



# Standard Specification for Crosslinked Polyethylene (PEX) Pipe for Gas Distribution Applications<sup>1</sup>

This standard is issued under the fixed designation F2968/F2968M; 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 ( $\epsilon$ ) indicates an editorial change since the last revision or reapproval.

## 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 appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

<sup>1</sup> 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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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:<sup>2</sup>

- 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
- D4218 Test Method for Determination of Carbon Black Content in Polyethylene Compounds by the Muffle-Furnace Technique

<sup>2</sup> 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

- 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*.<sup>3</sup>

FED-STD-123 Marking for Shipment (Civil Agencies)

2.3 *Military Standard*.<sup>3</sup>

MIL-STD-129 Marking for Shipment and Storage

2.4 *ISO Standards*.<sup>4</sup>

- 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*.<sup>5</sup>

- 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

<sup>5</sup> 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]

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

<sup>4</sup> 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/cm<sup>3</sup>.

### 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 to 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 process 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

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.

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

**TABLE 4 Metric-sized Wall Thickness and Tolerances for PEX Plastic Pipe**

Pipe Size [mm]	Minimum Wall Thickness (t), mm (tolerance is plus 12 %)							
	DR 6	DR 7.4	DR 9	DR 11	DR 13.6	DR 16.2	DR 17	DR 21
16	3.0	2.3	2.0	...	...	...	...	...
20	3.4	3.0	2.3	2.0	...	...	...	...
25	5.4	3.5	3.0	2.3	2.0	...	...	...
32	5.4	4.4	3.6	3.0	2.4	2.0	2.0	2.3
40	6.7	5.5	4.5	3.7	3.0	2.5	2.4	2.8
50	8.3	6.9	5.6	4.6	3.7	3.1	3.0	3.4
63	10.5	8.6	7.1	5.8	4.7	3.9	3.8	4.3
75	12.5	10.3	8.4	6.8	5.6	4.6	4.5	5.1
90	15.0	12.3	10.1	8.2	6.7	5.6	5.4	6.1
110	18.3	15.1	12.3	10.0	8.1	7.7	6.6	7.4
125	20.8	17.1	14.0	11.4	9.2	7.7	7.4	8.3
140	23.3	19.2	15.7	12.7	10.3	8.7	8.3	9.3
160	26.6	21.9	17.9	14.6	11.8	9.9	9.5	10.6
180	29.9	24.6	20.1	16.4	13.3	11.1	10.7	11.9
200	33.2	27.4	22.4	18.2	14.7	12.4	11.9	13.2
225	37.4	30.8	25.2	20.5	16.6	13.9	13.4	14.9
250	41.5	34.2	27.9	22.7	18.4	15.5	14.8	16.4
280	46.5	38.3	31.3	25.4	20.6	17.3	16.6	18.4
315	52.3	43.1	35.2	28.6	23.2	19.5	18.7	20.7
355	59.0	48.5	39.7	32.2	26.1	21.9	21.1	23.4
400	...	54.7	44.7	36.3	29.4	24.7	26.2	23.7
450	...	61.5	50.3	40.9	33.1	27.8	26.7	29.5
500	...	...	55.8	45.4	36.8	30.9	29.7	32.8
560	...	...	62.5	50.8	41.2	34.6	33.2	36.7
630	...	...	70.3	57.2	46.3	38.9	37.4	41.3
710	...	...	79.3	64.5	52.2	43.9	42.1	46.5
800	...	...	89.3	72.6	58.8	49.4	47.4	52.3
900	...	...	...	81.7	66.2	56.6	53.3	58.8
1000	...	...	...	90.2	72.5	61.8	59.3	65.4

**TABLE 5 Inch-sized Wall Thickness and Tolerances for PEX Plastic Pipe**

Pipe Size, in.	Minimum Wall Thickness (t), in (tolerance is plus 12 %)							
	DR 7.3	DR 8.3	DR 9	DR 11	DR 13.5	DR 15.5	DR 17	DR 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

6.11 *Elevated Temperature Service*—piping materials intended for use at temperatures above 100 °F [38 °C] shall have the PPI hydrostatic design basis (HDB) determined at the specific temperature in accordance with Test Method **D2837**. The 100 000-h intercept (long-term strength) shall be categorized in accordance with **Table 6** and be listed as the “hydrostatic design basis of XXX psi at XXX °F [C°] for (compound name).”

6.12 All tests shall be repeated if there is a change in the crosslinking agent, antioxidant package or the base PE resin for the PEX compound.

6.13 *Minimum Operating Temperature:*

6.13.1 Pipe shall have a minimum operating temperature established by testing in accordance with **6.13.2**. Squeeze-off tests are then conducted on the pipe at this minimum operating temperature in accordance with **6.14**.

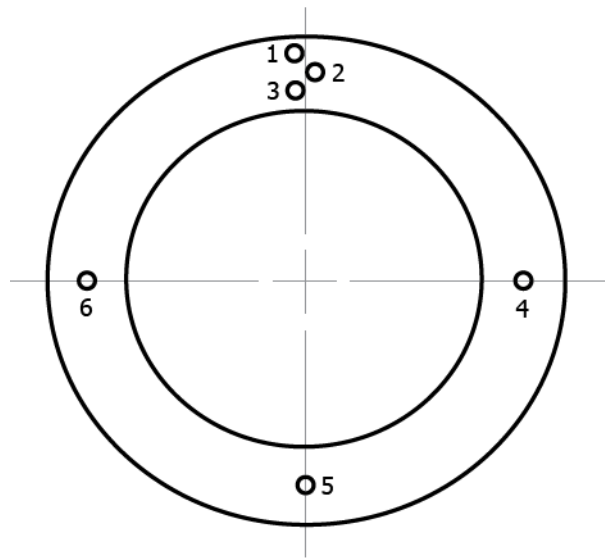


FIG. 1 Sample Location for Degree of Crosslink Test on Thick-wall Pipe

TABLE 6 Pipe Category

Property	Test Method	Category							
		A	B	C	D	E	F	G	H
Temperature, °F	...	100 [38]	120 [49]	140 [60]	160 [71]	180 [82]	200 [93]	...	...
Temperature, °C	...	...	...	...	...	...	...	...	...
Hydrostatic Design Basis, psi [MPa]	D2837	400 [2.8]	500 [3.4]	630 [4.3]	800 [5.5]	1000 [6.9]	1250 [8.6]	1600 [11.0]	2000 [13.8]

Example: EE - At 180 °F [82 °C] the HDB is 1000 psi [6.9 MPa].

6.13.1.1 These tests need only be performed for the original pipe made from a particular compound. Re-testing is required for a compound change that also requires re-testing of the new formulation. 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 (8.6 MPa), or 1160 psi (8.0 MPa) for PEX with an HDB of 1600 psi (11 MPa).

6.14 Squeeze-off:

6.14.1 Squeeze-Off 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 a hoop stress of 536 psi (3.7 MPa) for PEX with an HDB of 1250 psi (8.6 MPa), or 681 psi (4.7 MPa) for PEX with an HDB of 1600 psi (11 MPa).

6.15 Polyethylene Electrofusion Joints:

6.15.1 Qualification of Electrofusion Joints—For PEX pipe that is deemed suitable by the pipe manufacturer for joining to polyethylene (PE) electrofusion fittings, the pipe manufacturer

shall qualify the PEX pipe by testing joints made with PE electrofusion fittings and PEX pipe meeting this standard, and assuring that these joints meet the performance requirements of the PE electrofusion fitting standard, Specification F3373.

6.15.2 The pipe shall be marked in accordance with 8.1, if deemed suitable for electrofusion joining.

7. Test Methods

7.1 Conditioning—Condition the specimens at 73.4 °F ± 3.6 °F [23 °C ± 2 °C] and 50 % ± 10 % relative humidity for not less than 40 h prior to test in accordance with Procedure A of Practice D618, for those tests where conditioning is required. In cases of disagreement, the tolerances shall be ±1.8 °F [±1 °C] and ±2 % relative humidity.

7.2 Test Conditions—Conduct the test in the standard laboratory atmosphere of 73.4 °F ± 3.6 °F [23 °C ± 2 °C] and 50 ± 10 % relative humidity, unless otherwise specified in the test methods or in this specification. In cases of disagreement, the tolerances shall be ±1.8 °F [±1 °C] and ±2 % relative humidity.

7.3 Sampling—A sufficient quantity of pipe, as agreed upon by the purchaser and the seller, 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 in accordance with Test Method **D2122**.

**7.4.1 Outside Diameter**—Measure the outside diameter and out-of-roundness of the pipe in accordance with Test Method **D2122**. The referee method of measurement is to be by circumferential wrap tape. The tolerance for out-of-roundness shall apply only to pipe prior to shipment. Averaging micrometer or vernier caliper measurements, six (6) maximum and minimum diameter measurements at any cross section, may be used for quality control checks if desired.

**7.4.2 Wall Thickness**—Make micrometer measurements of the wall thickness in accordance with Test Method **D2122** to determine the maximum and minimum values.

**7.5 Density**—Determine the density of the PE base resin, without carbon black, in accordance with Test Method **D1505**, or Test Methods **D792**, for three specimens. The density is the average of the three measurements.

**7.6 Sustained Pressure Test:**

**7.6.1** Select six test specimens of pipe at random, condition at the standard laboratory test temperature and humidity, and pressure test in accordance with Test Method **D1598**.

**7.6.1.1** Test specimens shall be prepared so that the minimum length of pipe on each side of the fitting is equal to 5 times the diameter of the pipe but in no case less than 12 in. [304 mm] for sizes less than 160 mm [6 in]. For larger sizes, the minimum length shall be equal to 3 times the diameter or 30 in. [762 mm], whichever is shorter.

**7.6.1.2** Pressures used shall be calculated using the pipe's actual measured minimum wall thickness, outside diameter, and the applicable fiber stress, whichever is greater. 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.

**7.6.2** Maintain the specimens at the pressures required, held to  $\pm 10$  psi [0.07 MPa], for a period of 1000 h at the test temperature  $\pm 3.6$  °F [ $\pm 2$  °C] as specified in **7.6.1**.

**7.6.3** Failure of two of the six specimens tested shall constitute failure in the test. Failure of one of the six specimens tested is cause for retest of six additional specimens. Failure of one of the six specimens in retest shall constitute failure in the test. Evidence of failure of the pipe shall be as defined in Test Method **D1598**.

**7.7 Minimum Hydrostatic Burst Pressure (Quick Burst)**—The test equipment, procedures, and failure definitions shall be as specified in Test Method **D1599**. Pressures shall be as calculated using the pipe's actual measured minimum wall thickness, outside diameter, and the applicable fiber stress.

**7.8 Apparent Tensile Properties**—The procedure and test equipment shall be as specified in Test Method **D2290**, Procedure B. The speed of testing shall be 0.5 in. [12.7 mm]/min. Cut “ring” specimens from pipe. Test a minimum of five specimens. This method is applicable to all pipe of nominal  $\frac{3}{4}$  in. [20 mm] outside diameter and larger.

**7.9 Degree of Crosslinking**—Place a pipe sample in a lathe with automatic feeding. Shave a strip that consists of the full wall thickness. The strip thickness shall be approximately 0.004 in. [0.1 mm], which is obtained by setting the lathe feeding accordingly. Test the specimens in accordance with Test Methods **D2765**, Method B, with the only deviation: test specimen preparation. For the purpose of this specification, degree of crosslinking (X) is defined as 100 % minus extract percent equals X.

**7.10 Stabilizer Functionality**—The functionality of a stabilizer in a specific PEX compound shall be verified one time by hydrostatic testing of pipe made from the compound. Test six pipe samples continuously for 3000 h at a hoop stress of 0.70 MPa at 120 °C, or for 8000 h at a hoop stress of 2.8 MPa at 110 °C. This test is used to demonstrate the specific compound's ability to withstand long term temperature conditions set forth elsewhere in this standard.

**7.10.1 Procedure**—The test procedure shall be conducted in accordance with Test Method **D1599** or ISO 1167. Test six (6) samples at one of the temperature conditions in **7.10**. The internal medium is water the external medium is air. Failure of any one of the specimens constitutes failure of the test.

**7.11 Chemical Resistance**—Determine the resistance to the following chemicals in accordance with Practice **D543**. Where available, the test specimen shall be a ring of 63 mm SDR 11 pipe cut to the ring dimensions specified in **7.8**.

Chemicals	Concentration (% by volume)
Mineral oil (USP)	100
Tertiary-butyl mercaptan	5 in mineral oil
Antifreeze agents (at least one shall be used):	
Methanol, or	100
Ethylene glycol	100
Toluene	15 in methanol

Test five specimens with each chemical. Weigh the specimens to the nearest 0.005 g and completely immerse them in the chemicals for 72 h. On removal from the chemicals, wipe the specimens with a clean dry cloth. Condition in air for 2 to 2-¼ h and reweigh. Calculate the increase in weight to the nearest 0.01 % on the basis of initial weight. Test the specimen in tension in accordance with **7.8** within ½ h after weighing. Examine the weight and apparent tensile strength of each specimen for conformance to the requirement in **5.8**. **Warning**—Because of the possible toxicity of these reagents, refer to the Material Safety Data Sheet on each of these reagents before using or handling them.

**NOTE 4**—This pipe 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.

**7.12 Squeeze-off:**

**7.12.1** Prepare six randomly selected pipe specimens in accordance with Test Method **D1598** except they shall be unfilled.

**7.12.2** The squeeze-off shall be effected at the mid-point of the test specimen, 90° to the point of the measured minimum wall thickness. Close the squeeze bars to the gap stop in Specification **F1563** and hold in constraint for 4 h. Remove squeeze bar and reround pipe by closing squeeze bars at a point 90° from the squeeze area.