



Standard Specification for Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe, Schedules 40 and 80¹

This standard is issued under the fixed designation F441/F441M; 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 chlorinated poly(vinyl chloride) (CPVC) pipe made in Schedule 40 and 80 sizes and pressure-rated for water (see appendix). Included are criteria for classifying CPVC plastic pipe materials and CPVC plastic pipe, a system of nomenclature for CPVC 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.

NOTE 1—The CPVC pipe covered by this specification was covered previously in Specification D1785.

NOTE 2—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 2 in. [50 mm] and smaller. However, tests on larger pipe have shown these stress values to be valid.

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 3—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.

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 either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system may not be exact equivalents; therefore, each

system shall be used independently of the other. Combining values from the two systems may result in non-conformance with the standard.

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.

2. Referenced Documents

2.1 ASTM Standards:²

- D618 Practice for Conditioning Plastics for Testing
- 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
- D1784 Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds
- D1785 Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120
- D2122 Test Method for Determining Dimensions of Thermoplastic Pipe and Fittings
- D2837 Test Method for Obtaining Hydrostatic Design Basis for Thermoplastic Pipe Materials or Pressure Design Basis for Thermoplastic Pipe Products
- F412 Terminology Relating to Plastic Piping Systems

2.2 Federal Standard:

- Fed. Std. No. 123 Marking for Shipment (Civil Agencies)³

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 June 1, 2013. Published June 2013. Originally approved in 1974. Last previous edition approved in 2012 as F441–12. DOI: 10.1520/F0441_F0441M-13.

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.

³ Available from Standardization Documents Order Desk, DODSSP, Bldg. 4, Section D, 700 Robbins Ave., Philadelphia, PA 19111-5098, <http://www.dodssp.daps.mil>.

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

2.3 Military Standard:

MIL-STD-129 Marking for Shipment and Storage³

2.4 NSF Standards:

Standard No. 14 for Plastic Piping Components and Related Materials⁴

Standard No. 61 for Drinking Water Systems Components—Health Effects⁴

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 chlorinated poly(vinyl chloride) is CPVC.

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 dimensions, design stress, and pressure rating*—The following expression, commonly known as the ISO equation,⁵ is used in this specification to relate dimensions, hydrostatic design stress, and pressure rating:

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

where:

S = hydrostatic design stress, psi [MPa],

P = pressure rating, psi [MPa],

D_o = average outside diameter, in. [mm], and

t = minimum wall thickness, in. [mm].

3.2.4 *standard thermoplastic pipe materials designation code*—The pipe materials designation code shall consist of the abbreviation CPVC for the type of plastic, followed by the ASTM type and grade in Arabic numerals and the design stress at 73°F [23°C] in units of 100 psi [0.7 MPa] with any decimal figures dropped, followed by the design stress at 180°F [82°C] 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 four letters and six figures for CPVC plastic pipe materials (see Section 5).

4. Classification

4.1 *General*—This specification covers CPVC pipe made from one (see **X1.2**) CPVC plastic pipe material in Schedule 40 and 80 sizes.

4.2 *Hydrostatic Design Stresses*—This specification covers CPVC pipe made from CPVC plastic as defined by hydrostatic

design stresses which have been developed on the basis of long-term tests (see appendix).

NOTE 4—This specification does not include requirements for pipe fittings intended to be used to vent combustion gases.

5. Materials

5.1 *General*—Chlorinated 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 hydrostatic strength tests at both 73 and 180°F [23 and 82°C].

5.2 Basic Materials:

5.2.1 *Basic Materials – Short-term Tests*—This specification covers pipe made from CPVC plastics having certain physical properties as described in Specification **D1784**.

5.2.1.1 *Compound*—The CPVC compounds used for this pipe shall equal or exceed the classification 23447 described in Specification **D1784**.

5.2.2 *Basic Materials – Long-term Test*—This specification covers pipe made from CPVC plastics having certain Hydrostatic Design Bases (HDB) and Hydrostatic Design Stresses (HDS) described in Test Method **D2837**.

5.2.2.1 *Compound*—The CPVC compounds used for this pipe shall have a Hydrostatic Design Basis at 73°F [23°C] of 4000 psi [28 MPa], , and a Hydrostatic Design Basis at 180°F [82°C] of either 1000 psi [7.0 MPa] or 1250 psi [8.6 MPa] when evaluated in accordance with Test Method **D2837**.

5.2.3 *Standard thermoplastic pipe materials designation*—The pipe materials designation shall consist of the material designation code CPVC 4120-05 or CPVC 4120-06 for the type of plastic.

NOTE 5—As per Terminology **F412** (see, “code, thermoplastic pipe materials designation”) the pipe materials designation code CPVC 4120 is as follows: CPVC is the abbreviation for chlorinated poly(vinyl chloride) as per Terminology **D1600**, 41 represents Cell Classification 23447 per Specification **D1784**, and 20 represents a HDS of 2000 psi [14 MPa] for water at 73°F (23°C) per Test Method **D2837**. In addition, the -05 or -06 suffix represents a HDS of 500 psi [3.4 MPa] or 625 psi [4.3 MPa] respectively for water at 180°F [82°C] per Test Method **D2837**.

5.3 *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 Dimensions and Tolerances:

6.1.1 Dimensions and tolerances shall be as shown in **Table 1** and **Table 2** when measured in accordance with Test Method **D2122**. The tolerances for out-of-roundness shall apply only to pipe prior to shipment.

6.1.2 *Wall Thickness Range*—The wall thickness range shall not exceed 12 % when measured in accordance with Test Method **D2122**.

6.2 *Sustained Pressure*—The pipe shall not fail, balloon, burst, or weep as defined in Test Method **D1598**, 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

⁴ Available from NSF International, P.O. Box 130140, 789 N. Dixboro Rd., Ann Arbor, MI 48113-0140, <http://www.nsf.org>.

⁵ ISO R 161-1960, Pipes of Plastics Materials for the Transport of Fluids (Outside Diameters and Nominal Pressures) Part 1, Metric Series.

TABLE 1 Outside Diameters and Tolerances for CPVC Plastic Pipe, Schedules 40 and 80, in. [mm]

Nominal Pipe Size	Outside Diameter	Tolerances	
		Maximum Out-of-Roundness (maximum minus minimum diameter)	
		Schedule 40 sizes 3½ in. and over; Schedule 80 sizes 8 in. and over	Schedule 40 sizes 3 in. and less; Schedule 80 sizes 6 in. and less
¼ [8]	0.540 [13.7]	±0.004 [0.10]	...
⅜ [10]	0.675 [17.1]	±0.004 [0.10]	...
½ [15]	0.840 [21.3]	±0.004 [0.10]	...
¾ [20]	1.050 [26.7]	±0.004 [0.10]	...
1 [25]	1.315 [33.4]	±0.005 [0.13]	...
1¼ [32]	1.660 [42.2]	±0.005 [0.13]	...
1½ [40]	1.900 [48.3]	±0.006 [0.15]	...
2 [50]	2.375 [60.3]	±0.006 [0.15]	...
2½ [65]	2.875 [73.0]	±0.007 [0.18]	...
3 [80]	3.500 [88.9]	±0.007 [0.18]	...
3½ [90]	4.000 [101.6]	±0.008 [0.20]	0.100 (2.54)
4 [100]	4.500 [114.3]	±0.008 [0.20]	0.100 (2.54)
5 [125]	5.563 [141.3]	±0.010 [0.25]	0.100 (2.54)
6 [150]	6.625 [168.3]	±0.011 [0.28]	0.100 (2.54)
8 [200]	8.625 [219.1]	±0.015 [0.38]	0.150 (3.81)
10 [250]	10.750 [273.1]	±0.015 [0.38]	0.150 (3.81)
12 [300]	12.750 [323.9]	±0.015 [0.38]	0.150 (3.81)
14 [350]	14.000 [355.6]	±0.015 [0.380]	0.200 (5.08)
16 [400]	16.000 [406.4]	±0.019 [0.480]	0.320 (8.13)

TABLE 2 Wall Thicknesses and Tolerances for CPVC Plastic Pipe, Schedules 40 and 80, in.^{A,B} [mm]

Nominal Pipe Size	Wall Thickness ^A			
	Schedule 40		Schedule 80	
	Min	Tolerance	Min	Tolerance
¼ [8]	0.088 [2.24]	+0.020 [0.51]	0.119 [3.02]	+0.020 [0.51]
⅜ [10]	0.091 [2.31]	+0.020 [0.51]	0.126 [3.20]	+0.020 [0.51]
½ [15]	0.109 [2.77]	+0.020 [0.51]	0.147 [3.73]	+0.020 [0.51]
¾ [20]	0.113 [2.87]	+0.020 [0.51]	0.154 [3.91]	+0.020 [0.51]
1 [25]	0.133 [3.38]	+0.020 [0.51]	0.179 [4.55]	+0.021 [0.53]
1¼ [32]	0.140 [3.56]	+0.020 [0.51]	0.191 [4.85]	+0.023 [0.58]
1½ [40]	0.145 [3.68]	+0.020 [0.51]	0.200 [5.08]	+0.024 [0.61]
2 [50]	0.154 [3.91]	+0.020 [0.51]	0.218 [5.54]	+0.026 [0.66]
2½ [65]	0.203 [5.16]	+0.024 [0.61]	0.276 [7.01]	+0.033 [0.84]
3 [80]	0.216 [5.49]	+0.026 [0.66]	0.300 [7.62]	+0.036 [0.91]
3½ [90]	0.226 [5.74]	+0.027 [0.68]	0.318 [8.08]	+0.038 [0.96]
4 [100]	0.237 [6.02]	+0.028 [0.71]	0.337 [8.56]	+0.040 [1.02]
5 [125]	0.258 [6.55]	+0.031 [0.79]	0.375 [9.52]	+0.045 [1.14]
6 [150]	0.280 [7.11]	+0.034 [0.86]	0.432 [10.97]	+0.052 [1.32]
8 [200]	0.322 [8.18]	+0.039 [0.99]	0.500 [12.70]	+0.060 [1.52]
10 [250]	0.365 [9.27]	+0.044 [1.12]	0.593 [15.06]	+0.071 [1.80]
12 [300]	0.406 [10.31]	+0.049 [1.24]	0.687 [17.45]	+0.082 [2.08]
14 [350]	0.437 [11.10]	+0.053 [+1.35]	0.750 [19.05]	+0.090 [+2.29]
16 [400]	0.500 [12.70]	+0.060 [+1.52]	0.843 [21.14]	+0.101 [+2.57]

^A The minimum is the lowest wall thickness of the pipe at any cross section. All tolerances are on the plus side of the minimum requirement.

^B These dimensions conform to nominal IPS dimensions.

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 Table 1, Test Method D2837) for the CPVC material used in its manufacture. If the lower confidence value at 100 000 h differs from the extrapolated LTHS value by more than 15 % of the latter; or *M* in Appendix X2 (Test Method D2837) is zero or negative; or *b* in the equation $h = a + bf$ in Appendix X1 (Test Method D2837) is positive, consider the data unsuitable.

6.3 *Burst Pressure*—The minimum burst pressures for CPVC plastic pipe shall be as given in Table 4, when determined in accordance with Test Method D1599.

6.4 *Flattening*—There shall be no evidence of splitting, cracking, or breaking when the pipe is tested in accordance with 8.5.

7. Workmanship, Finish, and Appearance

7.1 The pipe shall be homogeneous throughout and free from visible cracks, holes, foreign inclusions, or other defects.

TABLE 3 Sustained Pressure Test Conditions for Water at 73°F [23°C] for CPVC 4120 Plastic Pipe, Schedules 40 and 80

Nominal Pipe Size	Pressure Required for Test ^A			
	Schedule 40		Schedule 80	
	psi	[kPa]	psi	[kPa]
¼ [8]	1640	[11 310]	2370	[16 340]
⅜ [10]	1310	[9 030]	1930	[13 310]
½ [15]	1250	[8 620]	1780	[12 270]
¾ [20]	1010	[6 960]	1440	[9 930]
1 [25]	950	[6 550]	1320	[9 100]
1¼ [32]	770	[5 310]	1090	[7 520]
1½ [40]	690	[4 760]	990	[6 830]
2 [50]	580	[4 000]	850	[5 860]
2½ [65]	640	[4 410]	890	[6 140]
3 [80]	590	[4 070]	790	[5 450]
3½ [90]	500	[3 450]	730	[5 030]
4 [100]	470	[3 240]	680	[4 690]
5 [125]	410	[2 830]	610	[4 210]
6 [150]	370	[2 550]	590	[4 070]
8 [200]	330	[2 280]	520	[3 590]
10 [250]	300	[2 070]	490	[3 380]
12 [300]	280	[1 930]	480	[3 310]
14 [350]	270	[1 890]	470	[3 290]
16 [400]	270	[1 890]	470	[3 290]

^A The fiber stress used to derive these test pressures is 4200 psi [29.0 MPa].

TABLE 4 Burst Pressure Requirements for Water at 73°F [23°C] for CPVC 4120 Plastic Pipe, Schedules 40 and 80

Nominal Pipe Size	Minimum Burst Pressure ^A			
	Schedule 40		Schedule 80	
	psi	[kPa]	psi	[kPa]
¼ [8]	2490	[17 170]	3620	[24 960]
⅜ [10]	1990	[13 720]	2940	[20 270]
½ [15]	1910	[13 170]	2720	[18 760]
¾ [20]	1540	[10 620]	2200	[15 170]
1 [25]	1440	[9 930]	2020	[13 930]
1¼ [32]	1180	[8 140]	1660	[11 450]
1½ [40]	1060	[7 310]	1510	[10 410]
2 [50]	890	[6 140]	1290	[8 890]
2½ [65]	970	[6 690]	1360	[9 380]
3 [80]	840	[5 790]	1200	[8 270]
3½ [90]	770	[5 310]	1110	[7 650]
4 [100]	710	[4 900]	1040	[7 170]
5 [125]	620	[4 270]	930	[6 410]
6 [150]	560	[3 860]	890	[6 140]
8 [200]	500	[3 450]	790	[5 450]
10 [250]	450	[3 100]	750	[5 170]
12 [300]	420	[2 900]	730	[5 030]
14 [350]	410	[2 870]	720	[5 040]
16 [400]	410	[2 870]	710	[4 970]

^A The fiber stress used to derive these test pressures is 6400 psi [44.1 MPa].

relative humidity, unless otherwise specified in the test methods or in this specification.

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 [± 69 kPa]. Condition the specimens at the test temperature of $73 \pm 3.6^\circ\text{F}$ [$23 \pm 2^\circ\text{C}$]. Test in accordance with Test Method **D1598**, except maintain the pressure at the values given in **Table 3** for 1000 h. Evidence of failure of the pipe shall be as defined in Test Method **D1598**.

8.4.1 *Accelerated Regression Test*—Test in accordance with procedures in Test Method **D1598**, using either free end or restrained end fittings. A minimum of six specimens shall be tested. Test three specimens at a single pressure that will result in failures at or below 0.10 h. Test an additional three specimens at a single pressure that will result in failures at about 200 h. Additional data points may be generated if necessary to improve the LTHS or LCL, or both. No points shall be excluded unless an obvious defect is detected in the failure area of the test sample, or there was an obvious malfunction of the test equipment. Characterize the data using the least-squares regression described in Test Method **D2837**.

NOTE 7—**Caution:** Since the rupture of the test specimen is expected in quick burst and high stress regression testing, well shielded test equipment and protective personal equipment should be used when conducting the tests.

8.5 *Flattening*—Flatten three specimens of the pipe, 2 in. [50 mm] long, between parallel plates in a suitable press until the distance between the plates is 40 % of the outside diameter of the pipe or the walls of the pipe touch, whichever occurs first. The rate of loading shall be uniform and such that the compression is completed within 2 to 5 min. On removal of the load examine the specimens for evidence of splitting, cracking, or breaking.

9. Retest and Rejection

9.1 If the results of any test(s) do not meet the requirements of this specification, the test(s) shall be conducted again only by agreement between the purchaser and the seller. Under such agreement, minimum requirements shall not be lowered, changed, or modified, nor shall specification limits be changed. If upon retest, failure occurs, the quantity of product represented by the test(s) does not meet the requirements of this specification.

The pipe shall be as uniform as commercially practicable in color, opacity, density, and other physical properties.

NOTE 6—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 ± 5 % relative humidity for not less than 40 h prior to test in accordance with Procedure A of Practice **D618**, for those tests where conditioning is required.

8.2 *Test Conditions*—Conduct tests in the standard laboratory atmosphere of $73 \pm 3.6^\circ\text{F}$ [$23 \pm 2^\circ\text{C}$] and 50 ± 5 %