



# Standard Specification for Polyethylene (PE) Plastic Pipe (SIDR-PR) Based on Controlled Inside Diameter<sup>1</sup>

This standard is issued under the fixed designation D2239; 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 U.S. Department of Defense.*

## 1. Scope\*

1.1 This specification covers polyethylene (PE) pipe made to standard inside dimension ratios (SIDR) and pressure rated for water (see appendix). Included are requirements for PE compounds and requirements and test methods for workmanship, dimensions, elevated temperature sustained pressure, burst pressure, and marking.

NOTE 1—Refer to specification AWWA C901 and PPI Technical Note 49 (TN-49) for further information on pipe suitability for potable water end use applications. Oxidative Resistance Classification (CC# rating) information is available from NSF International.

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

1.3 The text of this specification references notes, footnotes, and appendixes which provide explanatory material. These notes and footnotes shall not be considered as requirements of the specification. Notes and footnotes in tables and figures, and Supplementary Requirements are 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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.5 *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.*

<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.

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## 2. Referenced Documents

### 2.1 ASTM Standards:<sup>2</sup>

- D618 Practice for Conditioning Plastics for Testing
- D638 Test Method for Tensile Properties of Plastics
- D1238 Test Method for Melt Flow Rates of Thermoplastics by Extrusion Plastometer
- 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
- D2565 Practice for Xenon-Arc Exposure of Plastics Intended for Outdoor Applications
- 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
- F412 Terminology Relating to Plastic Piping Systems
- F2263 Test Method for Evaluating the Oxidative Resistance of Polyethylene (PE) Pipe to Chlorinated Water
- G154 Practice for Operating Fluorescent Ultraviolet (UV) Lamp Apparatus for Exposure of Nonmetallic Materials
- G155 Practice for Operating Xenon Arc Lamp Apparatus for Exposure of Materials

### 2.2 APWA Standard:<sup>3</sup>

- APWA Uniform Color Code

<sup>2</sup> For referenced ASTM standards, visit the ASTM website, [www.astm.org](http://www.astm.org), or contact ASTM Customer Service at [service@astm.org](mailto:service@astm.org). For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

<sup>3</sup> APWA, 2345 Grand Boulevard, suite 500, Kansas, City, MO 64108-2641.

\*A Summary of Changes section appears at the end of this standard

### 2.3 AWWA Standards:<sup>4</sup>

**C901 Polyethylene (PE) Pressure Pipe and Tubing, ¾ in. (19 mm) through 3 in. (76 mm), for Water Service**

### 2.4 NSF Standards:<sup>5</sup>

**NSF/ANSI Standard No. 14 for Plastic Piping Components and Related Materials**

**NSF/ANSI/CAN Standard No. 61 for Drinking Water Systems Components—Health Effects**

### 2.5 PPI Publications:<sup>6</sup>

**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 HDB/SDB/PDB/MRS Listed Materials, 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 TN-49 Recommendations for AWWA C901 Service Tubes in Potable Water Applications**

## 3. Terminology

3.1 *Definitions*—Definitions are in accordance with Terminology **F412**, and abbreviations are in accordance with Terminology **D1600**, unless otherwise specified. The abbreviation for polyethylene plastic is PE.

## 4. Pipe Classification

4.1 *General*—This specification covers inside diameter controlled PE pipe made from PE compounds in standard inside dimension ratios and pressure rated for water. Pressure ratings for water are dependent on the PE compound in accordance with the following relationship:

$$PR = \frac{2 \times HDS}{(SIDR + 1)} \quad (1)$$

where:

*PR* = pressure rating for water, psi (kPa)

*HDS* = hydrostatic design stress for water at 73 °F (23 °C), psi (kPa)

*SIDR* = standard inside dimension ratio

NOTE 2—PR and HDS must have the same units. See **Appendix X1** for maximum pressure ratings for water.

## 5. Materials

5.1 *Polyethylene Compound*—Polyethylene compounds suitable for use in the manufacture of pipe under this specification shall meet thermoplastic materials designation codes PE2708 or PE3608 or PE4710, and shall meet **Table 1** requirements for PE2708 or PE3608 or PE4710, and shall meet thermal stability, brittleness temperature and elongation at

<sup>4</sup> Available from American Water Works Association (AWWA), 6666 W. Quincy Ave., Denver, CO 80235, <http://www.awwa.org>.

<sup>5</sup> Available from NSF International, P.O. Box 130140, 789 N. Dixboro Rd., Ann Arbor, MI 48113-0140, <http://www.nsf.org>.

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

break requirements in accordance with Specification **D3350**. Oxidative Resistance Classification of CC3 is required in specific end use applications in accordance with **5.3**.

5.1.1 *Color and Ultraviolet (UV) Stabilization*—in accordance with **Table 1**, polyethylene compounds shall meet Specification **D3350** code C, D or E. In addition, Code C polyethylene compounds shall have 2 to 3 percent carbon black, and Code D or E polyethylene compounds shall have sufficient UV stabilizer to protect pipe from deleterious UV exposure effects during unprotected outdoor shipping and storage for at least eighteen (18) months.

NOTE 3—Pipe users should consult with the pipe manufacturer about the outdoor exposure life of the product under consideration. Evaluation of UV stabilizer in Code E color PE compound using Practice **D2565** or Practice **G154** or Practice **G155** may be useful for this purpose.

5.1.2 *Colors for solid color, an external color layer or color stripes*—In accordance with the APWA Uniform Color Code, blue shall identify potable water service; green shall identify sewer service; and purple (lavender) shall identify reclaimed water service. Yellow identifies gas service and shall not be used. The base resin that is used for an external color layer or color stripes shall be the same base resin as the body of the pipe in accordance with **Table 1**.

5.2 *Health Effects Requirement*—PE compound intended for contact with potable water, or when otherwise required, shall be evaluated, tested, and certified for conformance with NSF/ANSI Standard No. 61 or the health effects portion of NSF/ANSI/CAN Standard No. 14 by a certifying organization acceptable to the regulatory authority having jurisdiction.

5.3 *Oxidative Resistance*—For pipe that is intended for use in the transport of potable water containing oxidizing disinfectants (for example, hypochlorous acid or chloramines), or when required by the application, customer or regulatory authority having jurisdiction, the PE compound shall have an oxidative resistance classification of CC3 in accordance with Specification **D3350**. The oxidative resistance classification of CC3 is used in conjunction with pipe dimensions in accordance with **6.2.1.1** and **6.2.2.1** to ensure the intended pipe service life is met with respect to oxidative resistance (see **Note 4**). When the pipe meets these requirements, it shall be marked CC3 as in accordance with **9.1.8**. When the pipe does not meet the compound and dimensional requirements as above it shall not be marked CC3. An oxidative resistance classification is not required for other potable water services that do not contain oxidizing disinfectants or when it is not required by the application, customer or regulatory authority having jurisdiction.

NOTE 4—See [www.plasticpipe.org](http://www.plasticpipe.org) for further information on potable water disinfectants in small diameter PE pipe and the use of oxidative resistance classification for specific applications.

NOTE 5—Pipe failure analysis for the oxidative resistance **5.3** is based on Type 2 failures and the brittle failure line extrapolation. See ASTM **F2263** Standard Test Method for Evaluating the Oxidative Resistance of Polyethylene (PE) Pipe to Chlorinated Water for brittle failure definition and **Fig. 1** for a pictorial lifetime representation.

5.4 *Rework Material*—Clean polyethylene compound from the manufacturer's own pipe production that met **5.1** through **5.3** as new PE compound is suitable for re-extrusion into pipe

TABLE 1 Polyethylene Compound Requirements

Requirement	Material Designation		
	PE2708	PE3608	PE4710
	Required Value		
Minimum HDB at 140 °F (60 °C), psi (MPa), in accordance with Test Method <b>D2837</b> and PPI TR-3	800 (5.5) <sup>A</sup>	800 (5.5) <sup>A</sup>	1000 (6.9) <sup>A</sup>
HDS for water at 73 °F (23 °C) psi (MPa), in accordance with Test Method <b>D2837</b> and PPI TR-3	800 (5.5)	800 (5.5)	1000 (6.9)
Melt flow rate in accordance with Test Method <b>D1238</b>	≤0.40 g/10 min Cond. 190/2.16 or ≤20 g/10 min Cond. 190/21.6	≤0.15 g/10 min Cond. 190/2.16 or ≤20 g/10 min Cond. 190/21.6	≤0.15 g/10 min Cond. 190/2.16 or ≤20 g/10 min Cond. 190/21.6
Specification <b>D3350</b> Cell Classification Property Requirement Density (natural base resin)	2	3	4
SCG Resistance	7	6	7
Color and UV Stabilizer Code <sup>B</sup>	C, D or E	C, D or E	C, D or E
Oxidative Resistance Classification in accordance with Test Method <b>F2263</b>	c	c	c

<sup>A</sup> Contact manufacturer or see PPI TR-4 for listed value.

<sup>B</sup> See 5.1.1.

<sup>C</sup> See 5.3 for when CC3 classification is required.

when blended with new PE compound having the same material designation and oxidative resistance classification. Pipe containing rework material 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. See 5.1.2.

### 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 **D2122**.

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

Pipe Size	Inside Diameter	Tolerance
1/2	0.622	+0.010 -0.010
3/4	0.824	+0.010 -0.015
1	1.049	+0.010 -0.020
1 1/4	1.380	+0.010 -0.020
1 1/2	1.610	+0.015 -0.020
2	2.067	+0.015 -0.020
3	3.068	+0.015 -0.030

6.2.1.1 Pipe for potable water service containing oxidizing disinfectants or that require an oxidative resistance classification as outlined in 5.3 Oxidative Resistance shall be pipe size 3/4 or greater as in accordance with Table 2 in order to meet the expected service life of the pipe in these specific conditions (see Note 4).

6.2.2 Wall Thicknesses—Subject to 6.2.3, wall thickness and tolerance shall be as shown in Table 3 when measured in accordance with 7.4. Wall thickness shall be inclusive of all extruded concentric layers.

6.2.2.1 Pipe for potable water service containing oxidizing disinfectants or that require an oxidative resistance classification as outlined in 5.3 Oxidative Resistance shall be SIDR 9, 7 or 5.3 as in accordance with Table 3 in order to meet the requirements for the expected service life of the pipe in these specific conditions (see Note 4).

6.2.3 Wall Thickness Range—The wall thickness variation shall not exceed 12 % when measured in accordance with 7.4.

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. (0.5 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 cleanly separate any two layers with a probe or point of a knife blade at any point.

6.4 Carbon Black—Polyethylene pipe produced using Code C polyethylene compound in accordance with 5.1.1 shall contain 2 to 3 % carbon black when tested in accordance with 7.5.

6.5 Burst Pressure—The minimum burst pressure for pipe shall be in accordance with Table 4, when determined in accordance with 7.6. In addition, the failure shall be ductile.

6.6 Elevated Temperature Sustained Pressure—Elevated temperature sustained pressure tests for each polyethylene compound designation in accordance with Table 1 used in production at the facility shall be conducted twice annually in accordance with 7.7.

6.7 Inside Surface Ductility for Pipe—Pipe shall be tested for inside surface ductility in accordance with 7.8 or 7.9.

NOTE 6—Tensile elongation testing in accordance with 7.9 provides a quantifiable result and is used for referee testing and in cases of disagreement.

7. Test Methods

7.1 Conditioning—Condition as specified in the test method. Where conditioning is not specified in the test method, condition the test specimens at 73 °F ± 4 °F (23 °C ± 2 °C) without regard to humidity for not less than 4 h in accordance with Procedure A of Practice D618, or at 73 °F ± 4 °F (23 °C ± 2 °C) for not less than 1 h in accordance with Procedure D of Practice D618.

7.2 Test Conditions—Conduct tests in accordance with the conditions specified in the test method, or if not specified in the test method, at 73 °F ± 4 °F (23 °C ± 2 °C) without regard to relative humidity.

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 the pipe sample that is at least one pipe diameter away from an end closure. The entire marking shall be documented in testing records.

7.4 Dimensions and Tolerances—Use any length of pipe to determine the dimensions. Inside diameter, wall thickness and wall thickness range shall be measured in accordance with Test Method D2122.

7.5 Carbon Black—For all pipe manufactured with Code C polyethylene compound, determine in duplicate the carbon black content in accordance with Test Method D1603 or Test Method D4218.

7.6 Burst Pressure—The test equipment, procedures and failure definitions shall be as specified in Test Method D1599.

7.7 Elevated Temperature Sustained Pressure Test—Elevated temperature sustained pressure tests for each Table 1 material designation used in production of pipe in accordance with this specification at the facility shall be conducted in accordance with Test Method D1598, and Table 5 using water as the pressurizing medium. The “test sample” shall be three specimens of any pipe size or SIDR. One Table 5 Condition for the applicable material designation shall be selected for the test.

7.7.1 For the selected Table 5 Condition, passing results are (a) non-failure for all three specimens at a time equal to or

TABLE 3 Wall Thickness and Tolerance for SIDR-PR PE Plastic Pipe, in.

Pipe Size	Wall Thickness <sup>A</sup>											
	SIDR 19		SIDR 15		SIDR 11.5		SIDR 9		SIDR 7		SIDR 5.3	
	Minimum	Tolerance	Minimum	Tolerance	Minimum	Tolerance	Minimum	Tolerance	Minimum	Tolerance	Minimum	Tolerance
1/2	0.060	+0.020	0.060	+0.020	0.060	+0.020	0.069	+0.020	0.089	+0.020	0.117	+0.020
3/4	0.060	+0.020	0.060	+0.020	0.072	+0.020	0.092	+0.020	0.118	+0.020	0.155	+0.020
1	0.060	+0.020	0.070	+0.020	0.091	+0.020	0.117	+0.020	0.150	+0.020	0.198	+0.024
1 1/4	0.073	+0.020	0.092	+0.020	0.120	+0.020	0.153	+0.020	0.197	+0.024	0.260	+0.031
1 1/2	0.085	+0.020	0.107	+0.020	0.140	+0.020	0.179	+0.020	0.230	+0.028	0.304	+0.036
2	0.109	+0.020	0.138	+0.020	0.180	+0.022	0.230	+0.028	0.295	+0.035	0.390	+0.047
3	...	...	0.205	+0.020	0.267	+0.032	...	...	...	...	...	...

<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. Wall thickness variation shall be in accordance with 6.2.3.

TABLE 4 Minimum Burst Pressure for SIDR Pipe

SIDR	Minimum Burst Pressure <sup>A</sup>			
	PE2708		PE3608, PE4710	
	psi	(kPa)	psi	(kPa)
5.3	800	(5517)	921	(6352)
7	630	(4345)	725	(5000)
9	504	(3476)	580	(4000)
11.5	403	(2779)	464	(3200)
15	315	(2174)	363	(2503)
19	252	(1738)	290	(2000)

<sup>A</sup>Minimum burst pressure calculated in accordance with

$$P_B = \frac{2S}{D_i} + 1$$

where:

- $P_B$  = burst test pressure, psi (kPa)
- $S$  = minimum hoop fiber stress, psi. (kPa)
- $S$  = 1260 psi (8690 kPa) for PE1404 compound
- $S$  = 2520 psi (17 370 kPa) for PE2708 compound
- $S$  = 2900 psi (20 000 kPa) for PE3608, PE4608 and PE4710 compound
- $D_i$  = measured average inside diameter, in. (mm)
- $t$  = measured minimum wall thickness, in (mm).

Test temperature tolerance  $\pm 4$  °F ( $\pm 2$  °C). Test pressure tolerance  $\pm 5$  psi ( $\pm 35$  kPa)

TABLE 5 Elevated Temperature Sustained Pressure Test<sup>A</sup> Requirements

Condition	Test Temperature, °F (°C)	PE2708, PE3608		PE4710	
		Test Pressure Hoop Stress, psi (kPa)	Minimum Average Time Before Failure, hours	Test Pressure Hoop Stress, psi (kPa)	Minimum Average Time Before Failure, hours
		1	176 (80)	670 (4620)	170
2	176 (80)	650 (4480)	340	730 (5020)	400
3	176 (80)	630 (4345)	510	705 (4870)	600
4	176 (80)	610 (4210)	680	685 (4715)	800
5	176 (80)	590 (4070)	850	660 (4565)	1000
6	176 (80)	580 (4000)	1000	640 (4415)	1200

<sup>A</sup>Calculate internal test pressure in accordance with

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

Where:

- $P$  = test pressure, psi (kPa)
- $S$  = test pressure hoop stress, psi. (kPa)
- $D_i$  = measured average inside diameter, in. (mm)
- $t$  = measured minimum wall thickness, in (mm)

Test temperature tolerance  $\pm 4$  °F ( $\pm 2$  °C). Test pressure tolerance  $\pm 5$  psi ( $\pm 35$  kPa); test pressure hoop stress values are rounded to the nearest 5 psi or 5 kPa.

NOTE-Table 5 conditions are based on PE validation requirements in accordance with PPI TR-3 with Condition 6 being 85 % of Condition 1 test pressure hoop stress and six times greater minimum average time before failure. Conditions 2 through 5 are linear stress and time interpolations between Conditions 1 and 6. The intent of multiple conditions is to maintain equivalent performance criteria, but provide for retest in the event of ductile failure. The test pressure hoop stress levels for Conditions 2-5 are linear interpolations for arbitrarily chosen time increments. An equivalent performance requirement, however, may be determined by arbitrarily choosing a test pressure hoop stress between Conditions 1 and 6 and linearly interpolating the minimum average time before failure. For example for PE3710 and PE4710 compound designations, at 670 psi test pressure hoop stress, the minimum average time before failure would be 927 hours:

$$927 = 200 + \left( (750 - 670) \times \frac{(1200 - 200)}{(750 - 640)} \right)$$

greater than the Table 5 minimum average time before failure, or (b) not more than one ductile specimen failure and the average time before failure for all three specimens shall be greater than the specified Table 5 minimum average time before failure for the selected Table 5 Condition, or (c) successful retest in accordance with 7.7.3.

7.7.2 For the selected Table 5 Condition, failure to meet this requirement is (a) brittle failure of any specimen when tested

at Table 5 Condition 1 through 6, or (b) ductile failure of all three specimens, or (c) unsuccessful retest in accordance with 7.7.3.

7.7.3 Provision for Retest for Table 5 Conditions 1 through 5—If a second ductile failure occurs before the Table 5 minimum average time before failure, it is permissible to conduct one retest at a Table 5 Condition of lower stress and longer minimum average time before failure for the material