



Standard Specification for Polyethylene (PE) Plastic Pipe, Schedules 40 and 80, Based on Outside Diameter¹

This standard is issued under the fixed designation D 2447; 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.

This standard has been approved for use by agencies of the Department of Defense.

1. Scope

1.1 This specification covers polyethylene (PE) pipe that is outside diameter controlled, made in Schedule 40 and 80 sizes for use with socket-type fittings and butt fittings joined by heat fusion, and pressure-rated for water (see appendix). Included are criteria for classifying PE plastic pipe materials and PE plastic pipe, a system of nomenclature for PE plastic pipe, and requirements and test methods for materials, workmanship, dimensions, sustained pressure, burst pressure, and environmental stress cracking. Requirements for marking are also given.

1.2 The values stated in inch-pound units are to be regarded as the standard. The values given in parentheses are for information only.

1.3 The following safety hazards caveat pertains only to the test methods portion, 7, 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 and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 ASTM Standards:

- D 618 Practice for Conditioning Plastics and Electrical Insulating Materials for Testing²
- D 792 Test Method for Specific Gravity (Relative Density) and Density of Plastics by Displacement²
- D 1238 Test Method for Flow Rates of Thermoplastics by Extrusion Plastometer²
- D 1248 Specification for Polyethylene Plastics Molding and Extrusion Materials³
- D 1505 Test Method for Density of Plastics by the Density-Gradient Technique²
- D 1598 Test Method for Time-to-Failure of Plastic Pipe Under Constant Internal Pressure³

¹ This specification is under the jurisdiction of ASTM Committee F-17 on Plastic Piping Systems and is the direct responsibility of Subcommittee F17.26 on Olefin Based Pipe.

Current edition approved April 10, 1999. Published July 1999. Originally published as D 2447 – 65. Last previous edition D 2447 – 95.

² Annual Book of ASTM Standards, Vol 08.01.

³ Annual Book of ASTM Standards, Vol 08.04.

D 1599 Test Method for Short-Time Hydraulic Failure Pressure of Plastic Pipe, Tubing, and Fittings³

D 1600 Terminology for Abbreviated Terms Relating to Plastics^{2,3}

D 1603 Test Method for Carbon Black in Olefin Plastics⁴

D 2122 Test Method for Determining Dimensions of Thermoplastic Pipe and Fittings³

D 2837 Test Method for Obtaining Hydrostatic Design Basis for Thermoplastic Pipe Materials³

D 3350 Specification for Polyethylene Plastics Pipe and Fittings Materials⁵

Fu412 Terminology Relating to Plastic Piping Systems³

2.2 NSF Standards:

Standard No. 14 for Plastic Piping Components and Related Materials⁶

Standard No. 61 for Drinking Water Systems Components—Health Effects⁶

3. Terminology

3.1 Definitions—Definitions are in accordance with Terminology F 412, and abbreviations are in accordance with Terminology D 1600, unless otherwise specified. The abbreviation for polyethylene plastic is PE.

3.2 Definitions of Terms Specific to This Standard:

3.2.1 *hydrostatic design stress*—the estimated maximum tensile stress in the wall of the pipe in the circumferential orientation due to internal hydrostatic water pressure that can be applied continuously with a high degree of certainty that failure of the pipe will not occur.

3.2.2 *pressure rating (PR)*—the estimated maximum pressure that water in the pipe can exert continuously with a high degree of certainty that failure of the pipe will not occur.

3.2.3 *relation among dimensions, hydrostatic design stress, and pressure rating*—the following expression, commonly known as the ISO equation,⁷ is used in this specification to relate dimensions, hydrostatic design stress, and pressure rating:

⁴ Annual Book of ASTM Standards, Vol 08.02.

⁵ Annual Book of ASTM Standards, Vol 08.03.

⁶ Available from the National Sanitation Foundation, P.O. Box 1468, Ann Arbor, MI 48106.

⁷ ISO R 161-1960, Pipes of Plastics Materials for the Transport of Fluids (Outside Diameters and Nominal Pressures) Part 1, Metric Series.

$$2S/P = (D_o/t) - 1 \quad (1)$$

where:

S = hydrostatic design stress, psi (or MPa),
 P = pressure rating, pse (or MPa),
 D_o = average outside diameter, in. (or mm), and
 t = minimum wall thickness, in. (or mm).

3.2.4 standard thermoplastic pipe materials designation code—the pipe materials designation code shall consist of the abbreviation PE for the type of plastic, followed by the ASTM grade in Arabic numerals and the hydrostatic design stress in units of 100 psi with any decimal figures dropped. Where the hydrostatic design stress code contains less than two figures, a cipher shall be used before the number. Thus a complete material code consists of two letters and four figures for PE plastic pipe materials (see Section 5).

4. Pipe Classification

4.1 General—This specification covers PE pipe made from five PE plastic pipe materials in Schedule 40 and 80 sizes with outside diameter controlled.

5. Materials

5.1 General—Polyethylene plastics used to make pipe meeting the requirements of this specification are categorized by means of two criteria, namely, (1) short-term strength tests, and (2) long-term strength tests.

5.2 Basic Materials—This specification covers PE pipe made from four PE plastics as defined in Specification D 1248, in which the requirements are based on short-term tests. These are Grade P14, Grade P23, Grade P24, Grade P33, and Grade P34. The PE plastics can also be described according to the appropriate cell classification in accordance with Specification D 3350. The 80°C sustained pressure performance requirements of 6.9 are not currently in PE material Specifications D 1248 or D 3350. To identify the correct pipe test category (C1 to C7), the PE material base resin density and melt index must be obtained from the PE material supplier.

NOTE 1—Committee F-17 has requested that Committee D-20 add the 80°C sustained pressure performance requirements to Specifications D 1248 and D 3350.

5.3 Hydrostatic Design Stresses—This specification covers PE pipe made from four PE plastics as defined by hydrostatic design stresses developed on the basis of long-term tests (appendix).

5.4 Compound—The PE plastic extrusion compound shall meet the requirements of either Grade P14, Class C; Grade P23, Class C; Grade P24, Class C; Grade P33, Class C; or Grade P34, Class C material as described in Specification D 1248 or the comparable cell classification in accordance with Specification D 3350.

5.5 Rework Material—Clean, rework material, generated from the manufacturer's own pipe production, may be used by the same manufacturer, as long as the pipe produced meets all the requirements of this specification.

6. Requirements

6.1 Workmanship—The pipe shall be homogeneous throughout and free from visible cracks, holes, foreign inclu-

sions, or other defects. The pipe shall be as uniform as commercially practicable in color, opacity, density, and other physical properties.

6.2 Dimensions and Tolerances—All dimensions shall be measured in accordance with Test Method D 2122, using an acceptable length of pipe.

6.2.1 Outside Diameters—In accordance with Test Method D 2122, classify the pipe as roundable or nonroundable and determine the average outside diameter accordingly. For non-roundable pipe the tolerance for out-of-roundness shall apply only to pipe prior to shipment. The outside diameters and tolerances shall be as shown in Table 1.

NOTE 2—Five-inch through twelve-inch pipe sizes in Schedule 40 meet the dimensional requirements of roundable pipe and most polyethylene pipe materials meet the tensile requirements for roundable pipe.

6.2.2 Wall Thickness—The wall thicknesses and tolerances shall be as shown in Table 2.

6.2.3 Wall Thickness Range—The wall thickness range shall be within 12 %.

6.2.4 Thickness of Outer Layer—For pipe produced by simultaneous multiple extrusion, that is, pipe containing two or more concentric layers, the outer layer shall be at least 0.020 in. (0.51 mm) thick.

6.3 Bond—For pipe produced by simultaneous multiple extrusion, the bond between the layers shall be strong and uniform. It shall not be possible to separate any two layers with a probe or point of a knife blade so that the layers separate cleanly at any point.

6.4 Carbon Black—The polyethylene pipe extrusion compound shall contain at least 2 % carbon black when tested in accordance with Test Method D 1603. For pipe produced by simultaneous multiple extrusion, this requirement shall apply to the outer layer.

NOTE 3—There is evidence that indicates that type, particle size, and dispersion quality of the carbon black affects the weatherability of the pipe. The problem is being investigated and when reliable test methods are developed, requirements for weatherability, or other suitable requirements to cover this property, will be included in a revision of this specification.

TABLE 1 Outside Diameters and Tolerances for PE Plastic Pipe, Schedules 40 and 80, in. (mm)

Nominal Pipe Size	Average Outside Diameter	Tolerance	
		For Average Diameter	For Maximum and Minimum Diameter (Out-of-Roundness)
½	0.840(21.34)	±0.004(±0.10)	±0.015(±0.38)
¾	1.050(26.67)	±0.004(±0.10)	±0.020(±0.51)
1	1.315(33.40)	±0.005(±0.13)	±0.025(±0.64)
1¼	1.660(42.16)	±0.005(±0.13)	±0.025(±0.64)
1½	1.900(48.26)	±0.006(±0.15)	±0.030(±0.76)
2	2.375(60.33)	±0.006(±0.15)	±0.035(±0.89)
2½	2.875(70.03)	±0.007(±0.18)	±0.035(±0.89)
3	3.500(88.90)	±0.008(±0.20)	±0.040(±1.02)
3½	4.000(101.60)	±0.008(±0.20)	±0.050(±1.27)
4	4.500(114.30)	±0.009(±0.23)	±0.050(±1.27)
5	5.563(141.30)	±0.010(±0.25)	±0.050(±1.27)
6	6.625(168.28)	±0.011(±0.28)	±0.050(±1.27)
8	8.625(219.08)	±0.015(±0.38)	±0.075(±1.91)
10	10.750(273.05)	±0.015(±0.38)	±0.075(±1.91)
12	12.750(323.85)	±0.015(±0.38)	±0.075(±1.91)

TABLE 2 Wall Thicknesses and Tolerances for PE Plastic Pipe, Schedules 40 and 80, in.(mm)

Nominal Pipe Size	Wall Thickness ^A			
	Schedule 40		Schedule 80	
	Minimum	Tolerance	Minimum	Tolerance
½	0.109(2.77)	+0.020(+0.51)	0.147(3.73)	+0.020(+0.51)
¾	0.113(2.87)	+0.020(+0.51)	0.154(3.91)	+0.020(+0.51)
1	0.133(3.38)	+0.020(+0.51)	0.179(4.55)	+0.021(+0.53)
1¼	0.140(3.56)	+0.020(+0.51)	0.191(4.85)	+0.023(+0.58)
1½	0.145(3.68)	+0.020(+0.51)	0.200(5.08)	+0.024(+0.61)
2	0.154(3.91)	+0.020(+0.51)	0.218(5.54)	+0.026(+0.66)
2½	0.203(5.16)	+0.024(+0.61)	0.276(7.01)	+0.033(+0.84)
3	0.216(5.49)	+0.026(+0.66)	0.300(7.62)	+0.036(+0.91)
3½	0.226(5.74)	+0.027(+0.69)	0.318(8.08)	+0.038(+0.97)
4	0.237(6.02)	+0.028(+0.71)	0.337(8.56)	+0.040(+1.02)
5	0.258(6.55)	+0.031(+0.79)	0.375(9.53)	+0.045(+1.14)
6	0.280(7.11)	+0.034(+0.86)	0.432(10.97)	+0.052(+1.32)
8	0.322(8.18)	+0.039(+0.99)	...	...
10	0.365(9.27)	+0.044(+1.12)	...	...
12	0.406(10.31)	+0.049(+1.24)	...	...

^AThe minimum is the lowest wall thickness of the pipe at any cross section. The maximum permitted wall thickness, at any cross section, is the minimum wall thickness plus the stated tolerance. All tolerances are on the plus side of the minimum requirement.

6.5 Density—The polyethylene base resin (uncolored PE) in the pipe compound shall have a density in the range from 0.910 to 0.925 g/cm³ for pipe made from Grade P14 of Specification D 1248, 0.926 to 0.940 g/cm³ for pipe made from Grade P23 and Grade P24 of Specification D 1248, 0.941 to 0.965 g/cm³ for pipe made from Grade P33 of Specification D 1248, and 0.941 to 0.965 g/cm³ for pipe made from Grade P34 of Specification D 1248 when determined in accordance with 7.5.

6.6 Sustained Pressure—The pipe shall not fail, balloon, burst, or weep as defined in Test Method D 1598, at the test pressures given in Table 3 and Table 4 when tested in accordance with 7.5.

6.7 Burst Pressure—The minimum burst pressure for PE plastic pipe shall be as given in Table 5, when determined in accordance with 7.8.

6.8 Environmental Stress Cracking—There shall be no loss of pressure in the pipe when tested in accordance with 7.7.

6.9 Elevated Temperature Sustained Pressure—The average failure time must meet or exceed the specified minimum average failure time in Table 6 for both hoop stresses of a given pipe test category when tested in accordance with 7.7.

7. Test Methods

7.1 Conditioning—Condition the test specimens at 73.4 ± 3.6°F (23 ± 2°C) and 50 ± 5 % relative humidity for not less than 40 h prior to test in accordance with Procedure A of Practice D 618, for those tests where conditioning is required.

7.2 Test Conditions—Conduct tests in the standard laboratory atmosphere of 73.4 ± 3.6°F (23 ± 2°C) and 50 ± 5 % relative humidity, unless otherwise specified in the test methods or in this specification.

7.3 Sampling—The selection of the sample or samples of pipe shall be as agreed upon by the purchaser and the seller. In case of no prior agreement, any sample 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 which is at least one pipe diameter away from an end closure.

7.4 Density—Determine the density of the pipe compound in accordance with Test Method D 1505 or D 792, using three specimens. Determine the percentage of carbon black by weight in accordance with 6.4. Calculate the density of the PE base resin (uncolored PE) in the pipe compound as follows:

$$D_R = D_P - 0.0044 C \quad (2)$$

where:

D_R = density of resin, g/cm³,

D_P = density of pipe compound, g/cm³, and

C = percentage by weight of carbon black.

7.5 Sustained Pressure Test—Select twelve pipe test specimens at random. Test the specimens individually with water at two controlled temperatures under the pressures given in Table 3 and Table 4, each specimen at least ten times the nominal diameter in length, but not less than 10 in. (250 mm) or more than 3 ft (1000 mm) between end closures and containing the permanent marking on the pipe. Test six specimens at each temperature. Maintain the specimens at the pressures indicated in Table 3 and Table 4 for the appropriate pipe size and temperature for a period of 1000 h or to failure, whichever occurs first. Hold the pressure as closely as possible, but within ±10 psi (±69 kPa) (±0.69 bar). Condition the specimens for at least 2 h to within ±2°C (±3.6°F) of the specified test temperature. Except as noted, test in accordance with Test Method D 1598. Failure of the pipe shall be as defined in Test Method D 1598.

7.6 Environmental Stress Cracking Test—Use six randomly selected 10-in. (250-mm) long specimens containing the permanent marking for this test. Connect one end of each specimen to a 600-psi (4-MPa) (40-bar) pressure gage and the other end to an air or nitrogen supply through a suitable valve. Subject the specimens to the pressures listed in Table 3 for 73.4°F (23°C), close the valve, and disconnect in such a manner that the pressure is retained in the specimen. Apply enough pressure in excess of the listed value to compensate for the pressure lost during disconnection of the pressure source. Test the assembly for leaks by immersion in water. Eliminate leaks or substitute nonleaking specimens for those that leak. Take care to dry the test specimen completely after immersion.