



Designation: F2905/F2905M – 13

Standard Specification for Black Crosslinked Polyethylene (PEX) Line Pipe, Fittings and Joints For Oil and Gas Producing Applications¹

This standard is issued under the fixed designation F2905/F2905M; 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 outside diameter controlled, pressure rated, black metric-sized and IPS-sized crosslinked polyethylene (PEX) pipe, fittings and joints, made in pipe dimension ratios ranging from 6 to 17. Included are requirements and test methods for material, workmanship, dimensions, burst pressure, hydrostatic sustained pressure, stabilizer functionality, bent-pipe hydrostatic pressure, degree of crosslinking, and chemical resistance. Requirements for pipe and fittings markings are also given. The pipe, fittings and joints covered by this specification are intended for pressure or non-pressure oil and gas producing applications to convey fluids such as oil, dry or wet gas, gas gathering, multiphase fluids, and non-potable oilfield water. This specification does not cover pipe for gas distribution 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 IPS 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.*

¹ This specification is under the jurisdiction of ASTM Committee F17 on Plastic Piping Systems and is the direct responsibility of Subcommittee F17.68 on Energy Piping Systems.

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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
- 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
- F1055 Specification for Electrofusion Type Polyethylene Fittings for Outside Diameter Controlled Polyethylene and Crosslinked Polyethylene (PEX) Pipe and Tubing
- F1948 Specification for Metallic Mechanical Fittings for Use on Outside Diameter Controlled Thermoplastic Gas Distribution Pipe and Tubing
- F2619 Specification for High-Density Polyethylene (PE) Line Pipe

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.

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 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*: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

PPI TR-9 Recommended Design Factors and Design Coefficients for Thermoplastic Pressure 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*—molecular chains chemically connected through irradiation with high-energy electron beams, or chemical agents such as organic peroxides or silanes.

3.2.2 *multiphase fluid, n*—oil, gas, and water in any combination produced from one or more oil or gas wells, or recombined oil or gas well fluids that may have been separated in passing through surface facilities.

3.2.3 *oilfield water, n*—fresh or salt water transported by pipeline, regardless of purity or quality, from wells or surface locations for the purpose of providing water injection to underground reservoirs; or disposing of waste water from hydrocarbon or gas production, processing, or storage facilities.

³ Available from Standardization Documents Order Desk, DODSSP, Bldg. 4, Section D, 700 Robbins Ave., Philadelphia, PA 19111-5098, <http://dodssp.daps.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>.

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

3.2.4 *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.

3.2.5 *production run, n*—the continuous extrusion of pipe of a specific diameter, wall thickness and material compound.

3.2.6 *sample, n*—pipe or an element of pipe that represents a quantity of pipe and provides a specimen or specimens for testing.

3.2.7 *specimen, n*—pipe or an element of pipe that is subjected to test.

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. See **Appendix X1** for additional information on PPI hydrostatic stress ratings.

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

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

TABLE 1 PEX Pipe Material Designation Codes

| PEX Pipe Material Designation Code | 73°F [23°C] HDB Psi [MPa] | 200°F [93°C] HDB 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] |

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 Method D1603 or Test Method 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.

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.

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 |

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

| Pipe Size | Outside Diameter | Tolerances or Outside Diameter ± |
|-----------|------------------|----------------------------------|
| in. | in. | in. |
| 3 | 3.500 | .016 |
| 4 | 4.500 | .020 |
| 5 | 5.563 | .025 |
| 6 | 6.625 | .030 |
| 8 | 8.625 | .039 |
| 10 | 10.750 | .048 |
| 12 | 12.750 | .057 |
| 14 | 14.000 | .063 |
| 16 | 16.000 | .072 |
| 18 | 18.000 | .081 |
| 20 | 20.000 | .090 |
| 22 | 22.000 | .099 |
| 24 | 24.000 | .108 |
| 26 | 26.000 | .117 |
| 28 | 28.000 | .126 |
| 30 | 30.000 | .135 |
| 32 | 32.000 | .144 |
| 34 | 34.000 | .153 |
| 36 | 36.000 | .162 |
| 42 | 42.000 | .189 |
| 48 | 48.000 | .216 |
| 54 | 54.000 | .243 |

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*—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 6.10.2.

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 Fittings and Joints:

6.10.1 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

TABLE 4 Metric-sized Wall Thickness and Tolerances for PEX Plastic Pipe Minimum Wall Thickness (t), mm (tolerance is plus 12%)

| Pipe Size [mm] | 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) | 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 |

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.

6.10.2 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 require-

ments as specified in the applicable fittings standard, such as Specification **F1055** or ISO 14531-2.

NOTE 2—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. 6.10.3 All mechanical fitting joints made between PEX