



## Standard Specification for Polyethylene (PE) Plastic Pipe, Schedules 40 and 80, Based on Outside Diameter<sup>1</sup>

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 ( $\epsilon$ ) 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:

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<sup>1</sup> This specification is under the jurisdiction of ASTM Committee F17 on Plastic Piping Systems and is the direct responsibility of Subcommittee F17.26 on Olefin Based Pipe.

Current edition approved Aug. 10, 2004<sub>3</sub>. Published ~~October 2001~~ September 2003. Originally published as D 2447 – 65, approved in 1965. Last previous edition approved in 2001 as D 2447 – 9901.

- D 618 Practice for Conditioning Plastics and Electrical Insulating Materials for Testing<sup>2</sup>
- D 792 Test Method for Density and Specific Gravity (Relative Density) of Plastics by Displacement<sup>2</sup>
- D 1238 Test Method for Melt Flow Rates of Thermoplastics by Extrusion Plastometer<sup>2</sup>
- D 1248 Specification for Polyethylene Plastics Molding and Extrusion Materials for Wire and Cable<sup>3</sup>
- D 1505 Test Method for Density of Plastics by the Density-Gradient Technique<sup>2</sup>
- D 1598 Test Method for Time-to-Failure of Plastic Pipe Under Constant Internal Pressure<sup>4</sup>
- D 1599 Test Method for Short-Time Hydraulic Failure Pressure of Plastic Pipe, Tubing, and Fittings<sup>4</sup>
- D 1600 Terminology for Abbreviated Terms Relating to Plastics<sup>2</sup>
- D 1603 Test Method for Carbon Black in Olefin Plastics<sup>2</sup>
- D 2122 Test Method for Determining Dimensions of Thermoplastic Pipe and Fittings<sup>4</sup>
- D 2837 Test Method for Obtaining Hydrostatic Design Basis for Thermoplastic Pipe Materials<sup>4</sup>
- D 3350 Specification for Polyethylene Plastics Pipe and Fittings Materials<sup>3</sup>
- F 412 Terminology Relating to Plastic Piping Systems<sup>4</sup>

### 2.2 NSF Standards:

Standard No. 14 for Plastic Piping Components and Related Materials<sup>5</sup>

Standard No. 61 for Drinking Water Systems Components—Health Effects<sup>5</sup>

## 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,<sup>6</sup> is used in this specification to relate dimensions, hydrostatic design stress, and pressure rating:

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

where:

$S$  = hydrostatic design stress, psi (or MPa),

$P$  = pressure rating, psi (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.

<sup>2</sup> Annual Book of ASTM Standards, Vol 08.01.

<sup>3</sup> Annual Book of ASTM Standards, Vol 08.03.

<sup>4</sup> Annual Book of ASTM Standards, Vol 08.04.

<sup>5</sup> Available from the National Sanitation Foundation, P.O. Box 1468, Ann Arbor, MI 48106.

<sup>6</sup> ISO R 161-1960, Pipes of Plastics Materials for the Transport of Fluids (Outside Diameters and Nominal Pressures) Part 1, Metric Series.

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 inclusions, 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 nonroundable 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.

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/cm<sup>3</sup> for pipe made from Grade P14 of Specification D 1248, 0.926 to 0.940 g/cm<sup>3</sup> for pipe made from Grade P23 and Grade P24 of Specification D 1248, 0.941 to 0.965 g/cm<sup>3</sup> for pipe made from Grade P33 of Specification D 1248, and 0.941 to 0.965 g/cm<sup>3</sup> for pipe made from Grade P34 of Specification D 1248 when determined in accordance with 7.5.

6.6 *Burst Pressure*—The minimum burst pressure for PE plastic pipe shall be as given in Table 3, when determined in accordance with 7.8.

**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 <sup>A</sup>			
	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)	...	...

<sup>A</sup>The 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.

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

6.8 *Sustained Pressure*—Pipe made from PE materials designated PE2406, PE3406 or PE3408 shall meet the requirement of 6.8.1. Pipe made from other PE materials shall meet the requirements of 6.8.2 and 6.8.3.

6.8.1 The average failure time and the failure time of two of the three specimens shall meet or exceed the minimum values shown in Table 4 when tested in accordance with 7.7.1.

6.8.2 *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 5 when tested in accordance with 7.5.

6.8.3 *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/cm<sup>3</sup>,

$D_P$  = density of pipe compound, g/cm<sup>3</sup>, and

$C$  = percentage by weight of carbon black.

7.5 *Sustained Pressure Test*—Select six pipe test specimens at random. Test the specimens individually with water under the pressures given in Table 5, 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. Maintain the specimens at the pressures indicated in Table 5 for the appropriate pipe size 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 5 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

**TABLE 3 Burst Pressure Requirements for Water at 73.4°F (23°C) for PE Plastic Pipe, Schedules 40 and 80**

Nominal Pipe Size, in.	Min Burst Pressure <sup>A</sup>					
	PE2306, PE2406, PE3306, PE3406		PE2305		PE1404	
	Schedule 40	Schedule 80	Schedule 40	Schedule 80	Schedule 40	Schedule 80
MPa						
½	5.17	7.38	4.14	5.86	2.55	3.65
¾	4.14	6.00	3.31	4.76	2.07	2.96
1	3.93	5.45	3.10	4.34	1.93	2.69
1¼	3.17	4.48	2.55	3.59	1.59	2.21
1½	2.90	4.07	2.28	3.24	1.38	2.00
2	2.41	3.52	1.93	2.76	1.17	1.72
2½	2.62	3.72	2.07	2.90	1.31	1.79
3	2.28	3.24	1.79	2.55	1.10	1.59
3½	2.07	2.96	1.65	2.34	1.03	1.45
4	1.93	2.83	1.52	2.21	0.97	1.38
5	1.65	2.48	1.31	2.00	0.83	1.24
6	1.52	2.41	1.17	1.93	0.76	1.17
8	1.38	...	1.03	...	0.69	...
10	1.24	...	0.97	...	0.62	...
12	1.17	...	0.90	...	0.55	...
psi						
½	750	1070	600	850	370	530
¾	600	870	480	690	300	430
1	570	790	450	630	280	390
1¼	460	650	370	520	230	320
1½	420	590	330	470	200	290
2	350	510	280	400	170	250
2½	380	540	300	420	190	260
3	330	470	260	370	160	230
3½	300	430	240	340	150	210
4	280	410	220	320	140	200
5	240	360	190	290	120	180
6	220	350	170	280	110	170
8	200	...	150	...	100	...
10	180	...	140	...	90	...
12	170	...	130	...	80	...

<sup>A</sup>The fiber stresses used to derive these test pressures are as follows:

PE2306, PE2406, PE3306, PE3406	2520 psi (17.37 MPa)
PE2305	2000 psi (13.79 MPa)
PE1404	1250 psi (8.62 MPa)

**TABLE 4 Minimum Average Time to Failure (h) versus Test Hoop Stress**

Base Resin Density (g/cc)	Minimum Average Failure Time (h)	
	S = 580 psi (4 MPa)	S = 670 psi (4.6 MPa)
>0.935	1000	170

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. Apply a coating of “Igepal CO-630”<sup>7</sup> to the pipe surface with a brush. Take care to keep the wetting agent at least ½ in. (12 mm) away from the clamps used on each end of the pipe. Use fresh reagent for each test and take care to store the reagent in closed containers because it is hygroscopic. Keep the coated pipe assembly at room temperature for 3 h and then examine. There shall be no loss of pressure in at least four of the six specimens. Discard specimens that leak at a connection and retest. Loss of pressure caused by expansion of the pipe shall not be cause for rejection.

**7.7 Elevated Temperature Test**—Determine pipe test category in Table 6 for a given piping material. Base resin melt index is determined in accordance with Test Method D 1238 and base resin density is determined in accordance with Test Method D 1505. Prepare at least three test specimens as in 7.5. Test at 176°F (80°C) and the hoop stress (S) specified in Table 6 for the given pipe

<sup>7</sup> This test method is based on the use of “Igepal CO-630,” a trademark for a nonylphenoxy poly(ethyleneoxy)ethanol, which may be obtained from the GAF Corp., Dyestuff and Chemical Div., 140 W. 51st St., New York, NY 10020.

**TABLE 5 Sustained Pressure Test Conditions for Water at 23°C (73.4°F) for PE Plastic Pipe, Schedules 40 and 80**

Nominal Pipe Size, in.	Pressure <sup>A</sup> Required for Test					
	PE2306, PE2406, PE3306, PE3406		PE2305		PE1404	
	Schedule 40	Schedule 80	Schedule 40	Schedule 80	Schedule 40	Schedule 80
MPa						
1/2	2.69	3.86	2.14	3.03	1.65	2.41
3/4	2.21	3.10	1.72	2.48	1.38	1.93
1	2.07	2.90	1.65	2.28	1.24	1.79
1 1/4	1.65	2.34	1.31	1.86	1.03	1.52
1 1/2	1.52	2.14	1.17	1.72	0.97	1.31
2	1.24	1.86	0.97	1.45	0.76	1.10
2 1/2	1.38	1.93	1.10	1.52	0.83	1.24
3	1.17	1.72	0.97	1.38	0.76	1.10
3 1/2	1.10	1.59	0.90	1.24	0.69	0.97
4	1.03	1.45	0.83	1.17	0.62	0.90
5	0.90	1.31	0.69	1.03	0.55	0.83
6	0.83	1.24	0.62	0.97	0.48	0.83
8	0.69	...	0.55	...	0.45	...
10	0.62	...	0.48	...	0.38	...
12	0.59	...	0.48	...	0.38	...
psi						
1/2	390	560	310	440	240	350
3/4	320	450	250	360	200	280
1	300	420	240	330	180	260
1 1/4	240	340	190	270	150	220
1 1/2	220	310	170	250	140	190
2	180	270	140	210	110	160
2 1/2	200	280	160	220	120	180
3	170	250	140	200	110	160
3 1/2	160	230	130	180	100	140
4	150	210	120	170	90	130
5	130	190	100	150	80	120
6	120	180	90	140	70	120
8	100	...	80	...	65	...
10	90	...	70	...	55	...
12	85	...	70	...	55	...

<sup>A</sup>The fiber stresses used to derive these test pressures are as follows:

PE2306, PE2406, PE3306, PE3406	1320 psi (9.10 MPa)
PE2305	1050 psi (7.24 MPa)
PE1404	820 psi (5.65 MPa)

category in accordance with Test Method D 1598. Use water as the internal test medium. Two of three specimens must meet or exceed the specified minimum average failure time.

7.7.1 Prepare at least three specimens as in 7.5 for the appropriate test hoop stress given in Table 4. Test at 176°F (80°C) and the hoop stresses given in Table 4 in accordance with Test Method D 1598.

7.8 *Burst Pressure*— The test equipment, procedures and failure definitions shall be as specified in Test Method D 1599. In addition, the failure must be ductile.

## 8. Retest and Rejection

8.1 If the results of any test(s) do not meet the requirements of this specification, the test(s) may be conducted again in accordance with an agreement between the purchaser and the seller. There shall be no agreement to lower the minimum requirement of the specification by such means as omitting tests that are a part of the specifications, substituting or modifying a test method, or by changing the specification limits. In retesting the product requirements of this specification shall be met and the test methods designated in the specification shall be followed. If, upon retest failure occurs, the quantity of product represented by the test(s) does not meet the requirements of this specification.

## 9. Marking

9.1 Marking on the pipe shall include the following, spaced at intervals of not more than 5 ft (1.5 m):

9.1.1 Nominal pipe size (for example, 2 in.).

9.1.2 Type of plastic pipe material in accordance with the designation code given in 3.5 (for example, PE2305).

9.1.3 Schedule size (40 or 80, whichever is applicable) and the pressure rating in pounds per square inch for water at 73.4°F (23°C) shown as the number followed by psi (for example, 100 psi). When the indicated pressure rating is lower than that



**TABLE 6 176°F (80°C) Sustained Pressure Requirements for Water Pipe<sup>A,B</sup>**

Pipe Test Category <sup>C</sup>	Base Resin Melt Index, D 1238 (g/10 min)	Base Resin Density, <sup>D</sup> D 1505 (g/cm <sup>3</sup> )	Minimum Average Hours to Failure		
			S = 725 psi (5 MPa)	S = 580 psi (4 MPa)	S = 435 psi (3 MPa)
C1	<0.05	0.941–0.948	100	200	—
C2	<0.05	0.935–0.940	100	200	—
C3	0.05–0.25	0.941–0.948	60	150	—
C4	0.05–0.25	0.935–0.940	60	150	—
C5	>0.25	0.941–0.948	45	100	—
C6	>0.25	0.935–0.940	45	100	—
C7	>0.50	0.926–0.940	—	80	150

<sup>A</sup>For inside diameter controlled pipe, calculate internal pressure in accordance with the following formula:

$$P = \frac{2S}{\frac{D_i}{t} + 1}$$

<sup>B</sup>For outside diameter controlled pipe, calculate internal pressure in accordance with the following formula:

$$P = \frac{2S}{\frac{D_o}{t} - 1}$$

where:

- $P$  = pressure, psig (MPa),
- $S$  = hoop stress, psi (MPa),
- $D_i$  = average inside diameter, in. (mm),
- $D_o$  = average outside diameter, in. (mm), and
- $t$  = minimum wall thickness, in. (mm).

<sup>C</sup>Supplier to determine pipe test category appropriate for his product.

<sup>D</sup>Pipe categories for water pipe with resin density below 0.926 g/cm<sup>3</sup> or above 0.948 g/cm<sup>3</sup> will be added to this table when the data are available.

calculated in accordance with 3.2.4(see appendix), this shall be indicated by placing a star after the pressure rating.

9.1.4 This designation “ASTM D 2447” with which the pipe complies.

9.1.5 Manufacturer’s name (or trademark) and code (Note 1).

9.1.6 Pipe intended for the transport of potable water shall also include the seal or mark of the laboratory making the evaluation for this purpose, spaced at intervals specified by the laboratory.

NOTE 4—Manufacturers using the seal or mark of a laboratory must obtain prior authorization from the laboratory concerned.

9.1.7 Pipe test category in accordance with Table 6.

9.2 Using Color to Identify Piping Service—It is not mandatory to use color to identify piping service, but when color is applied expressly to identify piping service, such as with stripes, a color shell or solid color, blue is used for potable water; green is used for sewer; and purple (violet, lavender) is used for reclaimed water.

## 10. Quality Assurance

10.1 When the product is marked with this designation, D 2447, 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.

## SUPPLEMENTARY REQUIREMENTS

This requirement applies whenever a Regulatory Authority or user calls for the product to be used to convey or to be in contact with potable water.

### S1. Potable Water Requirement

S1.1 Products intended for contact with potable water shall be evaluated, tested, and certified for conformance with ANSI/NSF Standard 61 or the health effects portion of NSF Standard 14 by an acceptable certifying organization when required by the regulatory authority having jurisdiction.

**APPENDIX****(Nonmandatory Information)****X1. SOURCE OF HYDROSTATIC DESIGN STRESSES**

X1.1 The hydrostatic design stresses recommended by the Plastics Pipe Institute are used to pressure rate PE plastic pipe. These hydrostatic design stresses are 400 psi (2.76 MPa) (27.6 bar), 500 psi (3.45 MPa) (34.5 bar), and 630 psi (4.34 MPa) (43.4 bar) for water at 73.4°F (23°C). These hydrostatic design stresses apply only to pipe meeting all the requirements of this specification.

X1.2 Six PE materials are included, based on the requirements of Specification D 1248 and the PPI-recommended hydrostatic design stresses as follows:

X1.2.1 Grade P 14 with a hydrostatic design stress of 400 psi (2.76 MPa) (27.6 bar) for water at 73.4°F (23°C), designated as PE1404.

X1.2.2 Grade P23, with a hydrostatic design stress of 500 psi (3.45 MPa) (34.5 bar) for water at 73.4°F (23°C), designated as PE2305.

X1.2.3 Grade P23, with a hydrostatic design stress of 630 psi (4.34 MPa) (43.4 bar) for water at 73.4°F (23°C), designated as PE2306.

X1.2.4 Grade P24, with a hydrostatic design stress of 630 psi (4.34 MPa) (43.4 bar) for water at 73°F (23°C), designated as PE2406.

X1.2.5 Grade P33, with a hydrostatic sign stress of 630 psi (4.34 MPa) (43.4 bar) for water at 73.4°F (23°C), designated as PE3306.

X1.2.6 Grade P34, with a hydrostatic design stress of 630 psi (4.34 MPa) (43.4 bar) for water at 73.4°F (23°C), designated as PE3406.

X1.3 Information regarding the test method and other criteria used in developing these hydrostatic design stresses may be obtained from the Plastics Pipe Institute, a division of The Society of the Plastics Industry, 355 Lexington Ave., New York, NY 10017 (Note X1.1). These hydrostatic design stresses may not be suitable for materials that show a wide departure from a straight line plot of log stress versus log time to failure. All the data available to date on PE pipe materials made in North America exhibit a straight-line plot under these plotting conditions.

NOTE X1.1—Refer also to Test Method D 2837.

X1.4 The pipe is rated for use with water at 73.4°F (23°C) at the maximum internal pressures shown in Table X1.1. Lower pressure ratings than those calculated in accordance with 3.2.3 may be recommended, at the option of the pipe manufacturer, in which case a star placed after the pressure rating shall be included in the marking. Experience of the industry indicates that PE plastic pipe meeting the requirements of this specification gives satisfactory service under normal conditions for a long period at these pressure ratings. The sustained pressure requirements (see 6.6) are related to these ratings through the slopes of the strength-time plots of these materials in pipe form.

X1.5 The hydrostatic design stresses recommended by the Plastics Pipe Institute are based on tests made on pipe ranging in size from ½ to 2 in.



**TABLE X1.1 Water Pressure Ratings at 73.4°F (23°C) for PE Plastic Pipe, Schedules 40 and 80**

Nominal Pipe Size, in.	Pressure Rating <sup>A</sup>					
	PE2306, PE2406, PE3306, PE3406		PE2305 <sup>B</sup>		PE1404 <sup>B</sup>	
	Schedule 40	Schedule 80	Schedule 40	Schedule 80	Schedule 40	Schedule 80
	MPa (bar)					
1/2	1.30(13.0)	1.84(18.4)	1.03(10.3)	1.46(14.6)	0.82(8.2)	1.17(11.7)
3/4	1.05(10.5)	1.49(14.9)	0.83(8.3)	1.19(11.9)	0.66(6.6)	0.94(9.4)
1	0.98(9.8)	1.37(13.7)	0.78(7.8)	1.09(10.9)	0.62(6.2)	0.87(8.7)
1 1/4	0.80(8.0)	1.13(11.3)	0.63(6.3)	0.90(9.0)	0.51(5.1)	0.72(7.2)
1 1/2	0.72(7.2)	1.02(10.2)	0.57(5.7)	0.81(8.1)	0.45(4.5)	0.65(6.5)
2	0.60(6.0)	0.88(8.8)	0.48(4.8)	0.70(7.0)	0.38(3.8)	0.56(5.6)
2 1/2	0.66(6.6)	0.92(9.2)	0.52(5.2)	0.73(7.3)	0.42(4.2)	0.59(5.9)
3	0.57(5.7)	0.81(8.1)	0.45(4.5)	0.65(6.5)	0.37(3.7)	0.52(5.2)
3 1/2	0.52(5.2)	0.75(7.5)	0.41(4.1)	0.59(5.9)	0.34(3.4)	0.48(4.8)
4	0.48(4.8)	0.70(7.0)	0.38(3.8)	0.56(5.6)	NPR	0.45(4.5)
5	0.42(4.2)	0.63(6.3)	0.34(3.4)	0.49(4.9)	NPR	0.40(4.0)
6	0.38(3.8)	0.61(6.1)	NPR	0.48(4.8)	NPR	0.39(3.9)
8	0.34(3.4)	...	NPR	...	NPR	...
10	NPR <sup>C</sup>	...	NPR	...	NPR	...
12	NPR	...	NPR	...	NPR	...
	psi					
1/2	188	267	149	212	119	170
3/4	152	217	120	172	96	137
1	142	199	113	158	90	126
1 1/4	116	164	92	130	74	104
1 1/2	104	148	83	118	66	94
2	87	127	69	101	55	81
2 1/2	96	134	76	106	61	85
3	83	118	66	94	53	75
3 1/2	75	109	60	86	50	69
4	70	102	55	81	NPR	65
5	61	91	50	72	NPR	58
6	55	88	NPR	70	NPR	56
8	50	...	NPR	...	NPR	...
10	NPR <sup>C</sup>	...	NPR	...	NPR	...
12	NPR	...	NPR	...	NPR	...

<sup>A</sup>These pressure ratings apply only to unthreaded pipe. The industry does not recommend threading PE plastic pipe.

<sup>B</sup>See 5.2 and appendix for code designation.

<sup>C</sup>NPR = not pressure rated. The industry does not recommend pressure ratings less than 50 psi (0.34 MPa)(3.4 bar).

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