



# Standard Specification for Black Crosslinked Polyethylene (PEX) Pipe, Fittings and Joints 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, black metric-sized and IPS-sized crosslinked polyethylene (PEX) pipe, fittings and joints, 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, and squeeze-off. Requirements for pipe and fittings markings are also given. The pipe, fittings and joints covered by this specification are intended for buried gas distribution and gas transmission pressure piping applications.

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 *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 may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in non-conformance with the standard.

NOTE 1—Metric sized (SI units) pipe should only be joined with corresponding metric sized fittings, and inch sized pipe should only be joined with corresponding inch sized fittings. Inch sized fittings should not be used for metric sized pipe, and metric sized fittings should not be used for inch sized pipe.

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

<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

**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

**F2897** Specification for Tracking and Traceability Encoding System of Natural Gas Distribution Components (Pipe, Tubing, Fittings, Valves, and Appurtenances)

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 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)

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

### 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 standard covers black 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**.

### 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 *Carbon Black*—PE compounds used to make PEX pipe shall contain 2.0 to 3.0 percent well dispersed carbon black as measured in the PEX pipe by Test Methods **D1603** or **D4218**.

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

**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>.

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

5.7 *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  $\pm 12$  % 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

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

Pipe Size	Outside Diameter	Tolerances for Outside Diameter ( $\pm$ )
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

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

**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	$\pm 0.15$	1.2
20	20.15	$\pm 0.15$	1.2
25	25.15	$\pm 0.15$	1.2
32	32.15	$\pm 0.15$	1.3
40	40.20	$\pm 0.20$	1.4
50	50.20	$\pm 0.20$	1.4
63	63.20	$\pm 0.20$	1.5
75	75.25	$\pm 0.25$	1.6
90	90.30	$\pm 0.30$	1.8
110	110.35	$\pm 0.35$	2.2
125	125.40	$\pm 0.40$	2.5
140	140.45	$\pm 0.45$	2.8
160	160.50	$\pm 0.50$	3.2
180	180.55	$\pm 0.55$	3.6
200	200.60	$\pm 0.60$	4.0
225	225.70	$\pm 0.70$	4.5
250	250.75	$\pm 0.75$	5.0
280	280.85	$\pm 0.85$	9.8
315	315.95	$\pm 0.95$	11.1
355	356.10	$\pm 1.10$	12.5
400	410.20	$\pm 1.20$	14.0
450	451.35	$\pm 1.35$	15.6
500	501.50	$\pm 1.50$	17.5
560	561.70	$\pm 1.70$	19.6
630	631.90	$\pm 1.90$	22.1
710	713.20	$\pm 3.20$	24.8
800	813.00	$\pm 3.60$	28.0
900	904.05	$\pm 4.05$	31.5
1000	1004.50	$\pm 4.50$	35.0

**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

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**—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: 73 % by peroxides, 65 % by electron beam, or 65 % by silane compounds.

**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.

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 *Fittings and Joints*:

6.12.1 Fittings intended for use with PEX pipe at temperatures up to 200°F [93°C] shall meet the dimensional, design and performance requirements for the corresponding fitting product standard, such as Specification F1055, ISO 14531-2, or ISO 14531-3. Fittings shall be compatible with PEX pipe made to this specification. The fittings manufacturer shall recommend their fittings for use with PEX pipe in the intended application. PEX pipe shall only be joined using qualified joining procedures.

6.12.2 PE electrofusion fittings shall only be used for temperatures up to 140°F [60°C]. PEX electrofusion fittings shall be used for temperatures above 140°F [60°C] up to 200°F [93°C]. All electrofusion joints made between PEX pipe and electrofusion fittings shall meet the joint performance requirements as specified in the applicable fittings standard, such as Specification F1055 or ISO 14531-2.

NOTE 4—The following performance requirements are described in these ASTM and ISO standards for electrofusion fittings – 68°F [20°C] or 73°F [23°C] hydrostatic strength, 176°F [80°C] hydrostatic strength, short-term internal pressure resistance, resistance to tensile loads, cohesive resistance for electrofusion saddle and socket fittings at both the minimum and maximum recommended temperatures, impact resistance for saddle fittings.

6.12.3 All mechanical fitting joints made between PEX pipe and mechanical fittings shall meet the joint performance requirements as specified in the applicable fitting standard, such as Specification F1948 or ISO 14531-3.

NOTE 5—The following performance requirements are described for mechanical fittings – 68°F [20°C] hydrostatic strength, elevated temperature hydrostatic strength, short-term internal pressure resistance, resistance to tensile loads, impact resistance for saddle fittings, leak tightness under internal pressure, leak tightness under internal pressure when subjected to bending, external pressure test, and resistance to pull out under constant longitudinal force.

6.13 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.

7. Test Methods

7.1 *Conditioning*—Condition the specimens at 73.4 ± 3.6°F [23 ± 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 ± 3.6°F [23 ± 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.

TABLE 6 Pipe Category

Property	Test Method	Category							
		A	B	C	D	E	F	G	H
Temperature, °F [°C]	...	100 [38]	120 [49]	140 [60]	160 [71]	180 [82]	200 [93]	...	...
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].

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  $\pm 3.6^\circ\text{F}$  [ $\pm 2^\circ\text{C}$ ] 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 **5.7**.

**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 6—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 rereound pipe by closing squeeze bars at a point 90° from the squeeze area.

7.12.3 Immediately upon removal of the squeeze-off tool, fill the specimens with ambient temperature water, that is  $67 \pm 10^\circ\text{F}$  [ $19.4 \pm 5.6^\circ\text{C}$ ], condition, and test in accordance with **7.6**.

**8. Marking**

8.1 *Pipe*—All required marking shall be legible, visible, and permanent. To ensure permanence, marking shall be applied so it can only be removed by physically removing part of the pipe wall. The marking shall (1) not reduce the wall thickness to less than the minimum value for the pipe, (2) not have any effect on the long-term strength of the pipe, and (3) not provide leakage channels when elastomeric gasket compression fittings are used to make the joints. These markings shall consist of the word GAS, this designation ASTM, the manufacturer's name or trademark, the nominal pipe size, DR, PEX pipe material designation code, and date of manufacture.

8.1.1 In addition to 8.1, the pipe marking shall include a coding that will enable the manufacturer to determine the location of manufacture, pipe production and resin lots, and any additional information, which is agreed upon between the manufacturer and purchaser. The manufacturer shall maintain such records for fifty years or for the design service life of the pipe, whichever is longer.

8.1.2 All the markings in 8.1 and 8.1.1 shall be repeated at intervals not exceeding 2 ft [0.61 m]. For indented printing, either the indented print line shall be in a color that contrasts with that of the pipe, or a separate print line shall be in a color that contrasts with the pipe. When color is applied to identify gas service, such as with color stripes, a color shell or solid color pipe, yellow color shall be used.

NOTE 7—Using color stripes to identify piping service is not mandatory, but if used, the color should be yellow.

NOTE 8—The non-mandatory, preferred order for all the items required in the print line in the marking 8.1 is:

- (1) Pipe size and sizing system – example 3 in. or 90 mm.
- (2) DR – example DR 11,
- (3) Manufacturer’s name or trademark,
- (4) GAS,
- (5) PEX pipe material designation code – example PEX 0008,
- (6) Elevated temperature code from Table 6,
- (7) ASTM F2968 or F2968M,
- (8) Manufacturer’s lot code (includes date of manufacture in some cases), and
- (9) Additional information, including date of manufacture, coil number sequential footage, third party certification mark etc. Example: 90 mm DR 11 MANUFACTURER NAME GAS PEX 0008 EE ASTM FXXXX LOT CODE INFO 02JAN12 coil #506.

8.1.3 Markings for potable water, sewer, reclaimed water, communications or electrical use are prohibited.

8.2 *Fittings*—Fittings shall be marked ASTM F2968, as well as with the applicable fitting specification, and with Specification F2897. All fittings shall be marked on the body or hub. The markings shall consist at least of the manufacturer’s name or trademark, or both, the size, the symbol for the type of material, In addition, the fittings markings shall include code that will enable the manufacturer to determine the date of manufacture, the location of manufacture, fitting production and resin lots, and any additional information which may be agreed upon between the manufacturer and purchaser. The manufacturer shall maintain such records for 50 years or for the design service life of the fittings, whichever is longer.

NOTE 9—8.2 is applicable to fusion type fittings only. The marking requirements in 8.2 are not applicable to mechanical fittings.

8.3 All PEX pipe, tubing, and fusion fittings meeting the requirements of this specification for gas distribution systems shall be marked with the 16-character gas distribution component tracking and traceability identifier in accordance with Specification F2897. The 16-character code shall be expressed in alphanumeric format and Code 128 bar code format with a minimum bar thickness value of 0.005 in. or an alternative 1D or 2D bar code symbology as agreed upon between manufacturer and end user. All fittings shall have the 16-character codes marked or affixed to the product, product packaging, or any manner agreed upon between manufacturer and end user.

## 9. Quality Assurance

9.1 When the product is marked with this designation, ASTM F2968, the manufacturer affirms that the product was manufactured, inspected, sampled, and tested in accordance with this specification and has been found to meet the requirements of this specification.

## 10. Keywords

10.1 crosslinked polyethylene; gas distribution; HDB; hydrostatic stress; metric; PEX; pipe; PPI; pressure

## SUPPLEMENTARY REQUIREMENTS

These requirements apply only to federal/military procurement, not domestic sales or transfers.

S1. *Responsibility for Inspection*—Unless otherwise specified in the contract or purchase order, the producer is responsible for the performance of all inspection and test requirements specified herein. The producer may use his own or any other suitable facilities for the performance of the inspection and test requirements specified herein, unless the purchaser disapproves. The purchaser shall have the right to perform any of the inspections and tests set forth in this specification where such inspections are deemed necessary to ensure that material conforms to prescribed requirements.

NOTE S1.1—In U.S. federal contracts, the contractor is responsible for inspection.

S2. *Packaging and Marking for U.S. Government Procurement*:

S2.1 *Packaging*—Unless otherwise specified in the contract, the materials shall be packaged in accordance with the supplier’s standard practice in a manner ensuring arrival at destination in satisfactory condition and which will be acceptable to the carrier at lowest rates. Containers and packing shall comply with Uniform Freight Classification rules or National Motor Freight Classification rules.

S2.2 *Marking*—Marking for shipment shall be in accordance with FED. STD. No. 123 for civil agencies and MIL-STD-129 for military agencies.

NOTE S2.1—The inclusion of U.S. Government procurement requirements should not be construed as an indication that the U.S. Government uses or endorses the products described in this specification.

APPENDIXES

X1. PRESSURE RATING PEX PIPE

X1.1 The HDB pressure rating method is used to pressure rate PEX plastic pipe, and these HDB values are also used for the PEX pipe material designation codes (PMDC). These codes are: PEX 0006 for HDB 1250 psi, PEX 0008 for HDB 1600 psi, and PEX 0009 for HDB 1800 psi. These HDB values apply only to pipe meeting all the requirements of this specification. These HDB values have been established from long-term pressure testing in accordance with Test Method D2837, and are based on a temperature of 73°F [23°C].

X1.2 More detailed information on the HDB method is in Test Method D2837. Additional information regarding the method of test and other criteria used in developing these pressure ratings may be obtained from PPI TR-3.

X1.3 The pressure rating “PR” or maximum operating pressure “MOP” is determined using the equation below.

$$PR = 2 \times HDB \times F / (DR - 1)$$

or

$$MOP = 2 \times HDB \times F / (DR - 1)$$

The design factor specified for gas distribution applications is dependant on regional or national requirements. Table X1.1 provides calculated pressure ratings at 23°C [73°F] for

**TABLE X1.1 Pressure Rating (PR) for PEX Pipes at 23°C [73°F] Based on HDB and DR Using a Design Factor of 0.40 for Gas.**

PMDC HDB (psi)	PEX 0006 1250	PEX 0008 1600	PEX 0009 1800
Dimension Ratio (DR)	Pressure Rating (PR), psig		
17	62	80	90
13.5	80	100	115
11	100	125	145
9	125	160	180
6	200	250	285

various DR values and HDB values using the above equation. For this example, we are using a design factor of 0.40, as specified in Canada.

X2. ELEVATED TEMPERATURE PRESSURE RATINGS

X2.1 When elevated temperatures are anticipated, the pipe’s pressure rating is determined by using the HDB at the elevated temperature as published in PPI TR-4. When the elevated temperature HDB is used, then the pressure rating equation in X1.3 becomes:

$$PR = 2 \times (\text{elevated temperature HDB from TR - 4}) \times F / (DR - 1)$$

For example, if the operating temperature is 200°F [93°C], then the 200°F [93°C] HDB is used.

X2.2 If a temperature between 73°F [23°C] and 200°F [93°C] is desired, calculate the HDB at the desired temperature using the temperature interpolation method in PPI TR-3.

X3. DESIGN AND INSTALLATION CONSIDERATIONS

X3.1 Design

X3.1.1 *Thermal Expansion*—The linear expansion rate for PEX is approximately 1.1 in./10°F temperature change for each 100 ft of pipe, or 28 mm/5.6°C temperature change for each 30 m of pipe. When installing long runs of pipe, allow 1/8 to 3/16 in. longitudinal clearance per ft [10 to 14 mm/m] of run to accommodate thermal expansion. Pipe should not be anchored rigidly to a support but allowed freedom of movement to expand and contract

requirement. PEX pipe should be covered if necessary to avoid unnecessary dirt accumulation. Pipe can be stored in coils of number size and length recommended by the manufacturer. Care should be used in handling to ensure that unnecessary abuse, such as abrasion on concrete, is avoided.

X3.2.2 *Repairs*—If a leak is discovered, that portion of the system should be cut out.

X3.2 Installation

X3.2.1 *Storage and Handling*—Black PEX pipe may be stored outdoors up to 10 years due to the carbon black



#### X4. OPTIONAL PERFORMANCE QUALIFICATION AND IN-PLANT ASSURANCE CONTROL- PROGRAM FOR PEX PIPE

##### X4.1 Scope

X4.1.1 The following program covers performance qualification and in-plant quality assurance to provide reasonable assurance that PEX pipes supplied under this specification consistently meet the requirements.

##### X4.2 Performance Qualifications

X4.2.1 Performance qualification tests are run initially on each size in accordance with the requirements of this specification.

##### X4.3 In-Plant Quality Control

X4.3.1 *Material*—The pipe material is PEX as defined in 3.2.1 of this specification.

X4.3.2 Pipe quality-control tests are run for each extrusion line in accordance with the requirements of this specification at a frequency agreed upon between the purchaser and the manufacturer. The program outlined in Table X4.1 is recom-

**TABLE X4.1 Suggested PEX Pipe Quality-Control Program**

Property	Frequency	Requirements
Workmanship	continuously	6.1
Dimensions	hourly	6.2
Density	weekly	6.4
Burst Pressure	daily	6.6
Sustained pressure	3 months	6.5
Degree of crosslinking	3 days	6.8
Bent pipe	yearly	6.10
Carbon black	weekly	5.4

mended. The test results are recorded and filed for inspection on request. Should a specimen fail to meet the specification in any test, production should be sampled back to the previous acceptable test result and tested to determine which specimens produced in the interim do not meet the requirement.

#### SUMMARY OF CHANGES

Committee F17 has identified the location of selected changes to this standard since the last issue (F2968/F2968M–14) that may impact the use of this standard.

(1) Added gas transmission to 1.1.

(2) Changed PEX definition to be consistent with F876.

(3) Added pipe sizes up to 1000 mm in Table 2 on outside diameter to be consistent with Table 4 on wall thickness.

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