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An American National Standard

Standard Specification for Multilayer Polyethylene-Polyamide (PE-PA) Pipe for Pressure Piping Applications[1]

This standard is issued under the fixed designation F2807; 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 requirements and test methods for ½ in. through 14 in. multilayer polyethylene-polyamide (PE-PA) pipe, which is a two-layer pipe (PE pipe layer bonded to an inner layer of PA). The multilayer pipe covered by this specification is intended for use in piping applications where the permeation and chemical resistance of polyamide (PA) compounds may be useful to protect the PE pipe layer, such as oil and gas producing applications that convey oil, dry or wet gas, and multiphase fluids.

NOTE 1—Permeability and chemical resistance depends on the type of PA used. The PA layer delays but does not prevent liquid hydrocarbons effects. Therefore, the hydrocarbon chemical design factor for this multilayer pipe should be the same as for PE pipe layer—see X1.2.

1.2 Electrofusion and mechanical joints are typically used for this multilayer pipe.

1.3 Unless specified otherwise, all the pipe requirements in this specification are for the multilayer pipe.

1.4 The PA layer is not taken into consideration for the design pressure of multilayer pipe meeting this specification. Design pressure rating is determined from the PE pipe layer alone—see Appendix X1.

1.5 *Units*—The values stated in inch-pound units are to be regarded as the standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

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

1.7 The following precautionary caveat pertains only to the test method portion, Section 6, of this specification. *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

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

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D618 Practice for Conditioning Plastics for Testing

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

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

D3350 Specification for Polyethylene Plastics Pipe and Fittings Materials

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

D6779 Classification System for and Basis of Specification for Polyamide Molding and Extrusion Materials (PA)

F412 Terminology Relating to Plastic Piping Systems

F1290 Practice for Electrofusion Joining Polyolefin Pipe and Fittings

[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] 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.

F2619/F2619M Specification for High-Density Polyethylene (PE) Line Pipe

2.2 *Federal Specifications:*

Fed. Std. No. 123 Marking for Shipment (Civil Agencies)[3]

MIL-STD 129 Military Marking for Shipment and Storage[4]

2.3 *ISO Standards:*[5]

ISO 1167 Thermoplastics pipes for the conveyance of fluids—Resistance to internal pressure

ISO 3126 Plastic piping systems—Plastic piping components—Measurement and determination of dimensions

ISO 6259 Thermoplastics pipes—Determination of tensile properties

ISO 8510-2 Adhesives—Peel test for a flexible-to-rigid specimen assembly—180° peel

2.4 *Plastic Pipe Institute:*[6]

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

PPI TR-23 Guidelines for Establishing the Pressure Rating for Multilayer and Co-extruded Plastic Pipes

2.5 *Other Documents:*

SAE J 2260 Nonmetallic Fuel System Tubing with One or More Layers[7]

EN 14125 Thermoplastic and flexible metal pipework for underground installation at petrol filling stations[8]

3. Terminology

3.1 *Definitions:*

3.1.1 Definitions are in accordance with Terminology F412, and abbreviations are in accordance with Terminology D1600, unless otherwise specified.

3.1.2 *multilayer pipe, n*—plastic pipe comprised of more than one layer.

3.1.3 *re-rounding equipment, n*—tooling used to reform the pipe and permanently reduce ovality to 5 % or less.

3.1.4 *rounding equipment, n*—tooling, devices, clamps, and so forth, used to temporarily hold the pipe round while a joining procedure (heat fusion, electrofusion, or mechanical) is performed.

4. Compound Requirements

4.1 *PE Compound Requirements*—The PE compound used to make the PE pipe layer shall be virgin compound and shall have a Plastics Pipe Institute (PPI) hydrostatic design basis (HDB) rating in accordance with PPI TR-3 using Test Method D2837. The PE compound used for the PE pipe layer shall have a pipe material designation code of PE 4710 in accordance with PPI TR-3 Section F.7 and shall be listed in PPI TR-4, and shall meet Specification D3350 requirements, with a minimum cell class of 444474C.

4.1.1 *Additive Classes*—PE compounds shall be Code C as defined in Specification D3350. Code C compound shall contain 2.0 to 3.0 percent carbon black as measured by Test Method D1603 or D4218. The pipe manufacturer shall measure carbon black content of the compound once per week.

4.1.2 *Chemical Resistance*—Testing shall be conducted per 6.10 on specimens of PE compound from compression molded plaques or from a ring specimen prepared from pipe.

NOTE 2—This test is only an indication of what may happen as a result of short-term exposure to these chemicals. Contact the manufacturer for specific chemical resistance information for this product.

4.1.3 *Elevated Temperature*—The PE 4710 compound shall have an HDB at 140 °F (60 °C) of at least 1000 psi listed in PPI TR-4.

4.2 *PA Compound Requirements*—The PA compound shall be a non-reinforced PA with the three-digit cell class (group, class, grade) in accordance with Classification D6779 per Table 1.

4.2.1 *Chemical Resistance*—Based on the intended application and the corresponding need for chemical resistance, the multilayer pipe manufacturer shall provide chemical resistance properties for the type of PA compound used in the PA layer of this multilayer pipe.

4.2.2 *Color*—The PA layer shall have a different color from the black PE pipe layer so that it can be easily recognized, such as the APWA color coding system of yellow for gas and oil lines.

4.3 *Rework Compound*—To prevent possible contamination between PE and PA, rework (regrind) shall not be used for the polyethylene and polyamide layers.

4.4 *Documentation*—A documentation system to allow for traceability of compounds used in the manufacture of the multilayer pipe product meeting the requirements of this specification shall exist and be supplied to the purchaser, if requested.

TABLE 1 Polyamide Type and Cell Class

Polyamide (PA) Type	PA Cell Class
PA 6	214
PA 11	322
PA 12	423

[3] Available from U.S. Government Publishing Office, 732 N. Capitol St., NW, Washington, DC 20401, http://www.gpo.gov.

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

[5] Available from International Organization for Standardization (ISO), ISO Central Secretariat, BIBC II, Chemin de Blandonnet 8, CP 401, 1214 Vernier, Geneva, Switzerland, http://www.iso.org.

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

[7] Available from National Fire Protection Association (NFPA), 1 Batterymarch Park, Quincy, MA 02169-7471, http://www.nfpa.org.

[8] Available from European Committee for Standardization (CEN), Avenue Marnix 17, B-1000, Brussels, Belgium, http://www.cen.eu.

5. Multilayer Pipe Requirements

5.1 *General*—Multilayer pipe shall be supplied in either coils or straight lengths. Pipe that will be supplied in coils shall meet the minimum test values required by this specification after being bent to minimum radius used for coiling and then uncoiled or straightened prior to testing.

5.1.1 The multilayer pipe shall meet all the performance requirements of this specification. There shall be no delamination of the bonded PA layer during coiling, shipping, handling or operation of the multilayer pipe.

5.2 *Workmanship*—The multilayer pipe shall be homogeneous throughout each layer. The multilayer pipe shall be free of visible cracks, holes, foreign inclusion, blisters, and dents, or other injurious defects. Each respective layer of the multilayer pipe shall be as uniform as commercially practicable in color, opacity, density, and other physical properties.

5.3 *Multilayer Pipe Dimensions and Tolerances:*

5.3.1 *PE Pipe Layer Dimensions*—The PE dimensions shall be specified by wall thickness and outside diameter.

5.3.1.1 *Diameters*—The average outside diameter of the polyethylene pipe layer shall meet the requirements given in Table 2 when measured in accordance with 6.5.1.1.

5.3.1.2 *Toe-In*—When measured in accordance with 6.5.1.1, or in accordance with the manufacturer's procedures for multilayer pipe dimensions, the outside diameter at the cut end of the multilayer pipe shall not be more than 1.5 % smaller than the undistorted outside diameter. Measurement of the undistorted outside diameter shall be made no closer than 1.5 pipe diameters or 11.8 in. (300 mm), whichever distance is less, from the cut end of the multilayer pipe. The undistorted outside diameter of the PE pipe layer shall meet the requirements of Table 2.

5.3.1.3 *Wall Thickness*—The wall thickness of the PE pipe layer shall be as specified in Table 3 when measured in accordance with 6.5.1.2.

5.3.2 *PA Layer Wall thickness*—The minimum wall thickness of the PA layer shall be 0.039 in. (1.0 mm) and the maximum wall thickness shall be 0.047 in. (1.2 mm) when measured in accordance with 6.5.1.2.

5.3.3 *Ovality*—The ovality (cross section) of 3 in. IPS (88.9 mm) and smaller multilayer pipe shall not exceed 5 % when determined in accordance with 6.5.2. Measurements of coiled multilayer pipe shall be made on a sample cut from the coil, and in case of disagreement, conditioned per 6.3.

NOTE 3—Other factors, that is, installation compaction, static soil loading, and dynamic vehicular loads may increase the ovality; therefore, 5 % was chosen as the limit for the amount contributed by manufacturing, packing, in-plant storage, and shipping. Before or during installation, coiled multilayer pipe larger than 3 in. IPS (89 mm) should be processed by the installer through re-rounding equipment that corrects ovality to 5 % or less.

NOTE 4—Ovality is a packaging condition that occurs when roundable pipe is wound into a coil—the pipe flattens out as it is coiled. Ovality is corrected when joining equipment is applied to roundable pipe, or by field processing roundable pipe through re-rounding and straightening equipment during installation.

5.3.3.1 *Length*—The multilayer pipe shall be supplied in straight lengths or coils as agreed upon between the manufacturer and the purchaser. The length shall not be less than the minimum length agreed upon when corrected to 73 °F (23 °C).

5.4 *Sustained Pressure*—To assure slow crack growth resistance of the multilayer pipe construction, the multilayer pipe shall not fail as defined in Test Method D1598, when tested in accordance with 6.6.

5.5 *Minimum Hydrostatic Burst Pressure:*

5.5.1 Multilayer pipe shall have a minimum burst stress of 3200 psi (22.1 MPa) when tested in accordance with 6.7 using the wall thickness for the multilayer pipe.

5.5.2 For multilayer pipe sizes above 4-in. nominal diameter, the apparent ring tensile strength test per 5.6 is an acceptable alternative.

5.6 *Apparent Tensile Stress at Yield*—Multilayer pipe shall have a minimum apparent tensile stress at yield of 3200 psi (22.1 MPa) when tested in accordance with 6.8 using the wall thickness for the multilayer pipe.

5.7 *Adhesion (Bonding) of PE and PA Layers:*

5.7.1 The PA layer shall be bonded to the PE pipe layer either with a bonding layer or by chemical means so that the peel force adhesion requirement of 5.7.2 is met. Layers shall not delaminate upon rapid decompression from the design pressure to atmospheric pressure at the design temperature in the operating environment.

5.7.2 When manufactured, the peel force adhesion for the PE pipe layer bonded to the PA layer shall be greater than 28.5

TABLE 2 Average Outside Diameters and Tolerances for Polyethylene Pipe Layer, in. (mm)

Nominal Pipe Size (NPS)	Average Outside Diameter	Tolerance	Maximum Out-of-Roundness SDR 32.5	Maximum Out-of-Roundness SDR 26	Maximum Out-of-Roundness SDR 21	Maximum Out-of-Roundness SDR 17, 13.5 and 11
½	0.840 (21.3)	±0.004 (±0.102)	...	...	0.03 (0.76)	0.016 (0.40)
¾	1.050 (26.7)	±0.004 (±0.102)	...	...	0.03 (0.76)	0.020 (0.50)
1	1.315 (33.4)	±0.005 (±0.127)	...	...	0.03 (0.76)	0.020 (0.50)
1¼	1.660 (42.1)	±0.005 (±0.127)	...	...	0.03 (0.76)	0.024 (0.6)
2	2.375 (60.3)	±0.006 (±0.152)	...	...	0.06 (1.52)	0.024 (0.6)
3	3.500 (88.9)	±0.008 (±0.203)	...	...	0.06 (1.52)	0.030 (0.76)
4	4.500 (114.3)	±0.009 (±0.229)	...	...	0.1 (2.5)	0.030 (0.76)
6	6.625 (168.3)	±0.011 (±0.279)	0.12 (3)	0.11 (2.74)	0.1 (2.5)	0.070 (1.77)
8	8.625 (219.1)	±0.013 (±0.330)	0.24 (6.1)	0.16 (4.06)	0.12 (3)	0.080 (2.0)
10	10.750 (273.0)	±0.015 (±0.381)	0.24 (6.1)	0.2 (5.08)	0.14 (3.58)	0.1 (2.5)
12	12.750 (323.8)	±0.017 (±0.432)	0.28 (7.12)	0.2 (5.08)	0.14 (3.58)	0.1 (2.5)
14	14.000 (355.6)	±0.063 (±1.60)	0.32 (8.12)	0.24 (6.1)	0.16 (4.06)	0.12 (3)

TABLE 3 Average Outside Diameters and Tolerances for Polyethylene Pipe Layer, in. (mm)

Nominal Pipe Size (NPS)	DR	Minimum	Tolerance
½	11.0	0.076 (1.93)	+0.009 (+0.22)
	9.33	0.090 (2.29)	+0.011 (+0.27)
¾	11.0	0.095 (2.41)	+0.011 (+0.27)
1	13.5	0.097 (2.46)	+0.012 (+0.30)
	11.0	0.120 (3.05)	+0.014 (+0.35)
1-¼	17.0	0.098 (2.49)	+0.012 (+0.30)
	13.5	0.123 (3.12)	+0.015 (+0.38)
	11.0	0.151 (3.84)	+0.018 (+0.45)
	9.33	0.178 (4.52)	+0.021 (+0.53)
2	21	0.113 (2.87)	+0.014 (+0.35)
	17	0.140 (3.56)	+0.017 (+0.43)
	13.5	0.176 (4.47)	+0.021 (+0.53)
	11	0.216 (5.49)	+0.026 (+0.66)
	9.33	0.255 (6.48)	+0.031 (+0.78)
3	21	0.167 (4.24)	+0.020 (+0.50)
	17	0.206 (5.23)	+0.025 (+0.63)
	13.5	0.259 (6.58)	+0.031 (+0.78)
	11	0.318 (8.08)	+0.038 (+0.96)
	9.33	0.375 (9.53)	+0.045 (+1.14)
4	21	0.214 (5.44)	+0.026 (+0.66)
	17	0.265 (6.73)	+0.032 (+0.81)
	13.5	0.333 (8.46)	+0.040 (+1.01)
	11.0	0.409 (10.39)	+0.049 (+1.24)
	9.33	0.482 (12.24)	+0.058 (+1.47)
6	32.5	0.204 (5.18)	+0.024 (+0.61)
	26	0.255 (6.48)	+0.031 (+0.78)
	21	0.315 (8.00)	+0.038 (+0.96)
	17	0.390 (9.91)	+0.047 (+1.19)
	13.5	0.491 (12.47)	+0.059 (+1.49)
	11.0	0.602 (15.29)	+0.072 (+1.82)
	9.33	0.710 (18.04)	+0.085 (+2.16)
8	32.5	0.265 (6.73)	+0.032 (+0.81)
	26	0.332 (8.43)	+0.040 (+1.01)
	21	0.411 (10.44)	+0.049 (+1.24)
	17	0.507 (12.90)	+0.061 (+1.54)
	13.5	0.639 (16.23)	+0.077 (+1.95)
	11	0.784 (19.91)	+0.094 (+2.38)
10	32.5	0.331 (8.41)	+0.040 (+1.01)
	26	0.413 (10.49)	+0.050 (+1.27)
	21	0.512 (13.00)	+0.061 (+1.54)
	17	0.632 (16.05)	+0.076 (+1.93)
	13.5	0.796 (20.22)	+0.096 (+2.43)
	11	0.977 (24.82)	+0.117 (+2.97)
12	32.5	0.392 (9.96)	+0.047 (+1.19)
	26	0.490 (12.45)	+0.059 (+1.49)
	21	0.607 (15.42)	+0.073 (+1.854)
	17	0.750 (19.05)	+0.090 (+2.28)
	13.5	0.944 (23.98)	+0.113 (+2.87)
	11	1.159 (29.44)	+0.139 (+3.53)
14	32.5	0.431 (10.95)	+0.052 (1.32)
	26	0.538 (13.66)	+0.065 (1.65)
	21	0.667 (16.94)	+0.080 (2.03)
	17	0.824 (20.93)	+0.099 (2.51)
	13.5	1.037 (26.34)	+0.124 (3.15)
	11	1.273 (32.33)	+0.153 (3.88)

lb/in. (50 N/cm), when tested in accordance with test method ISO 8510-2. At no point after installation shall the peel force adhesion between the PE pipe layer and PA layer be less than 20 lb/in. (35 N/cm).

5.8 *Permeability and Compatibility*—This is a multilayer pipe requirement, and the testing shall be conducted on the multilayer pipe. The multilayer pipe shall meet the requirements of 5.8.1 and 5.8.2 after conditioning as per 6.9.2.

5.8.1 *Permeability*—The pipe shall have a maximum permeation rate of 0.013 oz/ft^2/day (4 g/m^2/day), when measured in accordance with 6.9.1.

5.8.2 *Compatibility*—The pipe shall retain at least 70 % of the initial tensile strength at yield when measured in accordance with 6.8, and shall retain at least 70 % of the burst pressure as described in 6.7.

NOTE 5—This test is only an indication of what will happen as a result of short-term exposure to these chemicals.

5.9 *Outdoor Storage:*

5.9.1 Caps shall be placed on the pipe ends to prevent UV radiation on the inside.

5.9.2 The extruded PE pipe layer is tested to confirm the carbon black requirement in 4.1.1.

NOTE 6—There are no RCP requirements as there are no RCP test methods for multilayer pipe.

5.10 *Squeeze-off*—This multilayer pipe shall not be squeezed-off.

6. Test Methods

6.1 *Conditioning*—For those tests where conditioning is required or unless otherwise specified in the mentioned test method standards, condition the specimens prior to test at 73.4 ± 3.6 °F (23 ± 2 °C) and 50 ± 10 % relative humidity for not less than 40 h, in accordance with Practice D618.

6.2 *Sampling*—Take a representative sample of the multilayer pipe sufficient to determine conformance with this specification. About 40 ft (12 m) of multilayer pipe is required to perform all the tests prescribed.

6.3 *Multilayer Pipe 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 multilayer pipe, which is at least one pipe diameter away from an end closure.

6.4 *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.

6.5 *Dimensions:*

6.5.1 *PE Pipe Layer or PA Layer*—Any length of pipe is used to determine the dimensions. Coiled pipe shall be measured in the natural springback condition, unless specified otherwise.

6.5.1.1 *Diameter*—Measure the average outside diameter of the multilayer pipe in accordance with Test Method D2122 or ISO 3126.

6.5.1.2 *Wall Thickness*—Measure the wall thickness of the multilayer pipe in accordance with Test Method D2122 or ISO 3126. Measure the PA layer wall thickness with a measuring microscope. The PE layer wall thickness is the multilayer pipe wall thickness minus the PA layer wall thickness.

6.5.1.3 *Length*—Measure multilayer pipe length and other linear dimensions with a steel tape or other device, accurate to ±1/32 in. (±1 mm) in 10 ft (3 m).

6.5.2 *Ovality*—Measure ovality per Test Method D2122.

6.6 *Sustained Pressure Test:*

6.6.1 Select three test specimens of multilayer pipe at random, condition at the standard laboratory test temperature and humidity, and pressure test in accordance with Test Method D1598 or ISO 1167.

6.6.2 The multilayer pipe shall not fail in less than 1000 h at 176 ± 3 °F (80 ± 2 °C) when tested in accordance with Test Method D1598 or ISO 1167. The stress shall be 660 psi (4.6 MPa).

6.6.3 Failure of one of the three specimens tested shall constitute failure in the test, and is cause for retest of three additional specimens. Failure of one of the three specimens in retest shall constitute failure in the test. Evidence of failure of the multilayer pipe shall be as defined in Test Method D1598 or ISO 1167.

6.7 *Minimum Hydrostatic Burst Pressure (Quick Burst)*—The test equipment, procedures, and failure definitions shall be as specified in Test Method D1599.

6.8 *Apparent Ring Tensile Strength*—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 multilayer pipe. They shall be ½-in. (12.7 mm) wide with a ¼-in. (6.3-mm) wide reduced section. Test a minimum of five specimens. This method is applicable to all multilayer pipe of nominal ¾-in. (19.0-mm) outside diameter and larger. The procedure and test equipment as specified in Test Method ISO 6259 are used as an alternative to Test Method D2290.

6.9 *Permeability and Compatibility*—Permeability and compatibility tests shall be conducted with each of the following test fluids:

Chemicals	Concentration (% by volume)
ASTM Fuel C	100
Methanol, or	100
Ethylene glycol	100
Toluene	100

6.9.1 *Permeability:*

6.9.1.1 Prepare test samples and a control sample per EN 14125 by capping and sealing the base end of 18 in. (457 mm) lengths of ½ IPS PE/PA pipe. Secure the samples vertically and fill to 80 % capacity with test fluid. The control samples shall be unfilled. Weigh these prepared samples to 0.01 g at ambient temperature and pressure and store vertically at 73 ± 2 °F (23 ± 1 °C). (**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.)

6.9.1.2 Use a plot of mass loss vs. time to determine pipe permeation rate. A mass loss at the beginning of the test can indicate a leakage problem that must be addressed properly. If the mass loss exceeds 5 wt %, the fuel is to be replaced. The new weight shall become the starting point from which the mass loss is calculated.

6.9.1.3 After a period of time the mass loss rate shall become constant. The sample has achieved final steady-state when linear regression displays a constant gradient for 12 weeks with 13 successive measurements and at least 11 of the points (excluding the end points) fitted to the regression line have a correlation coefficient of at least 0.85. The piping permeation value shall be expressed in oz/ft^2/day (g/m^2/day). The final steady-state permeation value (P_{pipe}) is obtained by dividing the final steady-state rate of mass loss in oz/day (g/day) by the surface area (π L OD) in ft^2 (m^2), where L is the length of the pipe not covered by fittings, either internally or externally.

6.9.1.4 The weight measurements are to be repeated weekly. The time from the test start is to be recorded in days. The repeat measurements are to be taken the same day of the week at approximately the same time as the initial measurement, ±2 h, for consistency. The control sample is to be weighed at the same time as the test samples. The time between the removal of the sample from the oven and its reinsertion after weighing shall be no more than 15 min.

6.9.1.5 For pipe made of compounds with very low steady state permeation rates, a definitive steady state permeation value may not be possible. Very low mass loss (or even gain) may be seen due to differences in weighing technique of calibration of equipment. For pipe products that show a mass loss of less than 0.25 g over a 120-day period for all test fluids, the test results are to be considered acceptable and the test shall be terminated.

6.9.2 *Compatibility:*

6.9.2.1 Immerse 18 in. (457 mm) length of pipe with the smallest diameter in the test fluids listed. Allow an air gap for expansion of the fluid. Seal the container. Ensure that the end-closures used for pressure testing are sufficiently resistant to fluids.

6.9.2.2 Place the samples or containers in an environment maintained at 140 °F (60 °C) for a minimum period of 30 days.

6.9.2.3 After aging, cool the container to ambient temperature, remove the fuel and examine the samples internally and externally by eye without magnification for signs of damage, discoloration or swelling, for example of seals, which could impair correct functioning of the pipe. Then test the samples as per 5.8.2.

6.10 *Chemical Resistance*—Determine the resistance to each of the following individual chemicals. The test specimen shall be a ring of pipe.

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

6.10.1 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 2¼ 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 6.8 within ½ h after weighing. Examine the weight and apparent tensile strength of each specimen for conformance to the requirement in 5.6. (**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.)

7. Marking

7.1 Multilayer pipe marking shall be applied to the outside diameter of the 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 multilayer pipe wall. The marking shall *(1)* not reduce the wall thickness to less than the minimum value for the multilayer pipe, and *(2)* not have any effect on the long-term strength of the multilayer pipe. These markings shall consist of the designation ASTM F2807, the manufacturer's name or trademark, the nominal pipe size, DR, pipe material designation code, the date of manufacture, and the type of PA layer compound.

7.1.1 In addition to 7.1, the multilayer pipe marking shall include a coding that will enable the manufacturer to determine the location of manufacture, multilayer pipe production and resin lots, and any additional information that 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 multilayer pipe, whichever is longer.

7.1.2 All the markings in 7.1 and 7.1.1 shall be repeated at intervals not exceeding 2 ft (0.6 m). Abbreviations may be used to meet the 3-ft (0.91-m) requirement. For indented printing, either the indented print line shall be in a color that contrasts with that of the multilayer pipe, or a separate print line shall be in a color that contrasts with the multilayer pipe.

7.1.3 The order for all items required in the print line in the marking sections 7.1 and 7.1.2 shall be:

(1) Multilayer pipe size,

(2) SDR (DR) – based on PE pipe layer dimensions,

(3) Manufacturer's name or trademark,

(4) PE Pipe material designation code,

(5) ASTM F2807,

(6) Manufacturer's lot code (includes date of manufacture in some cases),

(7) Three digit D6779 code for PA compound used for PA layer (ex, PA-214),

(8) PE-PA, and

(9) Additional information, including date of manufacture, coil number, sequential footage, third party certification mark etc.

Example: 2 IPS SDR 11 MANUFACTURER NAME PE 4710 ASTM F2807 LOT CODE INFO PA-214 PE-PA 02JAN11 coil #506

8. Quality Assurance

8.1 When the product is marked with this designation, F2807, 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.

9. Fittings and Joining

9.1 As various designs of multilayer pipe are possible along with various types of polyamide materials, the user should consult with the multilayer pipe manufacturer for recommended fittings and joining procedures for use with this multilayer pipe. This information is in the pipe manufacturer's installation literature.

9.2 The only joining techniques that have been used for this multilayer pipe are electrofusion and mechanical fittings. Electrofusion joining procedures, such as in Practice F1290 or in the manufacturer's literature, are followed.

9.3 Hydrocarbon liquids will permeate into the PE material at joint locations.

NOTE 7—Since the PE material at joints is not protected, the hydrocarbon chemical design factor for this multilayer pipe should be the same as for PE pipe—see X1.2.

NOTE 8—Several years of experience with this multilayer pipe have shown that the inner PA layer protects the PE pipe layer in the presence of liquid hydrocarbons and prevents any swelling from liquid hydrocarbon permeation. Although this experience shows that for sections where there are no heat fusion joints the pipe layer is generally protected from liquid hydrocarbons, the operator should still evaluate the pipe layer for entrained liquid hydrocarbons either during or prior to heat fusion joining the sections of pipe. Multilayer pipe that has been in service may be heat fusion joined using the manufacturer's standard recommended joining procedures if there are no entrained liquid hydrocarbons. If bubbles from entrained liquid hydrocarbons are present during the heat fusion process, only mechanical joints should be used instead of heat fusion.

SUPPLEMENTARY REQUIREMENTS

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

S1. Responsibility for Inspection

S1.1 Unless otherwise specified in the contract or purchase order, the producer is responsible for performance of all inspection and test requirements specified herein. The producer shall 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 compound conforms to prescribed requirements.

NOTE S1—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 compounds shall be packaged in accordance with the supplier's standard practices 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—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.

APPENDIX

(Nonmandatory Information)

X1. DESIGN CONSIDERATIONS

X1.1 General

X1.1.1 The design of a PE piping system must include consideration of the combined effects of time, internal and external stress, and environment as an overall basis for selecting a specific kind and size of plastic pipe.

X1.2 Design Equation

X1.2.1 *Relation between Hydrostatic Design Basis (HDB) and Hydrostatic Design Stress (HDS)*—The HDS is determined by multiplying the HDB by a design factor, F. The design factor, F, has a value less than 1.0. Information on selection of design factors is in PPI TR-9. For this multilayer pipe, the design factor is based on the PE pipe layer only—there is no contribution from the PA layer. Even though the PA layer provides chemical resistance, the design factor (F) should be based on the PE pipe layer. The HDB is then used to determine the pressure rating (PR). In the presence of liquid hydrocarbons inside the pipe or in the surrounding soil, an additional chemical design factor (CDF) of 0.5 is recommended by PPI in TR-9 and also by Specification F2619/F2619M. Therefore, if liquid hydrocarbons are present, the chemical design factor (CDF) of 0.5 is used.

$$PR = \frac{2(H\ D\ B)(F)(C\ D\ F)}{DR - 1} \quad \text{(X1.1)}$$

NOTE X1.1—The actual choice of design factor for a given installation must be reviewed by the design engineer taking into account federal, state, and local code requirements. See PPI TR-9 for guidance.

X1.2.2 For example, since PE 4710 compound is used for the PE layer, the HDB is 1600 psi. If we assume a design factor (F) of 0.63 for DR 11 pipe, then the pressure rating (PR) of the multilayer pipe is 200 psig. If liquid hydrocarbons are present inside the pipe or in the surrounding soil, then the chemical design factor (CDF) of 0.5 is used, and the pressure rating (PR) for this multilayer pipe is 100 psig.