



Standard Specification for Polyethylene (PE) Plastic Pipe (DR-PR) Based on Controlled Outside Diameter¹

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

1. Scope

1.1 This specification covers polyethylene (PE) pipe made in thermoplastic pipe dimension ratios based on outside diameter and pressure rated for water (see Appendix X1). 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. Methods of marking are also given.

1.2 All pipes produced under this specification may be used for the transport of water, industrial process liquids, effluents, slurries, municipal sewage, etc. The user should consult the manufacturer to determine whether the material being transported is compatible with polyethylene pipe and will not affect the service life beyond limits acceptable to the user.

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

1.4 The following safety hazards caveat pertains only to the test methods portion, Section 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 Density and Specific Gravity (Relative Density) of Plastics by Displacement³
- D 1238 Test Method for Flow Rates of Thermoplastics by Extrusion Plastometer³

¹ 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.

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² Annual Book of ASTM Standards, Vol 08.01.

³ Annual Book of ASTM Standards, Vol 08.03.

- D 1505 Test Method for Density of Plastics by the Density-Gradient Technique³
- D 1598 Test Method for Time-to-Failure of Plastic Pipe Under Constant Internal Pressure⁴
- D 1599 Test Method for Short-Time Hydraulic Failure Pressure of Plastic Pipe, Tubing, and Fittings³
- D 1600 Terminology for Abbreviated Terms Relating to Plastics³
- D 1603 Test Method for Carbon Black in Olefin Plastics³
- D 2122 Test Method for Determining Dimensions of Thermoplastic Pipe and Fittings³
- D 2290 Test Method for Apparent Tensile Strength of Ring or Tubular Plastics and Reinforced Plastics by Split Disk Method³
- D 2837 Test Method for Obtaining Hydrostatic Design Basis for Thermoplastic Pipe Materials³
- D 3350 Specification for Polyethylene Plastics Pipe and Fittings Materials³
- F 412 Terminology Relating to Plastic Piping Systems³

2.2 NSF International Standards:

- ANSI/NSF Standard No. 14 for Plastic Piping Components and Related Materials⁵
- ANSI/NSF Standard No. 61 for Drinking Water System Components—Health Effects⁵

2.3 PPI Documents:

- TR-4 Listing of Hydrostatic Design Bases (HDB), Strength Design Bases (SDB), Pressure Design Bases (PDB) and Minimum Required Strength (MRS) Ratings for Thermoplastic Piping Materials or Pipe⁶
- TR-9 Recommended Design Factors for Thermoplastic Pressure Pipe⁶

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.

⁴ Annual Book of ASTM Standards, Vol 08.04.

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

⁶ Available from the Plastics Pipe Institute, Inc., 1825 Connecticut Ave., NW, Suite 680 Washington, DC 20009.

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 between dimension ratio, hydrostatic design stress, and pressure rating—the following expression, commonly known as the ISO equation,⁷ is used in this specification to relate dimension ratio, hydrostatic design stress, and pressure rating:

$$2S/P = R - 1 \text{ or } 2S/P = (D_o/t) - 1 \quad (1)$$

where:

- S* = hydrostatic design stress, psi (MPa),
- P* = pressure rating, psi (MPa),
- D_o* = average outside diameter, in. (mm)
- t* = minimum wall thickness, in. (mm), and,
- R* = thermoplastic pipe dimension ratio (*D_o*/*t* for PE pipe).

3.2.4 thermoplastic pipe dimension ratio (DR)—the ratio of pipe diameter to wall thickness. For PE pipe covered by this specification it is calculated by dividing the average outside diameter of the pipe, in inches, by the minimum wall thickness, in inches. If the wall thickness calculated by this formula is less than 0.062 in. (1.6 mm), it shall be arbitrarily increased to 0.062 in.

3.2.5 thermoplastic pipe materials designation code—the polyethylene pipe materials designation code shall consist of the abbreviation PE for the type of plastics, 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 zero shall be used before the number. Thus, a complete material code shall consist 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 three PE plastic pipe materials in various dimension ratios and water pressure ratings.

4.2 Thermoplastic Pipe Dimension Ratios (DR)—This specification covers PE pipe in various dimension ratios such as, but not limited to, DR 11, DR 13.5, DR 17, and DR 21. The pressure rating is uniform for all nominal sizes of pipe for a given PE pipe material and DR. (See Table X1.1.)

4.3 Special Sizes—Where existing system conditions or special local requirements make other diameters or dimension ratios necessary, other sizes or dimension ratios, or both, shall be acceptable in engineered products when mutually agreed upon by the customer and manufacturer if (1) the pipe is

manufactured from plastic compounds meeting the material requirements of this specification and (2) the strength and design requirements are calculated on the same basis as those used in this specification.

5. Materials

5.1 Classification—Polyethylene compounds suitable for use in the manufacture of pipe under this specification shall be classified in accordance with Specification D 3350 and as shown in Table 1.

NOTE 1—Piping intended for use in the transport of potable water should be evaluated and certified as safe for this purpose by a testing agency acceptable to the local health authority. The evaluation should be in accordance with requirements for chemical extraction, taste, and odor that are no less restrictive than those included in ANSI/NSF Standard No. 14 or ANSI/NSF Standard No. 61. The seal or mark of the laboratory making the evaluation should be included on the piping.

NOTE 2—Pipe users should consult with the pipe manufacturer about the outdoor exposure life of the product under consideration.

5.2 Long-term Property Requirements—Polyethylene compounds suitable for use in the manufacture of pipe under this specification shall meet or exceed the long-term property requirements in Table 2.

5.3 HDB Listing—Polyethylene compounds suitable for use in the manufacture of pipe under this specification shall be listed in PPI TR-4 with HDB ratings in accordance with Table 2.

5.4 Rework Material—Clean, rework material having the same classification and generated from the manufacturer's own pipe production, may be used by the same manufacturer, as long as the pipe produced meets all of 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:

6.2.1 Outside Diameters—The outside diameters and tolerances shall be as shown in Table 3 when measured in

TABLE 1 Specification D 3350 Cell Classifications for Polyethylene Pipe Materials

PE Material Designation Code	PE 1404	PE 2406	PE 3408
Physical Property:	Cell Classifications		
Density	1	2	3
Melt Index	2	3 or 4	3 or 4
Flexural Modulus	3	3 or 4	4 or 5
Tensile Strength at Yield	1	3 or 4	4 or 5
Slow Crack Growth Resistance	1 ^A	6 ^B	6 ^B
Hydrostatic Design Basis	1	3	4
Color and UV Stabilizer ^C	C	C or E	C or E

^A Test Method D 1693 ESCR.

^B Test Method F 1473 PENT.

^C Classification E compounds shall have sufficient UV stabilizer to protect pipe from deleterious effects due to continuous outdoor exposure during shipping and unprotected outdoor storage for up to 18 months. Pipe produced from Classification E compounds is not suitable for continuous use in exposed outdoor applications. Classification C and E compounds shall have sufficient antioxidants to meet requirements in Specification D 3350. Classification C compounds shall contain 2 to 3 % carbon black when tested in accordance with Test Method D 1603.

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

TABLE 2 Long-Term Property Requirements

PE Material Designation Code	Long-term Property in Accordance with Test Method D 2837 ^A
PE 1404	HDB of 800 psi at 73°F (5.52 MPa at 23°C)
PE 2406	HDB of 1250 psi at 73°F (8.62 MPa at 23°C)
PE 3408	HDB of 1600 psi at 73°F (11.03 MPa at 23°C)
PE 2406 and PE 3408	Minimum HDB of 630 psi at 140°F (4.34 MPa at 60°C)

^A The hydrostatic design basis shall be established using water or air as the pressurizing fluid.

TABLE 3 Outside Diameters and Tolerances for DR-PR PE Plastic Pipe

Nominal Pipe Size, in.	Outside Diameter, in. (mm)	Tolerances, in. (mm)
1/2	0.840 (21.34)	±0.004 (0.10)
3/4	1.050 (26.7)	±0.004 (0.10)
1	1.315 (33.4)	±0.005 (0.13)
1 1/4	1.660 (42.2)	±0.005 (0.13)
1 1/2	1.900 (48.3)	±0.006 (0.15)
2	2.375 (60.3)	±0.006 (0.15)
3	3.500 (88.9)	±0.008 (0.20)
4	4.500 (114.3)	±0.009 (0.23)
6	6.625 (168.28)	±0.011 (0.28)
8	8.625 (219.08)	±0.013 (0.33)
10	10.750 (273.05)	±0.015 (0.38)
12	12.750 (323.85)	±0.017 (0.43)
14	14.000 (355.60)	±0.063 (1.60)
16	16.000 (406.40)	±0.072 (1.83)
18	18.000 (457.20)	±0.081 (2.06)
20	20.000 (508.00)	±0.090 (2.29)
22	22.000 (558.80)	±0.099 (2.51)
24	24.000 (609.60)	±0.108 (2.74)

accordance with Test Method D 2122. For diameters not shown in Table 3, the tolerances shall be the same percentage of the outside diameter as those for the closest listed diameter.

6.2.2 Wall Thicknesses—The wall thicknesses and tolerances shall be as shown in Table 4 when measured in accordance with Test Method D 2122. For wall thicknesses (DRs) not shown in Table 4, the tolerances shall be the same percentage of the calculated minimum wall as for the closest listed minimum wall thickness.

6.2.3 Wall Thickness Range—The wall thickness range shall be within 12 % when measured in accordance with Test Method D 2122.

6.3 Short-term Properties—Specimens of pipe shall be tested in accordance with either Test Method D 1599 or Test Method D 2290. The test method used, Test Method D 1599 or Test Method D 2290, is determined by the pipe size and the availability of appropriate test equipment. Test Method D 1599 is generally used for 4 in. (114 mm) and smaller sizes and Test Method D 2290 for 2-in (60 mm) and larger sizes. Short-term hoop stress and failure mode data is provided by either test.

6.3.1 Burst Pressure—The minimum burst pressure for PE plastic pipe shall be as given in Table 5, when determined in accordance with Test Method D 1599 and 7.6, using a minimum fiber stress of 1250 psi (8.62 MPa) for PE 1404 and 2520 psi (17.37 MPa) for PE 2406 and PE 3408. The failure mode shall be ductile.

6.3.2 Apparent Ring Tensile Strength—The minimum apparent ring tensile strength at yield shall be 1250 psi (8.62 MPa) for PE 1404 and 2520 psi (17.37 MPa) for PE 2406 and

PE 3408 when tested in accordance with Test Method D 2290, Procedure B and 7.7. The failure shall be ductile.

6.4 Sustained Pressure at Ambient and Elevated Temperature—Pipes made from PE 2406 and PE 3408 shall be tested in accordance with 7.7 at the pressures and temperatures specified in Table 7. Tests may be conducted at either stress and on any size, but tests conducted on 6 in. (168 mm) nominal size pipe shall be considered representative of all pipe sizes. If ductile failures occur at the higher stress, repeat testing at the lower stress.

7. Test Methods

7.1 Conditioning—Condition the test specimens 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 ± 3.6°F (23 ± 2°C), 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, random samples as selected by the testing laboratory shall be deemed adequate.

7.4 Ambient Temperature Sustained Pressure Test—Select six specimens of pipe at random and test each specimen individually with water at controlled temperatures under the pressures given in Table 6. Each specimen shall be 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. Condition the specimens for at least 2 h at 73 ± 3.6°F (23 ± 2°C). Test for the minimum failure time specified in Table 6 in accordance with Test Method D 1598, at the pressure and temperature values given in Table 7. Maintain the specimens at the pressures indicated ± 10 psi (± 70 kPa) and the temperatures specified ± 3.6°F (± 2°C). Failure of two of the six specimens tested constitutes failure of the test. Failure of one of the six specimens tested is cause for retest of six additional specimens. Failure of one of six specimens tested in retest constitutes failure in the test. Failure of the pipe test specimen shall be as defined in Test Method D 1598.

7.5 Elevated Temperature Sustained Pressure Test—Prepare at least three test specimens as specified in 7.4. Using water as internal medium, test at 176°F (80°C) and the hoop stress (*S*) specified in Table 7 for the given pipe material in accordance with Test Method D 1598. Two of three specimens must meet or exceed the specified minimum average failure time.

7.6 Hydrostatic Burst Pressure—The test equipment, procedures, and failure definitions shall be as specified in Test Method D 1599.

7.7 Apparent Ring Tensile Strength at Yield—The method and test equipment shall be as specified in Test Method D 2290, Procedure B. Test a minimum of five specimens.

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