



Standard Specification for Coextruded Poly(Vinyl Chloride) (PVC) Plastic Pipe With a Cellular Core¹

This standard is issued under the fixed designation F 891; 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.

1. Scope

1.1 This specification covers coextruded poly(vinyl chloride) (PVC) plastic pipe with a cellular core and concentric inner and outer solid layers, and is produced using a multilayer coextrusion die for nonpressure use in three series: an IPS Schedule 40 series; a PS series with an iron pipe size outside diameter with varying wall thickness as required for pipe stiffness of 25, 50, and 100; and a sewer and drain series.

1.2 The function of this specification is to provide standardization of product-technical data and serve as a purchasing guide.

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

NOTE 1—All the pipe series covered by this specification are permitted to be perforated or belled for joining by solvent cement or belled for joining by an elastomeric seal (gasket). Because this pipe is OD controlled, the inside diameter will vary, and therefore, the pipe ID is not suitable for use as a socket.

1.4 *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.*

1.5 The values stated in inch-pound units are to be regarded as the standard.

NOTE 2—Specifications related to this specification are as follows: D 2665, D 2729, D 3034, F 512, F 758, and F 789.

2. Referenced Documents

2.1 ASTM Standards:

- D 618 Practice for Conditioning Plastics and Electrical Insulating Materials for Testing²
- D 1600 Terminology for Abbreviated Terms Relating to Plastics²
- D 1898 Practice for Sampling of Plastics²

¹ This specification is under the jurisdiction of ASTM Committee F-17 on Plastic Piping Systems and is the direct responsibility of Subcommittee F17.25 on Vinyl Based Pipe.

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² Annual Book of ASTM Standards, Vol 08.01.

- D 2122 Test Method for Determining Dimensions of Thermoplastic Pipe and Fittings³
- D 2152 Test Method for Degree of Fusion of Extruded Poly(Vinyl Chloride) (PVC) Pipe and Molded Fittings by Acetone Immersion³
- D 2321 Practice for Underground Installation of Flexible Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications³
- D 2412 Test Method for Determination of External Loading Characteristics of Plastic Pipe by Parallel-Plate Loading³
- D 2444 Test Method for Impact Resistance of Thermoplastic Pipe and Fittings by Means of a Tup (Falling Weight)³
- D 2564 Specification for Solvent Cements for Poly(Vinyl Chloride) (PVC) Plastic Piping Systems³
- D 2665 Specification for Poly(Vinyl Chloride) (PVC) Plastic Drain, Waste, and Vent Pipe and Fittings³
- D 2672 Specification for Joints for IPS PVC Pipe Using Solvent Cement³
- D 2729 Specification for Poly(Vinyl Chloride) (PVC) Sewer Pipe and Fittings³
- D 2855 Practice for Making Solvent-Cemented Joints With Poly(Vinyl Chloride) (PVC) Pipe and Fittings³
- D 3034 Specification for Type PSM Poly(Vinyl Chloride) (PVC) Sewer Pipe and Fittings³
- D 3212 Specification for Joints for Drain and Sewer Plastic Pipes Using Flexible Elastomeric Seals³
- D 3311 Specification for Drain, Waste, and Vent (DWV) Plastic Fittings Patterns³
- D 4396 Specification for Rigid Poly(Vinyl Chloride) (PVC) and Related Plastic Compounds for Nonpressure Piping Products⁴
- F 402 Practice for Safe Handling of Solvent Cements, Primers, and Cleaners Used for Joining Thermoplastic Pipe and Fittings³
- F 412 Terminology Relating to Plastic Piping Systems³
- F 477 Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe³
- F 512 Specification for Smooth-Wall Poly(Vinyl Chloride) (PVC) Conduit and Fittings for Underground Installation³
- F 545 Specification for PVC and ABS Injected Solvent Cemented Plastic Pipe Joints³

³ Annual Book of ASTM Standards, Vol 08.04.

⁴ Annual Book of ASTM Standards, Vol 08.03.

F 656 Specification for Primers for Use in Solvent Cement Joints of Poly(Vinyl Chloride) (PVC) Plastic Pipe and Fittings³

F 758 Specification for Smooth-Wall Poly(Vinyl Chloride) (PVC) Plastic Underdrain Systems For Highway, Airport, and Similar Drainage³

F 789 Specification for Type PS-46 Poly(Vinyl Chloride) (PVC) Plastic Gravity Flow Sewer Pipe and Fittings³

2.2 *Federal Standard:*

Fed. Std. No. 123 Marking for Shipment (Civil Agencies)⁵

2.3 *Military Standard:*

MIL-STD-129 Marking for Shipment and Storage⁵

2.4 *ANSI Standards:*

Z34.1 American National Standard for Certification-Third-Party Certification Program⁶

Z34.2 American National Standard for Certification-Self-Certification by Producer or Supplier⁶

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.

3.1.1 *cellular plastic*—a plastic containing numerous cells, intentionally introduced, interconnecting or not, distributed throughout the mass.

3.1.2 *coextruded pipe*—pipe consisting of two or more concentric layers of material bonded together in processing by any combination of temperature, pressure, grafting, crosslinking, or adhesion.

3.1.3 *coextrusion*—a process whereby two or more heated or unheated plastic material streams, forced through one or more shaping orifice(s), become one continuously formed piece.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *lot*—a lot shall consist of all pipe of the same size produced from one extrusion line during one designated shift.

3.2.2 *IPS Schedule 40 Series*—pipe produced to an iron pipe outside diameter with a Schedule 40 wall thickness.

3.2.3 *PS Series*— pipe produced to an IPS outside diameter and having the required wall thickness to meet a designated pipe stiffness.

3.2.4 *sewer and drain series*—pipe produced to a sewer and drain outside diameter and having a minimum wall thickness to meet a designated pipe stiffness.

4. Classification by Application

4.1 Coextruded PVC plastic pipe, in an IPS Schedule 40 series, is referenced in Table 1 for use in 4.1.1. A PS series with an iron pipe outside diameter, with varying wall thickness as required for pipe stiffness of 25, 50, and 100 is referenced in Table 2 for use in 4.1.2, and a sewer and drain series is referenced in Table 2 for use in 4.1.3 and 4.1.4.

⁵ Available from Standardization Documents Order Desk, Bldg. 4 Section D, 700 Robbins Ave., Philadelphia, PA 19111-5094, Attn: NPODS.

⁶ Available from American National Standards Institute, 11 W. 42nd St., 13th Floor, New York, NY 10036

TABLE 1 Minimum Wall Thickness,^A Pipe Stiffness, and Impact Strength for IPS Schedule 40 Series

Nominal Pipe Size, in.	Wall Thickness, in.	Pipe Stiffness, lb/in. ²	Impact Strength, ft-lbf
1¼	0.140	600	40
1½	0.145	600	50
2	0.154	300	80
3	0.216	300	100
3½	0.226	250	100
4	0.237	200	100
5	0.258	120	100
6	0.280	120	120
8	0.322	100	120
10	0.365	60	120
12	0.406	50	120

^A The maximum wall thickness shall not be greater than 1.25 times the minimum wall thickness.

4.1.1 Drain, waste, and vent pipe in IPS Schedule 40 series.

4.1.2 Underground communication conduit in PS series is not for underground electrical power distribution usage.

4.1.3 Nonpressure sewer and drain pipe for underground burial outside of the building.

4.1.4 Highway underdrain in sewer and drain series.

4.2 Recommendations for storage, joining, and installation are provided in Appendix X1, Appendix X2, and Appendix X3, respectively.

NOTE 3—Before installing pipe for industrial waste disposal use, the approval of the cognizant building code authority must be obtained, as conditions not commonly found in normal use may be encountered.

5. Material

5.1 *Material Specification*—The PVC material shall conform to the requirements prescribed in Specification D 4396 with a cell class of 11432. PVC material, which has a higher cell class than those listed, is acceptable.

5.2 *Rework Material*—The manufacturer shall use only his own clean rework pipe material conforming with these cell class requirements. It shall be used only in the core layer if it contains any residual blowing agent. The pipe produced shall meet all requirements of this specification.

6. Requirements

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

6.2 *Dimensions and Tolerances:*

6.2.1 *Outside Diameter*—The outside diameter and tolerances for the IPS Schedule 40 series, PS series, and the sewer and drain series shall meet the requirements of Table 3 when measured in accordance with Test Method D 2122. The tolerances for out-of-roundness shall apply to the pipe prior to shipment.

6.2.2 *Wall Thickness*—The wall thickness for the IPS Schedule 40 series shall equal or exceed the minimum dimensions in Table 1, and for the PS series and sewer and drain series it shall equal or exceed the minimum dimensions in Table 2, when measured in accordance with Test Method D 2122.

TABLE 2 Minimum Wall Thickness^A for PS Series or Sewer and Drain Series for Minimum Pipe Stiffness

Nominal Pipe Size, in.	Wall Thickness, in.						
	PS Series				Sewer and Drain Series		
	PS 25	PS 50	PS 100	PS 12.5	PS 25	PS 50	PS 100
2	...	...	0.100	...	...	...	...
3	...	0.103	0.130	...	...	0.100	0.120
3½	0.100	0.118	0.148	...	...	...	...
4	0.106	0.133	0.167	...	0.100	0.124	0.156
5	0.131	0.164	0.206	...	...	...	...
6	0.156	0.195	0.245	0.118	0.148	0.185	0.232
8	...	...	...	...	0.198	0.248	0.310
10	...	...	...	...	...	0.310	0.388
12	...	...	...	...	...	0.369	0.462
15	...	...	...	...	...	0.452	0.565
18	...	...	...	...	...	0.548	0.691

^AThe maximum wall thickness shall not be greater than 1.25 times the minimum wall thickness.

TABLE 3 Outside Diameter and Tolerances

Nominal Pipe Size, in.	Outside Diameter		Tolerance on Average Outside Diameter, in.	Out-of-Roundness Maximum Diameter Minus Minimum Diameter, in.
	IPS Schedule 40 Series, in.	Sewer and Drain Series, in.		
1¼	1.660	...	±0.005	0.060
1½	1.900	...	±0.006	0.060
2	2.375	...	±0.006	0.060
3	3.500	3.250	±0.008	0.060
3½	4.000	...	±0.008	0.100
4	4.500	4.215	±0.009	0.100
5	5.563	...	±0.010	0.100
6	6.625	6.275	±0.011	0.100
8	8.625	8.400	±0.015	0.150
10	10.750	10.500	±0.015	0.150
12	12.750	12.500	±0.015	0.150
15	...	15.300	±0.023	0.150
18	...	18.700	±0.028	0.200

6.2.3 Length—The pipe length may be 10 or 20 ft with a tolerance on length of +½, -0 in., unless otherwise specified.

6.3 Performance Requirements:

6.3.1 Pipe Stiffness—The minimum pipe stiffness values at 5 % deflection when measure in accordance with Test Method D 2412, shall equal or exceed the value in Table 1 for IPS Schedule 40 series, or the value in Table 2 or PS series and sewer and drain series. Three specimens shall be tested. If all three meet this requirement, the sample meets this requirement. If one or two fail, additional testing shall be conducted in accordance with 6.3.1.1. If all three fail, the sample does not meet the requirement.

6.3.1.1 Pipe Stiffness and Lower Confidence Limit—In the event that one or two of the specimens tested in 6.3.1 fail to meet the minimum requirement, the average pipe stiffness of 11 specimens shall meet or exceed the minimum requirement given in Table 1 for IPS Schedule 40 series pipe, and Table 2 for PS Series and Sewer and Drain pipe. The 99 % lower confidence limit (LCL) shall be within 15 % of the average value. The LCL shall be calculated using the Student's "t" distribution, with N-1 degrees of freedom, where N is the number of specimens (11). The critical t value shall be used to at least three significant digits. Alternatively, if the LCL exceeds the minimum PS requirement in the applicable table, but is not within 15 % of the average, the sample meets the requirements of the pipe stiffness testing. The 11 specimens include the three tested under 6.3.1, and an additional eight

with rotation by 35°, as specified in D 2412, continuing throughout the remaining specimens.

The LCL based on testing eleven specimens is calculated as follows:

$$LCL = (\text{avg PS}) - \{2.76 (\text{std. dev.})/\sqrt{N}\}$$

where:

$$N = 11$$

$$(\text{avg PS}) = \frac{[\sum(PS_i)]}{(11)}$$

$$(\text{std.dev.}) = \left[\frac{\sum PS^2 - (\sum PS)^2/N}{N-1} \right]^{1/2}$$

The 15 % requirement is calculated as follows:

$$(\text{avg} - LCL)/(\text{avg}) \times 100 \leq 15 \%$$

NOTE 4—The 5 % deflection criteria is arbitrarily selected for testing convenience. It should not be considered as a limitation with respect to in-use deflection. The engineer is responsible for establishing the acceptable deflection limit.

NOTE 5—The strength and load-carrying capabilities of plastic pipe are measured and reported as pipe stiffness, which is determined in accordance with Test Method D 2412. The term "crushing strength" is not applicable to plastic piping.

6.3.2 Pipe Flattening—There shall be no evidence of cracking, delamination, or rupture when pipe is deflected to 40 % of the initial inside diameter, when tested in accordance with Test Method D 2412. Three specimens shall be tested and all shall pass.

NOTE 6—This test is intended only for use as a quality control test, and not as a simulated service test.

6.3.3 *Impact Strength*—The minimum impact strength values, at the time of manufacture, shall comply with Table 1 for IPS Schedule 40 series and Table 4 for the PS series and sewer and drain series, when tested in accordance with Test Method D 2444, using Tup B and Holder B. A 20-lb tup is used for testing all pipe sizes and series 4 in. and smaller, and a 30-lb tup for pipe sizes and series larger than 4 in. Test conditions shall be in accordance with 7.4 or 7.5.2, whichever is applicable. Test ten specimens. When nine or ten specimens pass, accept the lot. When four or more specimens fail, reject the lot. When two or three specimens of ten fail, test ten additional specimens. When seventeen of twenty specimens tested pass, accept the lot. When seven or more of twenty fail, reject the lot. When four, five, or six of twenty fail, test twenty additional specimens. When thirty-two of forty specimens pass, accept the lot. When nine or more of forty specimens fail, reject the lot.

6.3.3.1 *Definition of Failure*—Failure in the test specimen shall be shattering or any crack or break extending entirely through the pipe walls, visible to the unaided eye.

6.3.4 *Bond*—The bond between layers shall be strong and uniform. It shall not be possible to separate any two layers with a probe or the point of a knife blade so that the layers separate cleanly, nor shall separation of the bond occur between layers during testing performed under the requirements of this specification.

6.3.5 *Extrusion Quality*—The pipe shall meet the requirements of Test Method D 2152.

6.4 *Other Requirements:*

6.4.1 *Joining*—Coextruded poly(vinyl chloride) PVC plastic pipe produced in IPS Schedule 40 series and PS series are joined using fittings meeting the requirements of Specifications D 2665, D 3311, or F 512. Fittings meeting the requirements of Specifications D 2729, D 3034, or F 789 are used with the sewer and drain series, and Specification F 545 are permitted for all series.

6.4.2 *Solvent Cement*—In the assembly of solvent cement joints, the safety requirements of Practice F 402 shall be followed and the joint shall be assembled following Practice D 2855, using a cleaner or primer.

6.4.3 *Gaskets*—Elastomeric seals (gaskets) shall meet the requirements of Specification F 477.

6.4.4 *Lubricant*—The lubricant used for assembly shall

have no detrimental effect on the gasket or on the pipe or fitting.

6.4.5 *Gasket Joints*—Gasket joints shall comply with Specification D 3212 and be designed so that the gasket inside the pipe will be compressed radially on the pipe spigot, when assembled, to form a water-tight seal.

6.4.6 *Gasket Displacement*—The joint shall be designed to avoid displacement of the gasket when installed. The assembly of the joint shall be in accordance with the manufacturer's recommendation.

7. *Sampling and Conditioning*

7.1 *Sampling*—For the purpose of testing, the lot shall consist of all pipe produced from one extrusion line during one designated shift. The number of specimens designated for each test shall be taken from pipe selected at random from each lot in accordance with the random sampling plan of Practice D 1898.

7.2 *Number of Tests for Quality Control*—When not specified, the following minimum number of specimens shall be tested.

7.2.1 *Outside Diameter*—One specimen per extrusion line every 2 h.

7.2.2 *Wall Thickness*—One specimen per extrusion line every 2 h.

7.2.3 *Length*—One specimen per extrusion line per shift.

7.2.4 *Pipe Stiffness*—Three specimens per extrusion line per shift.

7.2.5 *Pipe Flattening*—Three specimens per extrusion line per shift.

7.2.6 *Impact Strength*—Test ten specimens per extrusion line per lot of material or different size or series and one specimen per extrusion line per shift.

7.2.7 *Bond*—One specimen per extrusion line per week.

7.2.8 *Extrusion Quality*—One test per lot of material as specified in Test Method D 2152.

7.3 *Conditioning for Quality Control Testing*—Specimens shall be conditioned at the ambient temperature and humidity of the manufacturer's testing facility for not less than 1 h.

7.4 *Test Conditions for Quality Control Testing*—Routine quality control testing is conducted at the ambient temperature and humidity of the manufacturer's testing area.

7.5 *Referee Testing:*

7.5.1 *Conditioning*—Condition the specimens prior to test at $73.4 \pm 4^\circ\text{F}$ and $50 \pm 5\%$ relative humidity in accordance with Practice D 618, Procedure A.

7.5.2 *Test Conditions*—Conduct tests in the standard laboratory atmosphere of $73.4 \pm 4^\circ\text{F}$ and $50 \pm 5\%$ relative humidity.

7.5.3 *Sampling*—Specimens shall be collected in accordance with 7.1 and the number of specimens shall be sufficient to obtain an adequate set of test results for those properties to be measured.

7.5.4 *Test Methods*—Only specified ASTM test methods shall be used.

8. *Retest and Rejection*

8.1 If the results of any test(s) do not meet the requirements of this specification, the test(s) shall be conducted again in

TABLE 4 Minimum Impact Strength for PS Series or Sewer and Drain Series

Nominal Pipe Size, in.	Minimum Impact Strength, ft-lbf			
	PS 12.5	PS 25	PS 50	PS 100
2	80
3	...	80	80	100
3½	...	80	80	100
4	...	80	100	100
5	...	100	100	100
6	70	100	100	120
8	...	140	140	140
10	...	160	160	160
12	...	200	200	200
15	220	...
18	220	...

accordance with an agreement between the purchaser and the seller. There shall be no agreement to lower the minimum requirements of the specifications by such means as omitting test methods that are a part of the specification, substitution, or modifying test methods, or by changing the specification limits. In retesting, the product requirements of this specification shall be met, and the test methods designated in this specification shall be followed. If, upon retest, failure occurs, the quantity of product represented by the test(s) does not meet the requirements of this specification.

9. Marking

9.1 *Quality of Marking*—The marking shall be applied to the pipe for end-use application in such a manner that it remains legible (easily read) after installation and inspection.

9.2 *Content of Marking*—The pipe shall be marked at least every 5 ft in letters not less than 3/16 in. high and in a color that contrasts with the color of the pipe, and shall contain the following information:

9.2.1 Manufacturer’s name or trademark.

9.2.2 This designation, ASTM F 891, including the year of issue.

9.2.3 The wording “COEX CELLULAR CORE PVC PIPE”.

9.2.3.1 Typical marking for identification of each series shall be as follows: IPS Schedule 40 Series Coex Cellular Core PVC DWV Pipe, PS-25 or 50 or 100 Series Coex Cellular Core PVC Communication Conduit, and Sewer and Drain Series Coex Cellular Core PVC Sewer and Drain, or Highway Underdrain Pipe.

9.2.4 Nominal pipe size and series (for example: 1¼ in. IPS Schedule 40 series).

9.2.5 Manufacturer’s code for identifying lot number, date, and year of manufacture, or other information as needed.

NOTE 7—Code bodies may require that pipe be marked on two opposite sides. For example, “DWV pipe.”

10. Quality Assurance

10.1 When the product is marked with this designation, F 891, 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.

10.2 *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 shall 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. The testing and inspection shall be in accordance with ANSI Z34.1 or ANSI Z34.2.

11. Keywords

11.1 cellular core; coextruded; drain; waste; and vent; PVC; Schedule 40; thermoplastic

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 the 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. STORAGE

X1.1 *Outside Storage*—Plastic pipe should be stored on a flat surface or supported in a manner that will prevent sagging or bending.

X1.2 Inventories of plastic pipe should be used on a first-in-first-out basis.

X2. JOINING

X2.1 *Field Inspection*—Prior to use all pipe should be carefully inspected for cuts, gouges, deep scratches, damaged ends, and other major imperfections. Defective pipe should be rejected, and damaged sections should be cut out.

X2.2 *Pipe Fit*—Pipe is manufactured to close tolerances to ensure satisfactory “interference” fit between the pipe and the fittings socket during assembly. Use only combinations of pipe and fittings that give interference fits. Pipe that is a loose fit in the socket may not properly bond. The allowable tolerance assures a forced fit and when solvent cement is applied, the pipe and fitting will readily mate, thus assuring a physical fusion. The pipe should enter the dry fitting socket to between one half and two thirds of the fitting socket depth.

X2.3 *Cutting*—Pipe can be easily cut with an ordinary hacksaw or carpenter’s saw. Fine-tooth blades with little or no set should be used for best results. The pipe should be cut square and all burrs removed with a sharp knife, a fine-tooth file, or other suitable device. A miter box is recommended to ensure square cut ends. Standard steel pipe or tubing cutters are not recommended for cutting PVC pipe since they may cause excessive heat and pressure, which can result in cracked or irregular pipe ends. There are special cutters available with extra wide rollers and thin cutting wheels that have been designed for cutting plastic pipe, and their use is recommended.

X2.4 *Cleaning*—Chemical or mechanical cleaners should be used to clean the pipe after all burrs have been removed and prior to assembly.

X2.5 *Safety Requirements for Solvent Cement and Primers*—Practice F 402 should be followed.

X2.6 *Primers*—Primers may be used to clean, soften, and dissolve the joint surfaces prior to application of solvent cement for joining. Primers meeting the requirements of Specification F 656 are acceptable.

X2.7 *Solvent Cement*—Use only solvent cement designated for PVC. A solvent cement meeting the requirements of Specification D 2564, when used in accordance with the manufacturer’s recommendations, should provide satisfactory

results; or follow Practice D 2855.

X2.7.1 *Application of Cement*—Using the applicator supplied with the can of solvent cement, or a brush or roller with a width of about one half the pipe diameter for pipe sizes above 2 in., apply a moderate even coating of cement in the fitting socket to cover only the surfaces to be joined. Heavy or excessive application of solvent cement may become an obstruction in the pipe and prevent satisfactory joining. Quickly apply a heavy coat of solvent cement to the outside of the pipe. Make sure that the coated distance on the pipe is equal to the depth of the fitting socket.

X2.8 *Assembly*—Make the joint as quickly as possible after application of the solvent cement and before the solvent cement dries. Should the solvent cement dry partially before the joint is made up, reapply solvent cement before assembling. Insert the pipe into the fitting socket, making sure that the pipe is inserted to the full depth of the fitting socket. Hold the joint together firmly for about 30 s for small diameter pipe and 60 s for diameters above 6 in. to avoid push out. Remove excessive solvent cement from the exterior of the joint with a clean, dry cloth.

X2.9 *Set Time*—Do not attempt to disturb the pipe and fitting joint until after the solvent cement has set or damage to the joint and loss of fit may result. Reasonable handling of the assembly is permissible within 2 min after joining. Allow 15 min for the joint to develop good handling strength and the joint will withstand the stresses of normal installation. A badly misaligned installation will cause excessive stresses in the joint, pipe, and fittings and should be avoided. The recommendation of the solvent cement manufacturer should be followed for best results.

X2.10 *Cure Time*—Joint strength development is very rapid during periods of high-ambient temperatures, low relative humidity, and using interference-type fittings. Joint strength development is not as rapid during periods of low ambient temperatures, high relative humidity, and using loose fits. Therefore, the recommendations of the solvent cement manufacturer should be followed for best results prior to leak testing.

X3. INSTALLATION

X3.1 *Underground Installation*—Underground installations of pipe shall be in accordance with Practice D 2321, except maximum aggregate size shall be limited to 1/2 in. for angular and 3/4 in. for rounded particles.

X3.2 *DWV Installation*—Pipe should be installed in conformance with governing building codes. In areas not governed by codes, pipe should be installed in accordance with accepted engineering practices.

X3.3 *Installation Under Freezing Conditions*—PVC pipe has decreased resistance to impact under freezing conditions and increased care should be exercised if installation is likely to occur under these conditions, particularly during handling, transportation, installation, and backfilling. Where possible, installation should be avoided during freezing conditions. Allowance shall be made for expansion that will occur when the temperature of the pipe is raised.

X3.4 *Alignment and Grade*—Align all piping system components properly without strain. Do not bend or pull pipe into position after being solvent cemented. The grade of horizontal drainage and vent piping shall be as specified in the applicable code.

X3.5 *Supports and Spacing*—Hangers and straps should not compress, distort, cut, or abrade the piping and should allow free movement of pipe. Support all piping at intervals of not more than 4 ft (1.2 m) at end of branches and at changes of direction or elevation. Supports should allow free movement. Maintain vertical piping in straight alignment. Support trap arms in excess of 3 ft (1 m) in length as close as possible to the trap. Securely fasten closed rings with corrosion-resistant fasteners to the floor with the top surface 1/4 in. (6 mm) above the finish floor level. Stabilize closet bends or stubs against all horizontal or vertical movement. Protect pipe exposed to damage by sharp surfaces with grommets or sleeves of rubber or plastic.

X3.6 *Threaded Connections*—Do not cut threads on pipe. Molded threads on adapter fittings for transition to threaded construction is necessary except in the case of cleanout plugs. The joint between the pipe and transition fittings should be of

the solvent-cement type. Only approved thread tape or thread lubricant specifically intended for use with PVC plastic pipe should be used. Conventional pipe thread compound, putty, linseed oil-based products, and unknown mixtures should be avoided.

X3.7 *Thread Tightness*—Where a threaded joint is made, obtain tightness by a maximum hand tightening plus additional tightening with a strap wrench, not to exceed one full turn.

X3.8 *Connection to Nonplastic Pipe*—When connecting plastic pipe to other types of piping, use only approved types of fittings and adapters designed for the specific transition.

X3.9 *Connections to Traps*—Connect traps by means of approved threaded trap adaptors.

X3.10 *Connection to Closet Flanges*—Install screw-type closet flanges in the drainage system by means of a threaded connection.

X3.11 *Transition to Bell-and-Spigot Pipe*—Make connections of transition to bell-and-spigot cast iron soil pipe and fittings, and to bell-and-spigot pipe and fittings of other materials with approved mechanical compression joints designed for this use, or caulk joints made in an approved manner.

X3.12 *Building Drains Under Floor Slabs*—Make trench bottoms smooth and of uniform grade with either undisturbed soil or a layer of selected and compacted-backfill so that no settlement will be encountered. Pipe must bear on this material throughout the entire length of its barrel.

X3.13 *Thermal Expansion*—Allow for thermal expansion and movement in all piping installations by the use of approved methods. Support but do not rigidly restrain piping at branches or changes of direction. Do not anchor pipe rigidly in walls. Holes through framing members should be adequately sized to allow for free movement. Thermal expansion for installations subject to temperature changes may be determined from Table X3.1. The linear expansion shown is independent of the diameter of the pipe. Buried piping or piping installed in the

TABLE X3.1 Thermal Expansion Table for PVC Plastic Pipe

Length, ft	Temperature Change, °F ^A						
	40	50	60	70	80	90	100
	Length of Change, in. ^B						
20	0.28	0.35	0.42	0.49	0.56	0.63	0.70
40	0.56	0.70	0.84	0.97	1.11	1.25	1.39
60	0.84	1.04	1.25	1.46	1.67	1.88	2.09
80	1.13	1.39	1.67	1.95	2.23	2.51	2.78
100	1.39	1.74	2.09	2.44	2.78	3.13	3.48

^A Example of temperature change:

Highest temperature expected	100°F
Lowest temperature expected	50°F
Total variation	50°F

^B For a length of run of 60 ft, and a 50°F temperature variation, the chart indicates that the installation should provide for a linear expansion of 1.04 in.

crawl space under a building is normally subject to less than the ambient temperature changes.

X3.14 *Exposed Piping*—Provide adequate support where piping is exposed to wind, snow, and ice loading. Plumbing vents exposed to sunlight should be protected by water-based synthetic latex paints. Where surface temperatures exceed 165°F, piping shall be protected by means of shielding or some type of light-weight insulation. Exposure to sunlight during normal construction periods is not harmful. It is good practice to store pipe and fittings under suitable cover prior to installation.

X3.15 *Antifreeze Protection*—When necessary to protect traps and fixtures from freezing, do not use alcohol or petroleum products. Use only approved plastic pipe antifreeze packaged for this purpose or one of the following solutions:

X3.15.1 Sixty percent, by mass, of glycerin in water.

X3.15.2 Twenty-two percent, by mass, of magnesium chloride in water. Strong solutions of common table salt (sodium chloride) may also be used.

X3.16 *Commercial and Industrial Applications:*

X3.16.1 The DWV pipe will accommodate temperatures of 180°F (71°C) encountered in household applications, but the nature of some applications to run to higher temperatures, for example, commercial dishwashers, require special consideration.

X3.16.2 Waste disposal lines, where concentrated agents and certain chemicals that are routinely present and that may be aggressive to PVC, should only be installed with the specific approval of the cognizant building code authority. Service station bay area floor drains require special consideration.

X4. PIPE STIFFNESS CALCULATIONS

X4.1 The formula for pipe stiffness in a circular specimen is:

$$\text{Pipe Stiffness} = 0.559E\left(\frac{t}{r}\right)^3 \quad (X4.1)$$

where:

- t = wall thickness,
- r = mean radius, and
- E = flexural modulus of elasticity.

This formula can be derived from a formula for thin rings listed in Roark's *Formulas for Stress and Strain* (McGraw Hill).

X4.2 The pipe stiffness formula applies to specimens with uniform wall thickness, uniform means radius, and a uniform flexural modulus of elasticity. Individual plastic pipe specimens vary in wall thickness and in out-of-roundness defined as "Maximum O.D. Minus Minimum O.D." The flexural modulus of a coextruded product depends on the thickness of each of the layers, the modulus of the material, and the total thickness of the wall. Therefore, flexural modulus is based on a measured value for typical thicknesses and extrusion conditions.

X4.3 There are several methods for treating the variables which exist. The two methods used in ASTM standards for plastic pipe are as follows:

X4.3.1 *Method One:*

X4.3.1.1 Use the nominal wall thickness.

X4.3.1.2 Use the nominal mean radius.

X4.3.1.3 Determine E experimentally for the compound by making pipe specimens performing pipe stiffness tests at 5 % deflection, determine nominal wall thickness, and then calculate the materials flexural modulus.

X4.3.1.4 The flexural modulus used in calculating the

minimum pipe stiffness is chosen as the mean of the several values less two standard deviations.

X4.3.2 *Method Two:*

X4.3.2.1 Use minimum wall thickness as listed.

X4.3.2.2 Use the nominal mean radius.

X4.3.2.3 Use the required minimum flexural modulus published for that material and cell class. If there is no minimum flexural modulus requirement, use the tensile modulus requirements as published.

NOTE X4.1—The Plastic Pipe Institute in its Technical Report PPI-TR-7 of March 1968 titled "Recommended Method For Calculation of Nominal Weight of Plastic Pipe," under Definitions 3.1, *Nominal Weight* is defined as the weight which is calculated by using the nominal or stated diameter, without consideration of tolerance, and the nominal wall thickness of the pipe. The diameter and wall thickness values shall be obtained from the applicable standard or specification which shall be reported. *The nominal wall thickness is the minimum plus 6 % rounded to the nearest 0.001 in.*

NOTE X4.2—Experience has shown that Method One provides pipe which will reliably meet or exceed the minimum pipe stiffness values published in this specification when the pipe is in conformance with the minimum wall thickness requirements.

NOTE X4.3—Experience with Method Two has shown that by using the minimum wall and minimum modulus, both factors introduce conservative bias; therefore, the measured pipe stiffnesses for these products are well above the minimum pipe stiffness requirements listed in this specification.

X4.4 The calculated pipe stiffness for a nominal 4-in. sewer pipe with an outside diameter of 4.215 in., a minimum wall thickness of 0.156 in. and a value of E equal to 330 000 is as follows using Method One:

$$\begin{aligned} (0.156 \text{ in.}) \times (1.06) &= 0.1654 \text{ in.} & (X4.2) \\ (4.215 \text{ in.} - 0.1654 \text{ in.})/2 &= 2.0248 \text{ in.} = r \\ PS &= (0.559)(330\ 000)\left(\frac{0.1654 \text{ in.}}{2.0248 \text{ in.}}\right)^3 = 100.55 \text{ psi} \end{aligned}$$

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