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An American National Standard

Standard Specification for Polyethylene (PE) Plastic Pipe (SIDR-PR) Based on Controlled Inside Diameter[1]

This standard is issued under the fixed designation D 2239; 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 made in standard thermoplastic pipe dimension ratios 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. Methods of marking are also given.

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

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

1.4 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 for Testing[2]

D 792 Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement[2]

D 1238 Test Method for Flow Rates of Thermoplastics by Extrusion Plastometer[2]

D 1248 Specification for Polyethylene Plastics Molding and Extrusion Materials[2]

D 1505 Test Method for Density of Plastics by the Density-Gradient Technique[2]

D 1598 Test Method for Time-to-Failure of Plastic Pipe Under Constant Internal Pressure[3]

D 1599 Test Method for Short-Time Hydraulic Failure Pressure of Plastic Pipe, Tubing, and Fittings[3]

D 1600 Terminology for Abbreviated Terms Relating to Plastics[2]

D 1603 Test Method for Carbon Black in Olefin Plastics[2]

D 2122 Test Method for Determining Dimensions of Thermoplastic Pipe and Fittings[3]

D 2837 Test Method for Obtaining Hydrostatic Design Basis for Thermoplastic Pipe Materials[3]

D 3350 Specification for Polyethylene Plastics Pipe and Fittings Materials[4]

F 412 Terminology Relating to Plastic Piping Systems[3]

2.2 *NSF Standards:*

Standard No. 14 for Plastic Piping Components and Related Materials[5]

Standard No. 61 for Drinking Water Systems Components—Health Effects[5]

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 the material is capable of withstanding continuously with a high degree of certainty that failure of the pipe will not occur. This stress is circumferential when internal hydrostatic water pressure is applied.

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

3.2.3 *relation between standard dimension ratio, hydrostatic design stress, and pressure rating*—the following expression, commonly known as the ISO equation,[6] is used in this

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[2] *Annual Book of ASTM Standards*, Vol 08.01.

[3] *Annual Book of ASTM Standards*, Vol 08.04.

[4] *Annual Book of ASTM Standards*, Vol 08.02.

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

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

specification to relate standard dimension ratio, hydrostatic design stress, and pressure rating:

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

where:
S = hydrostatic design stress, MPa (or psi),
P = pressure rating, MPa (or psi),
D_i = average inside diameter, mm (or in.),
t = minimum wall thickness, mm (or in.), and
R = standard thermoplastic pipe dimension ratio (D_i/t for *PE* pipe), also known as SIDR.

3.2.4 *standard thermoplastic pipe dimension ratio (SIDR)*—the ratio of pipe diameter to wall thickness. For PE pipe it is calculated by dividing the average inside diameter of the pipe in millimetres or in inches by the minimum wall thickness in millimetres or in inches. If the wall thickness calculated by this formula is less than 1.52 mm (0.060 in.), it shall be arbitrarily increased to 1.52 mm. The SIDR values shall be rounded to the nearest 0.1.

3.2.5 *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 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 four PE plastic pipe materials in six standard dimension ratios and six water pressure ratings.

4.2 *Standard Thermoplastic Pipe Dimension Ratios (SIDR)*—This specification covers PE pipe in six standard dimension ratios, namely, 5.3, 7, 9, 11.5, 15, and 19. These are referred to as SIDR 5.3, SIDR 7, SIDR 9, SIDR 11.5, SIDR 15, and SIDR 19, respectively. The pressure rating is uniform for all nominal pipe sizes for a given PE pipe material and SIDR (see Table X1.1, appendix).

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 P 14, Grade P 23, Grade P 24, Grade P 33, and Grade P 34. The PE plastics can also be described in accordance with the appropriate cell classification as defined in Specification D 3350. The 80°C sustained pressure performance requirements of 6.9 (pipe test category in Table 1) 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 DesignStresses*—This specification covers PE pipe made from PE plastics as defined by four hydrostatic design stresses developed on the basis of long-term tests (Appendix X1).

5.4 *Compound*—The PE plastic extrusion compound shall meet the requirements of either Grade P 14, Class B or C; Grade P 23, Class B or C; Grade P 24, Class B or C; Grade P 33, Class B or C; or Grade P 34, Class B or C material as

TABLE 1 176°F (80°C) Sustained Pressure Requirements for Water Pipe[A,B]

Pipe Test Category[C]	Base Resin Melt Index, D 1238 (g/10 min)	Base Resin Density,[D] D 1505 (g/cm³)	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

[A] For inside diameter controlled pipe, calculate internal pressure in accordance with the following formula:

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

[B] 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).

[C] Supplier to determine pipe test category appropriate for his product.
[D] Pipe categories for water pipe with resin density below 0.926 g/cm³ or above 0.948 g/cm³ will be added to this table when the data are available.

described in Specification D 1248. The PE plastics can also be described in accordance with the appropriate cell classification as defined in Specification D 3350.

5.4.1 Class B compounds shall have sufficient UV stabilizer to protect pipe from deleterious effects due to continuous outdoor exposure during storage and shipping. Pipe produced from Class B compounds are not suitable for exposed outdoor application. Class B and C compounds shall have sufficient antioxidants to meet the requirements in Specification D 3350.

5.4.2 Class C compounds use carbon black for UV stabilization. There is evidence that indicates the type, particle size, and dispersion quality of the carbon black affect the weatherability of the pipe.

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

5.5 *Rework Material*—The manufacturers shall use only their own clean rework pipe material and the pipe produced shall meet all the requirements of this specification.

6. Requirements

6.1 *Workmanship*—The pipe shall be homogeneous throughout and free of visible cracks, holes, foreign inclusions, or other defects. The pipe shall be as uniform as commercially practicable in color, opacity, density, and other physical properties.

6.2 *Dimensions and Tolerances*:

6.2.1 *Inside Diameters*—The inside diameters and tolerances shall be as shown in Table 2 when measured in accordance with Test Method D 2122.

6.2.2 *Wall Thicknesses*—The wall thicknesses and tolerances shall be as shown in Table 3 when measured in accordance with Test Method D 2122.

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

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 0.50-mm (0.020-in.) thick.

TABLE 2 Inside Diameters and Tolerances for SIDR-PR PE Plastic Pipe, in.

Nominal Pipe Size	Average Inside Diameter	Tolerances
½	0.622	+0.010 −0.010
¾	0.824	+0.010 −0.015
1	1.049	+0.010 −0.020
1¼	1.380	+0.010 −0.020
1½	1.610	+0.015 −0.020
2	2.067	+0.015 −0.020
2½	2.469	+0.015 −0.025
3	3.068	+0.015 −0.030
4	4.026	+0.015 −0.035
6	6.065	+0.020 −0.035

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*—Class C polyethylene pipe extrusion compound shall contain at least 2 % carbon black when tested in accordance with 7.4. For pipe produced by simultaneous multiple extrusion, this requirement shall apply to the outer layer.

NOTE 2—The amount of pigment in Class B polyethylene is not established by this specification other than the compound shall meet all other requirements and the tubing shall meet all long- and short-term requirements 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^3 for pipe made from Grade P 14 of Specification D 1248, 0.926 to 0.940 g/cm^3 for pipe made from Grade P 23 and Grade P 24 of Specification D 1248, 0.941 to 0.965 g/cm^3 for pipe made from Grade P 33 of Specification D 1248, and 0.941 to 0.965 g/cm ^{3} for pipe made from Grade P 34 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 4 when tested in accordance with 7.7.

6.7 *Burst Pressure*—The minimum burst pressure for PE plastic pipe shall be as given in Table 5, when determined in accordance with 7.10.

6.8 *Environmental Stress Cracking*— There shall be no loss of pressure in the pipe when tested in accordance with 7.8.

6.9 *Elevated Temperature Sustained Pressure*—The average failure time must meet or exceed the specified minimum average failure time in Table 1 for both hoop stresses of a given pipe test category when tested in accordance with 7.9.

7. Test Methods

7.1 *Conditioning*—Condition the test specimens at 23 ± 2°C (73.4 ± 3.6°F) prior to test in accordance with Procedure A of Practice D 618, for those tests where conditioning is required.

7.2 *Test Conditions*—Conduct the tests in the standard laboratory atmosphere of 23 ± 2°C (73.4 ± 3.6°F), 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 *Carbon Black*—For all pipe manufactured with Class C extrusion compound, or the outer layer of pipe produced by simultaneous multiple extrusion, determine in duplicate the carbon black content in accordance with Test Method D 1603.

7.5 *Density*—Determine the density of the pipe compound