



Standard Specification for Poly(Vinyl Chloride) (PVC) Pressure-Rated Pipe (SDR Series)¹

This standard is issued under the fixed designation D 2241; 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 poly(vinyl chloride) (PVC) pipe made in standard thermoplastic pipe dimension ratios and pressure rated for water (see appendix). Included are criteria for classifying PVC plastic pipe materials and PVC plastic pipe, a system of nomenclature for PVC plastic pipe, and requirements and test methods for materials, workmanship, dimensions, sustained pressure, burst pressure, flattening, and extrusion quality. Methods of marking are also given.

1.2 The products covered by this specification are intended for use with the distribution of pressurized liquids only, which are chemically compatible with the piping materials. Due to inherent hazards associated with testing components and systems with compressed air or other compressed gases, some manufacturers do not allow pneumatic testing of their products. Consult with specific product/component manufacturers for their specific testing procedures prior to pneumatic testing.

NOTE 1—Pressurized (compressed) air or other compressed gases contain large amounts of stored energy which present serious safety hazards should a system fail for any reason.

NOTE 2—This standard specifies dimensional, performance and test requirements for plumbing and fluid handling applications, but does not address venting of combustion gases.

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

1.5 The following safety hazards caveat pertains only to the test methods portion, Section 8, 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. A specific precautionary statement is given in Note 7.

NOTE 3—CPVC plastic pipe (SDR-PR), which was formerly included in this specification, is now covered by Specification F 442/F 442M.

NOTE 4—The sustained and burst pressure test requirements, and the pressure ratings in the appendix, are calculated from stress values obtained from tests made on pipe 4 in. (100 mm) and smaller. However, tests conducted on pipe as large as 24 in. (600 mm) in diameter have shown these stress values to be valid for larger diameter PVC pipe.

NOTE 5—PVC pipe made to this specification is often belled for use as line pipe. For details of the solvent cement bell, see Specification D 2672 and for details of belled elastomeric joints, see Specifications D 3139 and D 3212.

2. Referenced Documents

2.1 ASTM Standards:²

- D 618 Practice for Conditioning Plastics for Testing
- D 1598 Test Method for Time-to-Failure of Plastic Pipe Under Constant Internal Pressure
- D 1599 Test Method for Resistance to Short-Time Hydraulic Failure Pressure of Plastic Pipe, Tubing, and Fittings
- D 1600 Terminology for Abbreviated Terms Relating to Plastics
- D 1784 Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds
- D 2122 Test Method for Determining Dimensions of Thermoplastic Pipe and Fittings
- D 2152 Test Method for Adequacy of Fusion of Extruded Poly(Vinyl Chloride) (PVC) Pipe and Molded Fittings by Acetone Immersion
- D 2444 Test Method for Impact Resistance of Thermoplastic Pipe and Fittings by Means of a Tup (Falling Weight)
- D 2672 Specification for Joints for IPS PVC Pipe Using Solvent Cement

¹ This specification is under the jurisdiction of ASTM Committee F17 on Plastic Piping Systems and is the direct responsibility of Subcommittee F17.25 on Vinyl Based Pipe.

Current edition approved Sept. 1, 2004. Published June 2004. Originally approved in 1964. Last previous edition approved in 2004 as D 2241 – 04a.

² For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

D 2837 Test Method for Obtaining Hydrostatic Design Basis for Thermoplastic Pipe Materials or Pressure Design Basis for Thermoplastic Pipe Products
 D 3139 Specification for Joints for Plastic Pressure Pipes Using Flexible Elastomeric Seals
 D 3212 Specification for Joints for Drain and Sewer Plastic Pipes Using Flexible Elastomeric Seals
 F 412 Terminology Relating to Plastic Piping Systems
 F 442/F 442M Specification for Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe (SDR-PR)

2.2 NSF Standards:³

Standard No. 14 for Plastic Piping Components and Related Materials

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

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 poly(vinyl chloride) plastic is PVC.

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,⁴ is used in this specification to relate standard dimension ratio, hydrostatic design stress, and pressure rating:

$$2S/P = R - 1 \text{ or } 2S/P = (D_0/t) - 1 \quad (1)$$

where:

S = hydrostatic design stress, psi (or MPa),
 P = pressure rating, psi (or MPa),
 D_0 = average outside diameter, in. (or mm),
 t = minimum wall thickness, in. (or mm), and
 R = standard thermoplastic pipe dimension ratio (D_0/t for PVC pipe), also known as SDR.

3.2.4 *standard thermoplastic pipe dimension ratio (SDR)*—the ratio of pipe diameter to wall thickness. For PVC pipe it is calculated by dividing the average outside diameter of the pipe in inches or millimetres by the minimum wall thickness in inches or millimetres. If the wall thickness calculated by this formula is less than 0.060 in. (1.52 mm), it shall be arbitrarily increased to 0.060 in. (1.52 mm). The SDR values shall be rounded to the nearest 0.5.

3.2.5 *standard thermoplastic pipe materials designation code*—The pipe materials designation code shall consist of the

abbreviation PVC for the type of plastic, followed by the ASTM type and grade in Arabic numerals and the design stress in units of 100 psi (0.7 MPa) with any decimal figures dropped. When the design stress code contains less than two figures, a cipher shall be used before the number, thus a complete material code shall consist of three letters and four figures for PVC plastic pipe materials.

4. Classification

4.1 *General*—This specification covers PVC pipe made and marked with one of six Type/Grade/Design Stress designations (see **X1.2**) in eleven standard dimension ratios.

4.2 *Standard Thermoplastic Pipe Dimension Ratios (SDR)*—This specification covers PVC pipe in eleven standard dimension ratios, namely, 13.5, 17, 21, 26, 32.5, 41, and 64 (in the body of the document) and 11, 35, 51 and 81 (in **Annex A1**.) Standard dimension ratios are uniform for all nominal pipe sizes for each material and pressure rating. These are referred to as SDR 11, SDR13.5, SDR17, SDR21, SDR26, SDR32.5, SDR35, SDR41, SDR51, SDR64, and SDR81, respectively. The pressure rating is uniform for all nominal pipe sizes for a given PVC pipe material and SDR (see **Table X1.1**).

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

5. Materials

5.1 *General*—Poly(vinyl chloride) 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.

NOTE 6—The PVC pipe 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 NSF **Standard No. 14**. The seal or mark of the laboratory making the evaluation should be included on the pipe. See pipe marking requirement for reclaimed water systems.

5.2 *Basic Materials*—This specification covers pipe made from PVC plastics having certain physical and chemical properties as described in Specification **D 1784**.

5.3 *Compound*—The PVC compounds used for this pipe shall equal or exceed one of the following classes described in Specification **D 1784**: PVC 12454 or 14333.

5.4 *Rework Material*—The manufacturer shall use only his own clean rework pipe material and the pipe produced shall meet all the requirements of this specification.

6. Requirements Requirements

6.1 Dimensions and Tolerances:

6.1.1 *Outside Diameters*—The outside diameters and tolerances shall be as shown in **Table 1** when measured in accordance with Test Method **D 2122**. The tolerances for out-of-roundness shall apply only on pipe prior to shipment.

³ Available from NSF International, P.O. Box 130140, 789 N. Dixboro Rd., Ann Arbor, MI 48113-0140.

⁴ ISO R161–1960, Pipes of Plastics Materials for the Transport of Fluids (Outside Diameters and Nominal Pressures) Part 1, Metric Series.

TABLE 1 IPS PVC Pipe—Outside Diameters and Tolerances

Nominal Pipe Size, in.	Average Outside Diameter, in. (mm)	For Average	Tolerances, in. (mm)	
			Maximum Out-of-Roundness (Maximum – Minimum Diameter)	
			SDR64, SDR41, SDR32.5, SDR26, SDR21	SDR17, SDR13.5
1/8	0.405 (10.29)	±0.004 (0.10)	0.030 (0.76)	0.016 (0.41)
1/4	0.540 (13.72)	±0.004 (0.10)	0.030 (0.76)	0.016 (0.41)
3/8	0.675 (17.14)	±0.004 (0.10)	0.030 (0.76)	0.016 (0.41)
1/2	0.840 (21.34)	±0.004 (0.10)	0.030 (0.76)	0.016 (0.41)
3/4	1.050 (26.67)	±0.004 (0.10)	0.030 (0.76)	0.020 (0.51)
1	1.315 (33.40)	±0.005 (0.13)	0.030 (0.76)	0.020 (0.51)
1 1/4	1.660 (42.16)	±0.005 (0.13)	0.030 (0.76)	0.024 (0.61)
1 1/2	1.900 (48.26)	±0.006 (0.15)	0.060 (1.52)	0.024 (0.61)
2	2.375 (60.32)	±0.006 (0.15)	0.060 (1.52)	0.024 (0.61)
2 1/2	2.875 (73.02)	±0.007 (0.18)	0.060 (1.52)	0.030 (0.76)
3	3.500 (88.90)	±0.008 (0.20)	0.060 (1.52)	0.030 (0.76)
3 1/2	4.000 (101.60)	±0.008 (0.20)	0.100 (2.54)	0.030 (0.76)
4	4.500 (114.30)	±0.009 (0.23)	0.100 (2.54)	0.030 (0.76)
5	5.563 (141.30)	±0.010 (0.25)	0.100 (2.54)	0.060 (1.52)
6	6.625 (168.28)	±0.011 (0.28)	0.100 (2.54)	0.070 (1.78)
8	8.625 (219.08)	±0.015 (0.38)	0.150 (3.81)	0.090 (2.29)
10	10.750 (273.05)	±0.015 (0.38)	0.150 (3.81)	0.100 (2.54)
12	12.750 (323.85)	±0.015 (0.38)	0.150 (3.81)	0.120 (3.05)
14	14.000 (355.60)	±0.015 (0.38)	0.200 (5.08)	0.150 (3.81)
16	16.000 (406.40)	±0.019 (0.48)	0.320 (8.13)	0.160 (4.06)
18	18.000 (457.20)	±0.019 (0.48)	0.360 (9.14)	0.180 (4.57)
20	20.000 (508.00)	±0.023 (0.58)	0.400 (10.2)	0.200 (5.08)
24	24.000 (609.60)	±0.031 (0.79)	0.480 (12.2)	0.240 (6.10)
30	30.000 (762.00)	±0.041 (1.04)	0.600 (15.2)	0.300 (7.62)
36	36.000 (914.40)	±0.050 (1.27)	0.720 (18.3)	0.360 (9.14)

6.1.2 *Wall Thickness*—The wall thicknesses and tolerances shall be as shown in **Table 2** when measured in accordance with Test Method **D 2122**.

6.2 *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 3** when tested in accordance with **8.4**.

6.2.1 *Accelerated Regression Test*—The accelerated regression test shall be used in place of both the sustained and burst pressure tests, at the option of the manufacturer. The test shall be conducted in accordance with **8.4.1**. The pipe shall demonstrate a hydrostatic design basis projection at the 100 000-h intercept that meets the hydrostatic design basis category requirement (see the table for “Hydrostatic Design Basis Categories” of Test Method **D 2837**) for the PVC material used in its manufacture. (*Example*: PVC 1120 pipe must have a minimum 100 000-h projection of 3830 psi and 85 % lower confidence limit (LCL).)

6.3 *Burst Pressure*—The minimum burst pressures for PVC plastic pipe shall be as given in **Table 4**, when determined in accordance with **8.5**.

6.4 *Flattening*—There shall be no evidence of splitting, cracking, or breaking when the pipe is tested in accordance with **8.6**.

6.5 *Extrusion Quality*—The pipe shall not flake or disintegrate when tested in accordance with Test Method **D 2152**.

6.6 *Impact Resistance*—The minimum impact resistance for PVC plastic pipe shall be as given in **Table 5**, when determined in accordance with **8.7**.

NOTE 7—The impact resistance test is intended for use only as a quality control test, not as a simulated service test. This test has been found to have no quality control significance in sizes over 12 in. (305 mm).

7. Workmanship, Finish, and Appearance

7.1 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.

NOTE 8—Color and transparency or opacity should be specified in the contract or purchase order.

8. Test Methods

8.1 *Conditioning*—Condition the test specimens at $73.4 \pm 3.6^\circ\text{F}$ ($23 \pm 2^\circ\text{C}$) and $50 \pm 5\%$ 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.

8.2 *Test Conditions*—Conduct the tests in the standard laboratory atmosphere of $73.4 \pm 3.6^\circ\text{F}$ ($23 \pm 2^\circ\text{C}$) and $50 \pm 5\%$ relative humidity, unless otherwise specified in the test methods or in this specification.

TABLE 2 Wall Thicknesses and Tolerances for PVC Plastic Pipe with IPS Outside Diameters

Nominal Pipe Size, in.	Wall Thickness, ^A in. ^B													
	SDR64		SDR41		SDR32.5		SDR26		SDR21		SDR17		SDR13.5	
	Minimum	Tolerance	Minimum	Tolerance	Minimum	Tolerance	Minimum	Tolerance	Minimum	Tolerance	Minimum	Tolerance	Minimum	Tolerance
1/8	...	...	...	...	...	...	...	...	...	...	...	...	0.060	+0.020
1/4	...	...	...	...	...	...	...	...	...	...	...	...	0.060	+0.020
3/8	...	...	...	...	...	...	...	...	...	...	...	...	0.060	+0.020
1/2	...	...	...	...	...	...	...	...	...	...	...	...	0.062	+0.020
3/4	...	...	...	...	...	...	...	...	0.060	+0.020	0.062	+0.020	0.078	+0.020
1	...	...	...	...	...	...	0.060	+0.020	0.063	+0.020	0.077	+0.020	0.097	+0.020
1 1/4	...	...	...	...	0.060	+0.020	0.064	+0.020	0.079	+0.020	0.098	+0.020	0.123	+0.020
1 1/2	...	...	...	...	0.060	+0.020	0.073	+0.020	0.090	+0.020	0.112	+0.020	0.141	+0.020
2	...	...	...	...	0.073	+0.020	0.091	+0.020	0.113	+0.020	0.140	+0.020	0.176	+0.020
2 1/2	...	...	...	...	0.088	+0.020	0.110	+0.020	0.137	+0.020	0.169	+0.020	0.213	+0.026
3	...	...	0.085	+0.020	0.108	+0.020	0.135	+0.020	0.167	+0.020	0.206	+0.025	0.259	+0.031
3 1/2	...	...	0.098	+0.020	0.123	+0.020	0.154	+0.020	0.190	+0.023	0.235	+0.028	0.296	+0.036
4	0.070	+0.020	0.110	+0.020	0.138	+0.020	0.173	+0.020	0.214	+0.026	0.265	+0.032	0.333	+0.040
5	0.087	+0.020	0.136	+0.020	0.171	+0.021	0.214	+0.027	0.265	+0.032	0.327	+0.039	0.412	+0.049
6	0.104	+0.020	0.162	+0.020	0.204	+0.024	0.255	+0.031	0.316	+0.038	0.390	+0.047	0.491	+0.059
8	0.135	+0.020	0.210	+0.025	0.265	+0.032	0.332	+0.040	0.410	+0.049	0.508	+0.061	...	...
10	0.168	+0.020	0.262	+0.031	0.331	+0.040	0.413	+0.050	0.511	+0.061	0.632	+0.076	...	...
12	0.199	+0.024	0.311	+0.037	0.392	+0.047	0.490	+0.059	0.606	+0.073	0.750	+0.090	...	...
14	...	...	0.341	+0.048	0.430	+0.052	0.538	+0.064	0.666	+0.080	0.823	+0.099	...	...
16	...	...	0.390	+0.055	0.492	+0.059	0.615	+0.074	0.762	+0.091	0.941	+0.113	...	...
18	...	...	0.439	+0.061	0.554	+0.066	0.692	+0.083	0.857	+0.103	1.059	+0.127	...	...
20	...	...	0.488	+0.068	0.615	+0.074	0.769	+0.092	0.952	+0.114	1.176	+0.141	...	...
24	...	...	0.585	+0.082	0.738	+0.088	0.923	+0.111	1.143	+0.137	1.412	+0.169	...	...
30	...	...	0.732	+0.102	0.923	+0.111	1.154	+0.138	1.428	+0.171	1.765	+0.212	...	...
36	...	...	0.878	+0.123	1.108	+0.133	1.385	+0.166	1.714	+0.205	2.118	+0.254	...	...

^A 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.

^B 1 in. = 25.4 mm (exact).

TABLE 3 Sustained Pressure Test Conditions for Water at 73°F (23°C) for PVC Plastic Pipe

SDR	Pressure ^A Required for Test							
	PVC 1120, PVC 1220, PVC 2120		PVC 2116		PVC 2112		PVC 2110	
	psi	MPa (bar)	psi	MPa (bar)	psi	MPa (bar)	psi	MPa (bar)
13.5	670	4.62 (46.2)	540	3.72 (37.2)	450	3.10 (31.0)	370	2.55 (25.5)
17	530	3.65 (36.5)	420	2.90 (29.0)	350	2.41 (24.1)	290	2.00 (20.0)
21	420	2.90 (29.0)	340	2.34 (23.4)	280	1.93 (19.3)	230	1.59 (15.9)
26	340	2.34 (23.4)	270	1.86 (18.6)	220	1.52 (15.2)	180	1.24 (12.4)
32.5	270	1.86 (18.6)	210	1.45 (14.5)	180	1.24 (12.4)	150	1.03 (10.3)
41	210	1.45 (14.5)	170	1.17 (11.7)	140	0.97 (9.7)	120	0.83 (8.3)
64	130	0.90 (9.0)	110	0.76 (7.6)	90	0.62 (6.2)	70	0.48 (4.8)

^A The fiber stresses used to derive these test pressures are as follows:

	psi	MPa (bar)
PVC 1120, PVC 1220, PVC 2120	4200	29.0 (290)
PVC 2116	3360	23.2 (232)
PVC 2112	2800	19.3 (193)
PVC 2110	2300	15.9 (159)

Some minor adjustments have been made to keep the test pressures uniform to simplify testing.

8.3 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.

8.3.1 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.

8.4 Sustained Pressure Test—Select the test specimens at random. Test individually with water at the internal pressures given in **Table 3**, six specimens of pipe, 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 bearing the permanent marking on the pipe. Maintain the specimens at the pressure indicated for a period of 1000 h. Hold the pressure as closely as possible, but within ±10 psi (±70 kPa). Condition the specimens at the test temperature of 73.4°F (23°C) to within ±3.6°F (2°C). Maintain the test temperature at 73.4 ± 3.6°F (23 ± 2°C). Test in accordance with Test Method **D 1598**, except maintain the pressure at the values given in **Table 3** for 1000 h. Failure of two of the six specimens tested shall constitute failure in the test. Failure of one of the six specimens tested is cause for