Designation: F949 – 15

Standard Specification for Poly(Vinyl Chloride) (PVC) Corrugated Sewer Pipe With a Smooth Interior and Fittings[1]

This standard is issued under the fixed designation F949; 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 U.S. Department of Defense.

1. Scope*

1.1 This specification covers requirements, test methods, and materials for 4 to 48 in. diameter poly(vinyl chloride) (PVC) corrugated pipe with a smooth interior. This profile wall pipe consists of an outer corrugated wall fused to a smooth inner wall providing pipe stiffness levels of 46 psi and 115psi. Joints and fittings are included in this specification.

1.2 The requirements of this specification are intended to provide pipe and fittings suitable for underground use in nonpressure applications for sanitary sewers, storm sewers, and perforated and unperforated pipes for subdrainage.

NOTE 1—Industrial waste disposal lines should be installed only with the specific approval of the cognizant code authority, since chemicals not commonly found in drains and sewers and temperatures in excess of 140°F (60°C) may be encountered.

1.3 Pipe and fittings produced to this specification shall be installed in accordance with Practice D2321.

NOTE 2—For perforated pipe applications, the size of the embedment zone and permeability of the embedment material are important to the system's ability to provide the desired level of infiltration or exfiltration. The gradation of the embedment material must be compatible with the perforation slot size to avoid backfill migration into the pipe.

1.4 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.

1.5 The following precautionary caveat pertains only to the test method 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:*[2]

D618 Practice for Conditioning Plastics for Testing

D1600 Terminology for Abbreviated Terms Relating to Plastics

D1784 Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds

D2122 Test Method for Determining Dimensions of Thermoplastic Pipe and Fittings

D2152 Test Method for Adequacy of Fusion of Extruded Poly(Vinyl Chloride) (PVC) Pipe and Molded Fittings by Acetone Immersion

D2321 Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications

D2412 Test Method for Determination of External Loading Characteristics of Plastic Pipe by Parallel-Plate Loading

D2444 Test Method for Determination of the Impact Resistance of Thermoplastic Pipe and Fittings by Means of a Tup (Falling Weight)

D2564 Specification for Solvent Cements for Poly(Vinyl Chloride) (PVC) Plastic Piping Systems

D2855 Practice for Making Solvent-Cemented Joints with Poly(Vinyl Chloride) (PVC) Pipe and Fittings

D3034 Specification for Type PSM Poly(Vinyl Chloride) (PVC) Sewer Pipe and Fittings

D3212 Specification for Joints for Drain and Sewer Plastic Pipes Using Flexible Elastomeric Seals

F412 Terminology Relating to Plastic Piping Systems

F477 Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe

F679 Specification for Poly(Vinyl Chloride) (PVC) Large-Diameter Plastic Gravity Sewer Pipe and Fittings

F1057 Practice for Estimating the Quality of Extruded Poly (Vinyl Chloride) (PVC) Pipe by the Heat Reversion Technique

[1] This specification is under the jurisdiction of ASTM Committee F17 on Plastic Piping Systems and is the direct responsibility of Subcommittee F17.62 on Sewer.

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[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.

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

2.2 *American Water Works Association (AWWA) Document:*
AWWA Manual M45, Fiberglass Pipe Design[3]

2.3 *Federal Standard:*
Fed. Std. No. 123 Marking for Shipments (Civil Agencies)[4]

2.4 *Military Standard:*
MIL-STD-129 Marking for Shipment and Storage[4]

3. Terminology

3.1 Definitions are in accordance with Terminology F412 and abbreviations are in accordance with Terminology D1600, unless otherwise specified. The abbreviation for poly(vinyl chloride) plastic is PVC.

3.2 *parting line*—a slight mark or surface irregularity in the pipe or fitting surface as a result of a mold separation at that location.

4. Materials and Manufacture

4.1 *Material Specification*—The pipe shall be made of PVC compound having a minimum cell classification of 12454 in accordance with Specification D1784. The fittings shall be made of PVC compound having a cell classification of 12454, or 13343 as defined in Specification D1784. Compounds that have different cell classifications because one or more properties are superior to those of the specified compounds are also acceptable.

4.2 *Rework Material*—Clean rework material, generated from the manufacturer's own pipe or fitting production, or both, may be used by the same manufacturer provided that the rework material meets the requirements of 4.1 and that the pipe and fittings produced meet the requirements of this specification.

4.3 *Pipe* shall be manufactured by simultaneous extrusion of the smooth and corrugated walls with the smooth inner wall fused to the outer corrugated wall.

4.4 *Fittings* shall be molded or fabricated.

4.5 *Joining Materials:*

4.5.1 *Gaskets*—Elastomeric seals (gaskets) shall be in accordance with the requirements of Specification F477.

4.5.2 *Lubricant*—The lubricant used for assembly shall be as recommended by the manufacturer and shall have no detrimental effect on the gasket or on the pipe and fittings.

4.5.3 *Solvent Cement*—The PVC cement shall comply with Specification D2564. The solvent cement shall be used only for bushings and saddle connections (see Fig. 1).

5. Requirements

5.1 *Workmanship*—The pipe and fittings shall be homogeneous throughout and free from visible cracks, holes, foreign inclusions, or other injurious defects. The pipe shall be as uniform as commercially practical in color, opacity, density, and other physical properties. Slots deliberately placed in pipe for perforations for subdrainage, etc., applications are acceptable.

5.2 *Dimensions and Tolerances:*

5.2.1 *Pipe*—Pipe dimensions shall meet the requirements given in Table 1 when measured in accordance with 7.3.

5.2.2 *Sockets*—All sockets (bells), dimensions on pipe, and fittings shall meet the requirements given in Table 2 when measured in accordance with 7.4. In the case of belled pipe, the thickness of wall in the bell shall be considered satisfactory if the pipe meets the minimum thicknesses listed in Table 1.

5.2.3 *Fittings*—Molded fitting dimensions shall meet the requirements of Table 3 when measured in accordance with 7.4. The wall thickness of molded fittings shall meet the requirements given in Table 4, when measured in accordance with 7.4. Fittings may also be fabricated from pipe, meeting the requirements of this specification or from pipe meeting the requirements of Specification D3034 or F679. In the case of a fabricated fitting with a formed bell, the thickness of the bell shall be considered satisfactory if it was formed from pipe meeting the requirements of the standard to which the pipe was produced. For reducing fittings or those with smaller inlets, the minimum wall thickness of each inlet shall be no less than the minimum wall thickness for that size pipe.

5.2.4 *Perforations*—Perforation slots shall be clearly cut and uniformly spaced along the length of pipe. Slots shall be centered in the corrugation valleys. Dimensions and spacing of the slots shall be as listed in Table 5. Other slot dimensions and spacing may be provided to meet the needs of the specifier. Alternatively, where the valley is large enough to accommodate a suitably sized round hole perforation without penetrating the void under the corrugation, round hole perforations of a size, pattern, and open area agreed upon by the specifier may be provided. All measurements shall be made in accordance with 7.9.

5.3 *Performance Requirements:*

5.3.1 *Pipe Stiffness*—Pipe stiffness shall be a minimum of 46 psi or 115 psi when tested in accordance with 7.5. Pipe stiffness shall be marked on pipe as per 11.2.3.

NOTE 3—This test is intended only for use as a quality control test and not as a simulated service test.

5.3.2 *Flattening*—There shall be no evidence of splitting, cracking, breaking, or separation of the two walls when the pipe is tested in accordance with 7.5 (see Note 4).

5.3.3 *Impact Strength*—Pipe shall have the minimum impact strengths listed in Table 6, when tested in accordance with 7.6. Failure of the test specimen shall be any crack, split, or shattering of either the waterway or corrugation wall. Separation of the ribs of the exterior corrugation from the waterway wall constitutes a failure.

NOTE 4—This test is intended only for use as a quality control test at time of manufacture, and not as a simulated service test.

5.3.4 *Extrusion Quality:*

5.3.4.1 *Acetone Immersion*—The pipe shall not flake, disintegrate, or exhibit separation of the two walls when tested in accordance with 7.7.1.

[3] Available from American Water Works Association (AWWA), 6666 W. Quincy Ave., Denver, CO 80235, http://www.awwa.org.

[4] DLA Document Services Building 4/D 700 Robbins Avenue Philadelphia, PA 19111-5094 http://quicksearch.dla.mil/

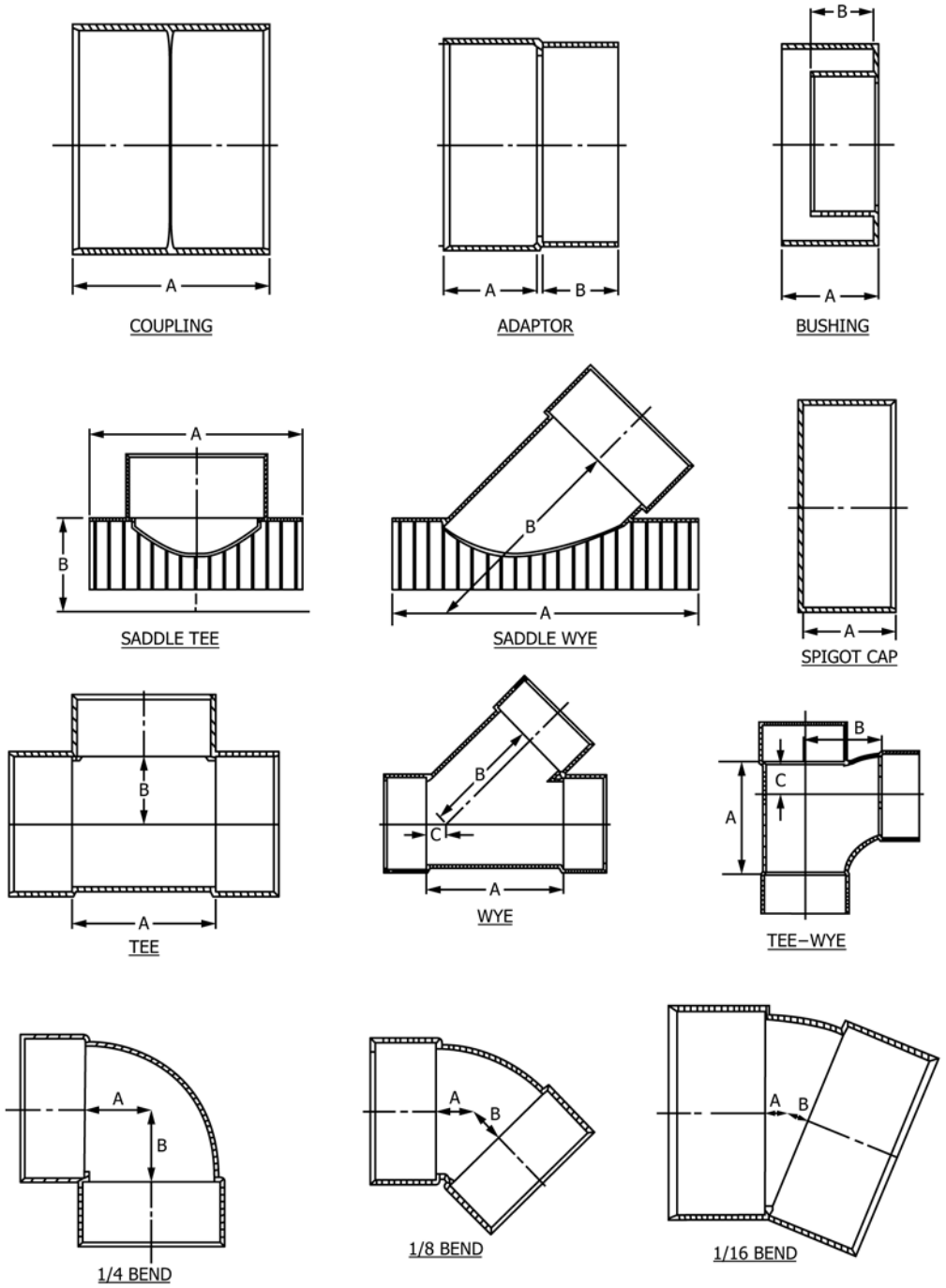


FIG. 1 Molded Fitting Dimensions (see Table 3)

5.3.4.2 *Heat Reversion*—The pipe shall not exhibit any of the effects listed in the suggested interpretation of results of Practice F1057 when tested in accordance with 7.7.2.

5.3.5 *Bond*—The bond between the inner and outer walls (at the corrugation valley) shall not separate when tested in accordance with 7.10.

5.4 *Joint Tightness*—Gasketed pipe joints shall show no leakage when tested in accordance with 7.8.

NOTE 5—Testing for joint tightness is not intended to be a routine quality control test. The test is used to qualify pipe and fitting joints at a specified level of performance.

6. Sampling

6.1 *Sampling*—The selection of the sample or samples of pipe and fittings shall be as agreed upon between the purchaser and the seller. In the case of no prior agreement, any samples selected by the testing laboratory shall be deemed adequate.

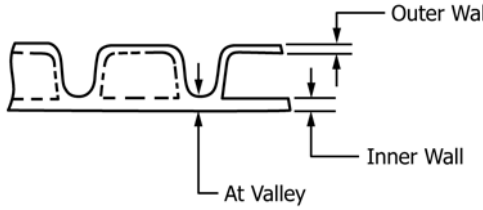
7. Test Methods

7.1 *Conditioning:*

7.1.1 *Referee Testing*—When conditioning is required for referee tests, condition the specimens in accordance with Procedure A of Practice D618 at 73.4 ± 3.6°F (23 ± 2°C) and

TABLE 1 Pipe Dimensions

NOTE 1—Other corrugation configurations, meeting the following dimensional requirements are permissible.



For Pipe Stiffness of 46 PSI

Nominal Size in.	Outside Diameter		Inside Diameter		Minimum Wall Thickness		
	Average, in. (mm)	Tolerance on Average, in. (mm)	Average, in. (mm)	Tolerance on Average, in. (mm)	Inner Wall, in. (mm)	Outer Wall, in. (mm)	At Valley, in. (mm)
4	4.300 (109.2)	±0.009 (±0.229)	3.950 (100.3)	±0.011 (±0.279)	0.022 (0.559)	0.018 (0.457)	0.028 (0.711)
6	6.420 (163.1)	±0.011 (±0.279)	5.909 (150.1)	±0.015 (±0.381)	0.025 (0.635)	0.022 (0.559)	0.032 (0.813)
8	8.600 (218.4)	±0.012 (±0.305)	7.881 (200.2)	±0.018 (±0.457)	0.035 (0.889)	0.030 (0.762)	0.045 (1.143)
10	10.786 (273.9)	±0.015 (±0.381)	9.846 (250.1)	±0.021 (±0.533)	0.045 (1.143)	0.036 (0.914)	0.055 (1.397)
12	12.795 (325.0)	±0.018 (±0.457)	11.715 (297.6)	±0.028 (±0.711)	0.058 (1.397)	0.049 (1.245)	0.072 (1.829)
15	15.658 (397.7)	±0.023 (±0.584)	14.338 (364.2)	±0.035 (±0.889)	0.077 (1.956)	0.055 (1.397)	0.092 (2.337)
18	19.152 (486.5)	±0.028 (±0.711)	17.552 (445.8)	±0.042 (±1.067)	0.084 (2.134)	0.067 (1.702)	0.103 (2.616)
21	22.630 (574.8)	±0.033 (±0.838)	20.705 (525.9)	±0.049 (±1.24)	0.095 (2.413)	0.073 (1.854)	0.110 (2.800)
24	25.580 (649.7)	±0.039 (±0.991)	23.469 (596.1)	±0.057 (±1.448)	0.110 (2.791)	0.085 (2.161)	0.123 (3.124)
27	28.860 (733.0)	±0.049 (±1.25)	26.440 (671.6)	±0.069 (±1.75)	0.120 (3.048)	0.091 (2.311)	0.137 (3.486)
30	32.150 (816.6)	±0.059 (±1.50)	29.469 (748.5)	±0.081 (±2.057)	0.130 (3.302)	0.105 (2.667)	0.147 (3.734)
36	38.740 (984.0)	±0.079 (±2.007)	35.475 (901.1)	±0.105 (±2.667)	0.150 (3.810)	0.125 (3.175)	0.171 (4.343)
42	45.800 (1163.3)	±0.093 (±2.36)	41.500 (1054.1)	±0.127 (±3.23)	0.160 (4.06)	0.135 (3.43)	0.188 (4.78)
48	52.800 (1341.1)	±0.108 (±2.74)	47.500 (1206.5)	±0.143 (±3.63)	0.165 (4.19)	0.140 (3.56)	0.195 (4.95)

For Pipe Stiffness of 115 PSI

Nominal Size	Outside Diameter		Inside Diameter		Minimum Wall Thickness		
	Average, in. (mm)	Tolerance on Average, in. (mm)	Average, in. (mm)	Tolerance on Average, in. (mm)	Inner Wall, in. (mm)	Outer Wall, in. (mm)	At Valley, in. (mm)
8	8.600 (218.4)	±0.012 (±0.305)	7.710 (195.8)	±0.018 (±0.457)	0.037 (0.940)	0.050 (1.270)	0.048 (1.219)
10	10.786 (273.9)	±0.015 (±0.381)	9.644 (245.0)	±0.021 (±0.533)	0.046 (1.295)	0.052 (1.320)	0.065 (1.651)
12	12.795 (325.0)	±0.018 (±0.457)	11.480 (291.6)	±0.028 (±0.711)	0.070 (1.778)	0.068 (1.727)	0.091 (2.311)
15	15.658 (397.7)	±0.023 (±0.584)	14.053 (356.97)	±0.035 (±0.889)	0.092 (2.337)	0.088 (2.235)	0.118 (2.997)

50 ± 10 % relative humidity for not less than 40 h prior to test. Conduct tests under the same conditions of temperature and humidity, unless otherwise specified.

7.1.2 *Quality Control Tests*—For quality control tests, condition the specimens for a minimum of 4 h in air or 1 h in water at 73.4 ± 3.6°F (23 ± 2°C). Test the specimens at 73.4 ± 3.6°F without regard to relative humidity.

7.2 *Test Conditions*—Conduct tests in the Standard Laboratory Atmosphere at 73.4 ± 3.6°F (23 ± 2°C) and 50 ± 5 % relative humidity, unless otherwise specified in the test methods or in this specification. In cases of disagreement, the tolerance shall be ±1.8°F (±1°C) and ±2 % relative humidity.

7.3 *Pipe Dimensions:*

7.3.1 *Pipe Diameters*—Measure the average outside diameter of the pipe in accordance with Test Method D2122 using a circumferential wrap tape accurate to ±0.001 in. (±0.02 mm). The average inside diameter may be calculated from the average outside diameter and wall thickness measurements in accordance with Test Method D2122.

7.3.2 *Wall Thickness*—Measure the wall thicknesses in accordance with Test Method D2122. Each specimen will need to be cut lengthwise into at least eight segments in order to obtain a minimum of eight measurements in accordance with Test Method D2122. Do not measure on a mold line.

7.3.3 Measure the length of pipe with a steel tape with precision of at least 1/16-in. (1-mm) graduations in accordance with Test Method D2122.

7.4 *Fitting Dimensions:*

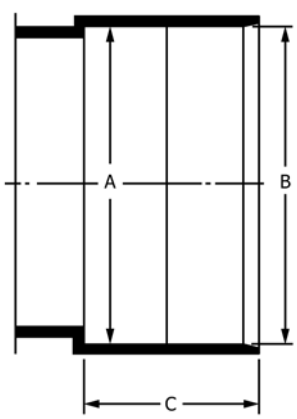
7.4.1 *Socket Diameters*—Measure the inside diameters of the sockets in accordance with Test Method D2122. Calculate the average inside diameters of the socket as the arithmetic mean of all of the diameters measured at each cross section.

7.4.2 *Socket Depth*—Measure the fittings socket depth using a good commercial quality scale calibrated in 1/32-in. (1-mm) increments in accordance with Test Method D2122.

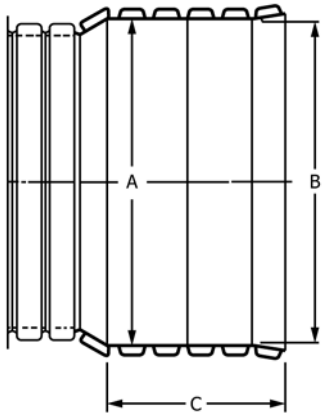
7.4.3 *Wall Thickness*—Measure the wall thickness in accordance with Test Method D2122. Make sufficient readings, a minimum of 8, to ensure that the minimum thickness has been determined. Use a ball anvil or a cylindrical anvil tubing micrometer accurate to ±0.001 in. (±0.02 mm).

7.4.4 *Laying Lengths*—Measure the laying length of molded fittings with a good commercial steel scale calibrated in 1/32-in. (1-mm) increments in accordance with Test Method D2122.

TABLE 2 Bell (Socket) Dimensions for Gasketed Joints



MOLDED SOCKET



INTEGRAL SOCKET

Nominal Diameter	A[A] in. (mm)	B[A] in. (mm)	C in. (mm)
4	4.362 ± 0.025 (110.79 ± 0.64)	4.372 ± 0.025 (111.05 ± 0.64)	1.75 (44.5)
6	6.492 ± 0.030 (164.90 ± 0.76)	6.512 ± 0.030 (165.40 ± 0.76)	2.75 (69.9)
8	8.680 ± 0.035 (220.47 ± 0.89)	8.700 ± 0.035 (220.98 ± 0.84)	3.75 (95.3)
10	10.876 ± 0.045 (276.26 ± 1.14)	10.900± 0.045 (276.86 ± 1.14)	4.75 (120.7)
12	12.873 ± 0.055 (326.97 ± 1.40)	12.898± 0.055 (327.61 ± 1.40)	5.75 (146.1)
15	15.751 ± 0.065 (400.08 ± 1.65)	15.776± 0.065 (400.71 ± 1.65)	6.75 (171.5)
18	19.260 ± 0.075 (489.20 ± 1.91)	19.285± 0.075 (489.84 ± 1.91)	6.75 (171.5)
21	22.751 ± 0.080 (577.88 ± 2.032)	22.781± 0.080 (578.64 ± 2.032)	8.5 (215.9)
24	25.758 ± 0.085 (654.25 ± 2.159)	25.788± 0.085 (655.02 ± 2.159)	8.5 (215.9)
27	29.058 ± 0.090 (738.07 ± 2.286)	29.088± 0.090 (738.84 ± 2.286)	8.5 (215.9)
30	32.368 ± 0.095 (822.15 ± 2.413)	32.398± 0.095 (822.91 ± 2.413)	8.5 (215.9)
36	38.998 ± 0.105 (990.55 ± 2.667)	39.028± 0.105 (991.31 ± 2.667)	8.5 (215.9)
42	45.965 ± 0.130 (1167.51 ± 3.3)	45.995 ± 0.130 (1168.27 ± 3.3)	12.5 (317.5)
48	52.970 ± 0.130 (1345.44 ± 3.3)	53.000 ± 0.130 (1346.20 ± 3.3)	15.9 (403.9)

[A] Some sockets, dependent on the method of the manufacturer, do not have taper on inside diameter of socket. Total bell inside diameter is equal to "A" dimension.

7.5 *Pipe Stiffness and Flattening:*

7.5.1 For purposes of conducting pipe stiffness and flattening tests, the pipe inside diameter shall be considered as the nominal diameter and the ΔY shall be the plate travel of the apparatus.

7.5.2 *Pipe Stiffness*—Determine the pipe stiffness at 5 % deflection in accordance with Test Method D2412. For diameters 4 through 18 in., test three specimens, each a minimum of 6 in. (152 mm) in length. For diameters 21 through 48 in., test three specimens, each a minimum of 12 in. (305 mm) in length. Specimens shall be cut in corrugation valley. All three specimens must pass.

NOTE 6—The 5 % deflection criterion that was arbitrarily selected for testing convenience should not be considered as a limitation with respect to in-use deflection. The engineer is responsible for establishing the acceptable deflection limit.

7.5.3 *Pipe Flattening*—Flatten three specimens between parallel plates until the distance between the plates, expressed as a % of the inside pipe diameter, is reduced by the value as determined by [3.43 (OD)/ (OD-ID)] for pipes with a 46 psi pipe stiffness or by the value as determined by [4.62 (OD)/ (OD-ID)] for pipes with a 115 psi pipe stiffness. OD and ID are the average outside and inside diameters of the pipe. (See Table 1.) The test specimens for pipes 4 through 18 in. in diameter shall be a minimum of 6 in. (152 mm) long. The specimens shall be a minimum of 12 in. (305 mm) long for larger

TABLE 3 Minimum Molded Fitting Dimensions (see Fig. 1)

NOTE 1—Fittings 10 in. and larger are typically fabricated. Contact the manufacturer for details on fittings. Bell dimensions meet the requirements of Table 2.

Fitting, in.	A in. (mm)	B in. (mm)	Fitting, in.	A in. (mm)	B in. (mm)	C in. (mm)
Couplings			Tees			
4	4.0 (102)		4 × 4 × 4	4.6 (117)	2.1 (53)	
6	6.0 (152)		6 × 6 × 4	6.7 (170)	3.1 (79)	
8	8.0 (203)		6 × 6 × 6	6.7 (170)	3.0 (7)	
10	10.0 (254)		8 × 8 × 4	8.5 (216)	5.0 (127)	
Saddle Tees			8 × 8 × 6	10.2 (259)	5.3 (135)	
6 × 4	8.0 (203)	3.3 (84)	8 × 8 × 8	9.0 (229)	4.1 (104)	
8 × 4	10.3 (262)	4.6 (117)	Wyes			
8 × 6	10.3 (262)	4.5 (114)	4 × 4 × 4	6.5 (165)	5.6 (142)	1.0 (25)
10 × 4	10.7 (272)	5.6 (137)	6 × 6 × 4	9.5 (241)	8.2 (208)	1.3 (33)
10 × 6	10.7 (272)	5.4 (137)	6 × 6 × 6	9.5 (241)	8.1 (206)	1.3 (33)
Saddle Wyes			8 × 8 × 4	11.5 (292)	7.5 (191)	0.7 (18)
6 × 4	9.0 (229)	6.5 (168)	8 × 8 × 6	13.3 (338)	8.0 (203)	1.7 (43)
8 × 4	14.5 (368)	10.3 (262)	8 × 8 × 8	17.0 (432)	8.3 (211)	3.5 (89)
8 × 6	14.5 (368)	10.2 (259)	Tee-Wye			
10 × 4	15.1 (384)	11.5 (292)	8 × 8 × 4	5.4 (137)	6.3 (160)	2.8 (71)
10 × 6	15.1 (384)	11.4 (290)	8 × 8 × 6	5.4 (137)	6.2 (157)	2.8 (71)
Spigot Caps			Bushing			
4	2.0 (51)		6 × 4	3.0 (76)	2.0 (51)	
6	3.0 (76)		8 × 6	4.0 (102)	3.0 (76)	
8	4.0 (102)		Adaptors			
10	5.0 (127)		4	2.0 (51)	2.0 (51)	
¼ Bend			6	3.0 (76)	2.5 (63)	
4	2.1 (53)	2.3 (58)				
6	3.1 (79)	2.4 (86)				
⅛ Bend						
4	1.1 (28)	1.1 (28)				
6	1.6 (41)	1.6 (41)				
8	2.2 (56)	2.2 (56)				
1⁄16 Bend						
4	0.5 (13)	0.5 (13)				
6	0.7 (18)	0.7 (18)				

TABLE 4 Molded Fittings

Nominal Diameter	Minimum Wall[A,B] Thickness, in.
4	0.120
6	0.180
8	0.240
10	0.300
12	0.360
15	0.437
18	0.499

[A] The skirts on saddle fittings have a minimum wall thickness of 0.180 in.
[B] The wall thickness is a minimum value except that a ±10 % variation resulting from core shift is allowable. In such a case, the average of two opposite wall thicknesses shall equal or exceed the value shown in the table.

TABLE 5 Perforation Dimensions[A]

Nominal Size, in.	Rows of Slots	Slot Size		Spacing, in. (mm)
		Maximum Width, in. (mm)	Length, in. (mm)	
4	2	0.125 (3.2)	1 1⁄16 ± ¼ (27.0 ± 6.4)	0.416 (10.49)
6	2	0.125 (3.2)	1⅜ ± ¼ (34.9 ± 6.4)	0.516 (13.11)
8	2	0.125 (3.2)	1¾ ± ¼ (44.5 ± 6.4)	0.689 (17.50)
10	2	0.125 (3.2)	2⅛ ± ¼ (54.0 ± 6.4)	0.826 (20.98)
12	2	0.125 (3.2)	1 11⁄16 ± ¼ (42.9 ± 6.4)	1.033 (26.24)
15	2	0.125 (3.2)	2¼ ± ¼ (57.1 ± 6.4)	1.377 (34.98)
18	2	0.125 (3.2)	2¼ ± ¼ (57.1 ± 6.4)	1.377 (34.98)
21	2	0.125 (3.2)	1¾ ± ¼ (44.5 ± 6.4)	1.897 (48.18)
24	2	0.125 (3.2)	1¾ ± ¼ (44.5 ± 6.4)	1.897 (48.18)
27	2	0.125 (3.2)	2 3⁄16 ± ¼ (55.6± 6.4)	2.318 (58.88)
30	2	0.125 (3.2)	2 3⁄16 ± ¼ (55.6 ± 6.4)	2.318 (58.88)
36	2	0.125 (3.2)	2 7⁄16 ± ¼ (61.9 ± 6.4)	2.608 (66.24)

[A] Minimum slot inlet areas of 1.5 in.^{2}/ft of pipe length for diameters through 18 in. and 2.0 in.^{2}/ft of pipe length for larger diameters must be provided.

diameters. All specimens shall be cut to length by cutting through the corrugation valleys. After flattening, remove the load and examine the specimens for evidence of splitting, cracking, breaking, or the separation of the two walls.

NOTE 7—Flattening test may be run in conjunction with pipe stiffness test in accordance with Test Method D2412.

NOTE 8—The amount of flattening required in 7.5.3 develops bending strains at least as great as those developed when flattening of a DR 35 pipe by 60 %. See Appendix X4.

7.6 *Impact Resistance*—Determine the impact resistance of the pipe in accordance with the conditions and apparatus in Test Method D2444. Impact tests shall be conducted at two different locations.

TABLE 6 Minimum Impact Strength at 73°F (23°C)

Nominal Size, in.	Impact Strength, ft·lb (J)
4	60 (81)
6	80 (108)
8	80 (108)
10	100 (135)
12	140 (189)
15	140 (189)
18	140 (189)
21	140 (189)
24	140 (189)
27	140 (189)
30	140 (189)
36	140 (189)
42	140 (189)
48	140 (189)

These are (*1*) directly on the crown of the corrugation so that it receives the impact essentially centered on the tup face, and (*2*) directly on the midway point between corrugations. Omit Location (*2*) if the geometry of the corrugation does not provide a sufficiently wide valley to allow the tup to strike the valley wall directly. Failure of the test specimen shall be any crack, split, or shatter of the waterway. Separation of the corrugation from the inner wall constitutes a failure. Test a total of six specimens, with three specimens at each orientation. Where the valley wall orientation is omitted, test all six specimens at the first orientation.

7.6.1 In sizes 4 through 36 in., test six specimens, using a 20-lb (9-kg) Tup B or a 30-lb (15kg) Tup B and flat plate Holder B. Specimens shall be a minimum of 6 in. long such that the specimens are cut in the valley and contain and odd number of corrugations. All six specimens shall pass. If one specimen fails, test another six specimens. Eleven passes out of twelve tested shall be acceptable.

7.7 *Extrusion Quality:*

7.7.1 *Acetone Immersion*—This test shall be conducted in accordance with Test Method D2152.

7.7.2 *Heat Reversion*—When substituted for acetone immersion, this test shall be conducted in accordance with Practice F1057.

7.8 *Joint Tightness:*

7.8.1 *Elastomeric Seal (Gasketed) Joints*—Conduct joint tightness test in accordance with Specification D3212, except use the shear loading saddle shown in Fig. 2.

7.8.2 *Solvent Cement Joints*—Join bushing to fitting or saddle to pipe in accordance with Practice D2855, using solvent cement in accordance with 4.5.3. Allow the joined unit

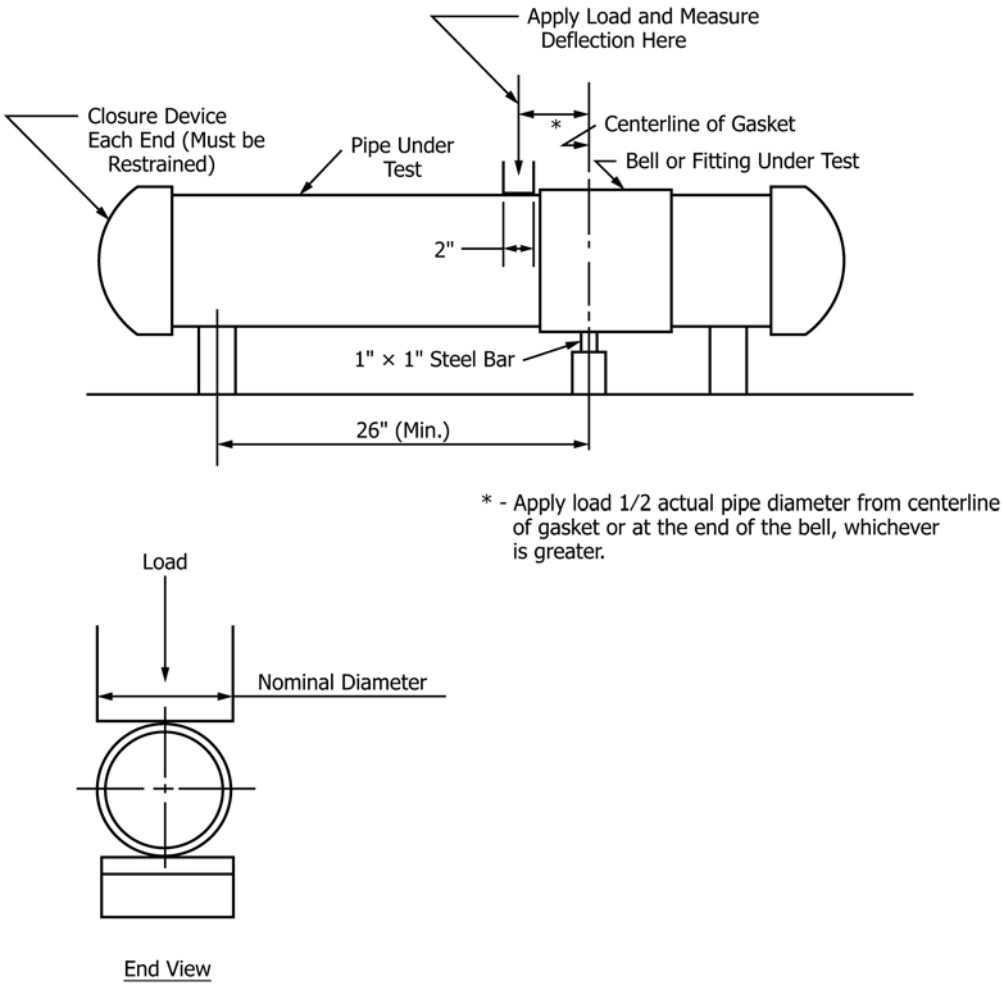


FIG. 2 Shear Load Deflection Test

to stand 24 h at room temperature. Subject the unit to an internal water pressure of 10.8-psi (74-kPa) gage (25-ft head) for 1 h, and examine the pipe fittings and joints for leakage (see 4.5.3).

7.9 *Perforations*—Measure dimensions of perforations on a straight specimen with no external forces applied. Make linear measurements with an instrument accurate to 0.01 in. (0.25 mm). Measure slot width with a taper gage and slot length with a vernier caliper.

7.10 *Bond*—Test the bond between the inner and outer wall with a probe or knife point. It shall not be possible to separate cleanly the two walls at the corrugation valley. Test samples at eight equally spaced points around its circumference.

8. Inspection

8.1 *General*—Inspection of the material shall be as agreed upon between the purchaser and the seller as part of the purchase contract. Inspection by the purchaser shall not relieve the manufacturer of the responsibility of furnishing products meeting in all respects the requirements of this specification.

8.2 *Notification*—If inspection is specified by the purchaser, the manufacturer shall notify the purchaser in advance of the date, time, and place of testing of the pipe or fittings, or both, so that the purchaser may be represented at the test.

8.3 *Access*—The inspector shall have free access to those parts of the manufacturer's plant that are involved in work performed under this specification. The manufacturer shall afford the inspector all reasonable facilities for determining whether the pipe or fittings, or both, meet the requirements of this specification.

9. Rejection and Rehearing

9.1 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. In retesting, the product requirements of this specification shall be met, and the test methods designated in the specification shall be followed. Pipe for retesting shall be selected from the same lot (extrusion code) represented by the pipe that failed the requirements of this specification. If, upon retest, failure occurs, the quantity of product represented by the test(s) does not meet the requirements of this specification.

10. Certification

10.1 When agreed upon in writing between the purchaser and the producer, a certification shall be made the basis of acceptance of material. This shall consist of a copy of the manufacturer's test report or a statement by the producer that the material has been sampled, tested, and inspected in accordance with the provisions of this specification. Each certification, so furnished, shall be signed by an authorized agent of the seller or the manufacturer.

11. Product Marking

11.1 *Quality of Marking*—The markings shall be applied to the pipe and fittings in such a manner that the lettering shall be legible and permanent under normal conditions of handling and storage.

11.2 Pipe in compliance with this specification shall be marked on the barrel at intervals not exceeding 5 ft (1.5 m) in letters and not less than ¼ in. (9.3 mm) in height with the following:

11.2.1 Manufacturer's name, tradename, or trademark,

11.2.2 Nominal pipe size,

11.2.3 This designation "ASTM F949 (46 psi)" or "ASTM F949 (115 psi)",

11.2.4 Type of plastic "PVC" and minimum cell classification, and

11.2.5 Extrusion code, including date and location of manufacture.

11.3 Fittings in compliance with this Specification shall be marked with the following:

11.3.1 Manufacturer's name, tradename, and trademark,

11.3.2 Nominal size,

11.3.3 This designation "ASTM F949," and

11.3.4 Material designation "PVC."

11.3.5 Fitting code, including date of manufacture.

12. Quality Assurance

12.1 *Quality Assurance*—When the product is marked with this designation, ASTM F949, the manufacturer affirms that the product was manufactured, inspected, sampled, and tested in accordance with this specification and has been found to meet the requirements of this specification.

SUPPLEMENTARY REQUIREMENTS

GOVERNMENT/MILITARY PROCUREMENT

These requirements apply only to Federal/Military procurement, not domestic sales or transfers.

S1. *Responsibility for Inspection*—Unless otherwise specified in the contract or purchase order, the producer is responsible for the performance of all inspection and test requirements specified herein. The producer may use his own or any other suitable facilities for the performance of the inspection and test requirements specified herein, unless the purchaser disapproves. The purchaser shall have the right to perform any of the inspections and tests set forth in this specification where such inspections are deemed necessary to ensure that material conforms to prescribed requirements.

NOTE S1.1—In U.S. Federal contracts, the contractor is responsible for inspection.

S2. *Packaging and Marking for U.S. Government Procurement:*

S2.1 *Packaging*—Unless otherwise specified in the contract, the materials shall be packaged in accordance with the supplier's standard practice in a manner ensuring arrival at destination in satisfactory condition and which will be acceptable to the carrier at lowest rates. Containers and packing shall comply with Uniform Freight Classification rules or National Motor Freight Classification rules.

S2.2 *Marking*—Marking for shipment shall be in accordance with Fed. Std. No. 123 for civil agencies and MIL-STD-129 for military agencies.

NOTE S2.1—The inclusion of U.S. Government procurement requirements should not be construed as an indication that the U.S. Government uses or endorses the products described in this specification.

APPENDIXES

(Nonmandatory Information)

X1. MAXIMUM PIPE LENGTHS

X1.1 To avoid gasketed joint pull apart, pipe lengths should be limited by the engineer to account for thermal contraction due to the differential between pipe installation temperature and ground temperature. Maximum length calculations should take into account socket depths, gasket seal location, and a suitable factor of safety.

X1.2 Tests on pipes covered by this specification indicate that a coefficient of thermal expansion and contraction of 49.7 by 10^{-6} in./in./°F (89.5 mm/mm/°C) is suitable for temperatures in the 0°F (−18°C) to 140°F (60°C) range.

X2. BASE INSIDE DIAMETER FOR CALCULATION OF DEFLECTION LIMITS

X2.1 Table X2.1 is provided to establish a uniform number representing the inside diameter to be used as a base for calculation of deflection limits (see also Table X2.2). For the purpose of monitoring the quality of installation, a specifier may apply a deflection limit that he deems appropriate to the base inside diameter to arrive at a mandrel dimension for a go/no-go gage. For economy in fabrication of mandrels, it is suggested that the outside diameter of each mandrel be rounded to the nearest 0.01 in. (0.2 mm) for machining purposes. This procedure is demonstrated here for the 7½ % recommended limit of Appendix X3. (Example: (100 % − 7.5 %)/100 × 5.785 = 5.33)

X2.2 This base inside diameter is not a product quality control requirement, nor should it be used for flow calculations.

TABLE X2.1 Base Inside Diameter and 7½ % Deflection Mandrel Dimensions

Nominal Size, in.	Average Inside Diameter		Base Inside Diameter[A]		7½ % Deflection Mandrel	
	in.	(mm)	in.	(mm)	in.	(mm)
Pipes with 46 psi pipe stiffness						
6	5.909	(150.1)	5.758	(146.2)	5.33	(135.4)
8	7.881	(200.2)	7.655	(194.4)	7.08	(179.8)
10	9.846	(250.1)	9.546	(242.5)	8.83	(224.2)
12	11.715	(297.56)	11.340	(288.04)	10.490	(266.45)
15	14.338	(364.19)	13.862	(352.09)	12.822	(325.68)
18	17.552	(445.82)	16.963	(430.86)	15.691	(398.55)
21	20.705	(525.91)	20.004	(508.1)	18.50	(469.9)
24	23.469	(596.11)	22.656	(575.5)	20.96	(532.4)
27	26.440	(671.58)	25.514	(648.1)	23.60	(599.4)
30	29.469	(748.51)	28.429	(722.1)	26.30	(668.0)
36	35.475	(901.07)	34.210	(868.9)	31.64	(803.7)
42	41.500	(1054.1)	40.009	(1016.2)	37.01	(940.1)
48	47.500	(1206.5)	45.784	(1162.9)	42.35	(1075.7)
Pipes with 115 pipe stiffness						
8	7.710	(195.8)	7.483	(190.1)	6.92	(175.8)
10	9.644	(245.0)	9.313	(237.4)	8.61	(219.6)
12	11.480	(291.6)	11.104	(282.05)	10.271	(260.89)
15	14.053	(356.90)	13.577	(344.87)	12.559	(319.00)

[A] Base inside diameter is a minimum pipe inside diameter derived by subtracting a statistical tolerance package from the pipe's average inside diameter. The tolerance package is defined as the square root of the sum of squared standard manufacturing tolerances.

$$Tolerance\ Package = \sqrt{A^2 + 2B^2 + C^2}$$

where:

A = outside diameter tolerance (see Table 1),
B = excesss wall thickness tolerance (excess wall thickness is insignificant and is taken as zero for all sizes), and
C = out-of-roundness tolerance, given in Table X2.2.

TABLE X2.2 Out-of-Roundness Tolerance

Nominal Size, in.	Values for *C*	
	in.	(mm)
6	0.150	(3.81)
8	0.225	(5.72)
10	0.300	(7.62)
12	0.375	(9.525)
15	0.475	(12.065)
18	0.587	(14.910)
21	0.700	(17.78)
24	0.812	(20.62)
27	0.925	(23.50)
30	1.038	(26.37)
36	1.263	(32.08)
42	1.488	(37.80)
48	1.713	(43.51)

X3. RECOMMENDED LIMIT FOR INSTALLED DEFLECTIONS

X3.1 Poly(vinyl) chloride corrugated sewer pipe with a smooth interior, made to this specification and installed in accordance with Practice D2321 can be expected to perform satisfactorily provided that the internal diameter of the barrel is not reduced by more than 7½ % of its base inside diameter when measured not less than 30 days following completion of installation.

X4. METHOD FOR DETERMINING FLATTENING LEVEL

X4.1 Profile wall pipes have thicker major walls (deeper profiles) than the wall thickness of equal stiffness, solid wall pipes of the same material. Therefore, profile wall pipes develop greater bending strains when flattened to the same degree. The methodology presented here selects a flattening level for profile wall pipes that better equates these strain levels. Because bending tension strains cause failure, they are the major consideration here. Bending strains for profile and solid wall pipes may be expressed as follows see AWWA Manual 45.:

$$\varepsilon p = Df(\Delta p)\,(C_{max}/R) \quad \text{(X4.1)}$$

$$\varepsilon s = Df(\Delta s)\,(0.5\,t/R) \quad \text{(X4.2)}$$

where:

εp = bending strain in the profile wall pipe,
εs = bending strain in an equal stiffness solid wall pipe,
Δp = flattening level in the profile wall pipe, %,
Δs = flattening level in a solid wall pipe = 60 %,
Df = factor to account for the shape of the defected pipe, Since the deflected shape varies with stiffness, the value of *Df* is the same for pipes with the same stiffness; *Df* cancels out in this analysis.
C_{max} = extreme fiber distance of the pipe wall,
t = thickness of solid wall pipe wall = *OD/DR*,
DR = dimension ratio of a solid wall pipe = outside diameter/*t* = OD/*t*, and
R = mean pipe radius.

X4.2 To select an equivalent flattening level to develop equal strains, set Eq X4.1 equal to Eq X4.2 and solve for the profile wall pipe deflection (Δ_P) necessary to produce the strain level in the solid wall pipe (ε_S) as follows:

$$\Delta_p = 0.3[2R/DR\,(C_{max})] \quad \text{(X4.3)}$$

X4.3 For an approximate solution, simplify by setting $2R$ = OD and multiply by 100 to express Δp as a percent as follows:

$$\Delta_p = 0.3\,[\mathrm{OD}/DR\,(C_{max})]\,100,\ \% \quad \text{(X4.4)}$$

If C_{max} is not known, for bending tension at the spring line, conservatively assume the following:

$$C_{max} = (\mathrm{OD} - \mathrm{ID})/4 \text{ and for } DR35 \text{ (that is, } 46 - \text{psi or } 320 - \text{kPa pipe stiffness)} \quad \text{(X4.5)}$$

$$\Delta_p = 3.43\ \mathrm{OD}/(\mathrm{OD} - \mathrm{ID}),\ \% \quad \text{(X4.6)}$$

where:

OD and ID = average outside and inside pipe diameters from Table 1.

SUMMARY OF CHANGES

Committee F17 has identified the location of selected changes to this standard since the last issue (F949–10) that may impact the use of this standard. (Approved April 1, 2015)

(1) 7.1.1 was revised.