maximum temperature for intermittent operation shall require special design considerations and consultation with the

⁵ Available from Plastics Pipe Institute (PPI), 105 Decker Court, Suite 825, Irving, TX 75062, <http://www.plasticpipe.org>.

TABLE 1 PEX Pipe Material Designation Codes

PEX Pipe Material Designation Code	73 °F [23 °C] HDB	200 °F [93 °C] HDB
	Psi [MPa]	Psi [MPa]
PEX 0006	1250 [8.62]	630 [4.34]
PEX 0008	1600 [11.03]	630 [4.34]
PEX 0009	1800 [12.41]	630 [4.34]

³ DLA Document Services Building 4/D 700 Robbins Avenue Philadelphia, PA 19111-5094 <http://quicksearch.dla.mil/>

⁴ Available from International Organization for Standardization (ISO), 1, ch. de la Voie-Creuse, CP 56, CH-1211 Geneva 20, Switzerland, <http://www.iso.org>.

pipe manufacturer and shall be consistent with the PPI “*PEX Pipe Design Manual for Water, Oil, Gas & Industrial Applications*”.

5. Materials

5.1 *General*—PEX pipes, meeting the requirements of this specification, are defined by means of (1) degree of crosslinking per 6.7, and (2) long-term strength tests per Test Method D2837 to determine HDB per Table 1. The HDB is a property of the PEX compound, which is used to make the PEX pipe.

5.2 *Basic Materials*—PEX pipe and fittings shall be made from PE compounds, which have been crosslinked by peroxides, azo compounds, or silane compounds in extrusion, or by electron beam after extrusion, such that the pipe meets the performance requirements of Section 6. The materials, procedure for mixing, and the process for crosslinking shall result in a product with Hydrostatic Design Basis ratings equal to or better than those shown in Table 1, when determined in accordance with procedures no less restrictive than those of Test Method D2837, and the PEX material shall have a Plastics Pipe Institute (PPI) long-term hydrostatic design stress and hydrostatic design basis rating per PPI TR-3. See Appendix X1 for additional information on PPI hydrostatic stress ratings.

5.3 *Pipe Material Designation Code*—The PEX material meeting the requirements of this specification shall be designated PEX 0006, PEX 0008 or PEX 0009.

NOTE 2—The first two digits in the pipe material designation code are for chlorine resistance and UV resistance. A “0” indicates “not tested”. If either of these properties has been tested, then the “0” is replaced by the appropriate digit.

5.4 *Density*—When determined in accordance with 7.5, the PE base resin used for PEX pipe, without carbon black, used for PEX pipe shall have a minimum average density of 0.926 g/cm³.

5.5 Color:

5.5.1 PE compounds used to make black PEX pipe shall contain well dispersed carbon black as a colorant.

5.5.2 PE compounds used to make yellow PEX pipe shall contain a yellow pigment as a colorant.

5.6 UV Protection:

5.6.1 Black pipe with or without yellow stripes shall be stabilized and protected against deterioration from unprotected UV exposure for not less than 10 years. Yellow pipe shall be stabilized and protected against deterioration from unprotected UV exposure for not less than 3 years.

5.6.2 If the carbon black content is less than 2.0 %, the pipe shall be tested 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 (for stress values, use 536 psi (3.7 MPa) for PEX 0006, 681 psi (4.7 MPa) for PEX 0008, or 768 psi (5.3 MPa) for PEX 0009), and elongation at break requirements of ISO 14531-1, Table 8.

5.6.3 If the carbon black content is greater than 2.0 % and less than 3.0 % as measured by Test Method D1603 or Test Method D4218, the UV exposure time requirement of 5.6.2 is not applicable. This is consistent with ISO 14531-1, Table 8.

The carbon black shall be well dispersed, and have the correct type (furnace) and particle size (40 nm or less), such as N550. To demonstrate good carbon black dispersion the PEX pipe shall meet the ISO 14531-1 dispersion requirement of less than or equal to grade 3 when measured in accordance with ISO 18553, or in accordance with an equivalent ASTM test method for carbon black dispersion, such as Test Method D5596.

5.7 *Rework Material*—PEX rework shall not be used in the manufacture of PEX pipes and fittings made in accordance to this specification.

5.8 *Chemical Resistance*—The PEX material shall not increase in weight more than 0.5 % (1.0 % for toluene in methanol). Where the test specimen is a pipe ring, the material shall not change more than ± 12 % in apparent tensile yield strength when measured in accordance with 7.11.

NOTE 3—This test is only an indication of what will happen as a result of short-term exposure to these chemicals. For long-term results, additional testing is required.

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 2 and Table 3 for pipe apply to the average measured diameter in accordance with 7.4.1.

6.3 Dimensions and Tolerances:

6.3.1 *Outside Diameters*—The outside diameters and tolerances shall be as shown in Table 2 or Table 3, when measured in accordance with 7.4 and 7.4.1.

6.3.2 *Wall Thickness*—The wall thickness and tolerances shall be as shown in Table 4 or Table 5, when measured in accordance with 7.4 and 7.4.2.

6.4 *Sustained Pressure 73 °F [23 °C]*—The PEX pipe shall not fail in less than 1000 h when tested in accordance with 7.6. For PEX 0006 the stress shall be 1320 psi [9.1 MPa], for PEX 0008 the stress shall be 1650 psi [11.3 MPa], and for PEX 0009 the stress shall be 2050 psi [14.1 MPa]. Piping intended for use at temperatures of 100 °F [38 °C] and higher shall be tested at both 73 °F [23 °C] and the maximum design temperature. The test fiber stress shall be 90 % of the HDB.

6.5 *Minimum Hydrostatic Burst Pressure (Quick Burst)*—The pipe shall fail in a ductile manner when tested in accordance with 7.7. For pipe sizes above 4 in [110 mm] nominal diameter, the testing lab shall be allowed to replace the quick burst test by the apparent ring tensile strength test in 6.6.

6.6 *Apparent Tensile Strength at Yield*—When tested in accordance with 7.8, the PEX pipe shall demonstrate a minimum of 3000 psi [20.7 MPa] for PEX 0006, 3700 psi [25.5 MPa] for PEX 0008, and 4600 psi [31.7 MPa] for PEX 0009.

6.7 Degree of Crosslinking:

6.7.1 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 test method used, the

TABLE 2 Metric-sized Outside Diameters and Tolerances for PEX Pipe

Pipe Size	Average Outside Diameter	Tolerances for Average Diameter	Out-of-Roundness
mm	mm	mm	mm
16	16.15	±0.15	1.2
20	20.15	±0.15	1.2
25	25.15	±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	24.8
800	813.00	±3.60	28.0
900	904.05	±4.05	31.5
1000	1004.50	±4.50	35.0

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

Pipe Size	Outside Diameter	Tolerances for Outside Diameter (±)
in.	in.	in.
3	3.500	0.016
4	4.500	0.020
5	5.563	0.025
6	6.625	0.030
8	8.625	0.039
10	10.750	0.048
12	12.750	0.057
14	14.000	0.063
16	16.000	0.072
18	18.000	0.081
20	20.000	0.090
22	22.000	0.099
24	24.000	0.108
26	26.000	0.117
28	28.000	0.126
30	30.000	0.135
32	32.000	0.144
34	34.000	0.153
36	36.000	0.162
42	42.000	0.189
48	48.000	0.216
54	54.000	0.243

following minimum percentage crosslinking values shall be achieved: 70 % by peroxides, 65 % by electron beam, or 65 % by silane compounds. PEX pipe shall meet these minimum crosslink requirements before the manufacturer can release this pipe for installation by the user.

6.7.2 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 below. Collect shaving samples, about 0.004 in. (0.10 mm) thick, by drilling a hole in the axial pipe direction with a 1/8 in. (3 mm) drill to collect a 0.007 – 0.014 ounce (0.2 – 0.4 gram) sample size.

6.7.3 The degree of crosslinking over the entire wall thickness of all thick-wall pipe tested per 6.7.2 shall meet the minimum requirements specified in 6.7.1. The degree of crosslinking shall not vary outside the limits specified in 6.7.1 at any time at any part of the pipe.

6.8 *Stabilizer Functionality*—Stabilizer Functionality shall be tested in accordance with 7.10. The test need only be performed for the original validation of pipe made from a particular compound.

6.9 *Bent Pipe Hydrostatic Sustained Pressure Strength:*

6.9.1 *General*—PEX pipe sizes and DR's deemed suitable for bending by the pipe manufacturer shall meet the requirements in 6.9.2.

6.9.2 Cold-bent pipe, with a radius of six (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 in 6.4 when tested in accordance with 7.6.

6.10 *Squeeze-Off*—This requirement is limited to pipe sizes, wall thicknesses, squeeze procedures, and conditions deemed suitable for squeeze-off in service by the pipe manufacturer. Squeeze-off shall be performed per Guide F1041 using tools that meet Specification F1563. There shall be no leakage or visual evidence of splitting, cracking, breaking or reduction in 1000 h sustained pressure category when pipe is tested in accordance with 7.12.