



Designation: F1504 – 21^{ε1}

Standard Specification for Folded Poly(Vinyl Chloride) (PVC) Pipe for Existing Sewer and Conduit Rehabilitation¹

This standard is issued under the fixed designation F1504; 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.

^{ε1} NOTE—Table 3 was editorially corrected in August 2022.

1. Scope*

1.1 This specification covers requirements and test methods for materials, dimensions, workmanship, flattening resistance, impact resistance, pipe stiffness, extrusion quality, and a form of marking for folded poly(vinyl chloride) (PVC) pipe for existing sewer and conduit rehabilitation.

1.2 Folded PVC pipe produced to this specification is for use in non-pressure sewer and conduit rehabilitation where the folded PVC pipe is inserted into and then expanded to conform to the wall of the original conduit forming a new pipe-within-a-pipe.

NOTE 1—For installation procedures and engineering design considerations refer to Practice F1947.

1.3 This specification includes folded PVC pipe made only from materials specified in Section 6. This specification does not include folded pipe manufactured from reprocessed, recycled, or reclaimed PVC.

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 statement pertains to the test method portion only, Section 11, of this specification: *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.6 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recom-*

mendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.

2. Referenced Documents

2.1 ASTM Standards:²

- D618 Practice for Conditioning Plastics for Testing
 - D790 Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials
 - D1600 Terminology for Abbreviated Terms Relating to Plastics
 - D1784 Classification System and Basis for Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds
 - F1947 Practice for Installation of Folded Poly(Vinyl Chloride) (PVC) Pipe into Existing Sewers and Conduits
 - 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
 - D2412 Test Method for Determination of External Loading Characteristics of Plastic Pipe by Parallel-Plate Loading
 - D2444 Practice for Determination of the Impact Resistance of Thermoplastic Pipe and Fittings by Means of a Tup (Falling Weight)
 - F412 Terminology Relating to Plastic Piping Systems
 - F1057 Practice for Estimating the Quality of Extruded Poly(Vinyl Chloride) (PVC) Pipe by the Heat Reversion Technique
- ### 2.2 Federal Standard:³
- Fed. Std. No. 123 Marking for Shipment (Civil Agencies)
- ### 2.3 Military Standard:³
- MIL-STD-129 Marking for Shipment and Storage

¹ This specification is under the jurisdiction of ASTM Committee F17 on Plastic Piping Systems and is the direct responsibility of Subcommittee F17.67 on Trenchless Plastic Pipeline Technology.

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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.

³ Available from DLA Document Services Building 4/D 700 Robbins Avenue Philadelphia, PA 19111-5094 <http://quicksearch.dla.mil/>

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

3. Terminology

3.1 *General*—Abbreviations used in this specification are in accordance with Terminology D1600 and definitions are in accordance with Terminology F412 unless otherwise indicated.

3.2 Definitions of Terms Specific to This Standard:

3.2.1 *folded pipe*—pipe that has been manufactured in a folded shape or that is subsequently folded for use in existing sewer and conduit rehabilitation. See Fig. 1.

3.2.2 *formed pipe*—folded pipe that has been inserted into an existing sewer or conduit and expanded with heat, pressure, and, if applicable, a rounding device to conform to and take the shape of the existing pipe (see Fig. 1).

3.2.3 *rounded pipe sample*—a folded pipe that has been inserted into a pipe mold and expanded with heat and pressure to conform to the mold pipe, intended for testing purposes.

4. Significance and Use

4.1 The requirements of this specification are intended to provide folded pipe suitable for the rehabilitation of existing pipelines and conduits conveying sewage, process flow, and storm water, under non-pressure conditions, through the heating, insertion, and expansion of the folded pipe.

NOTE 2—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) can be encountered.

5. Application of Materials

5.1 The nominal folded pipe sizes specified in Section 8 are applicable for a range of pipe inside diameters.

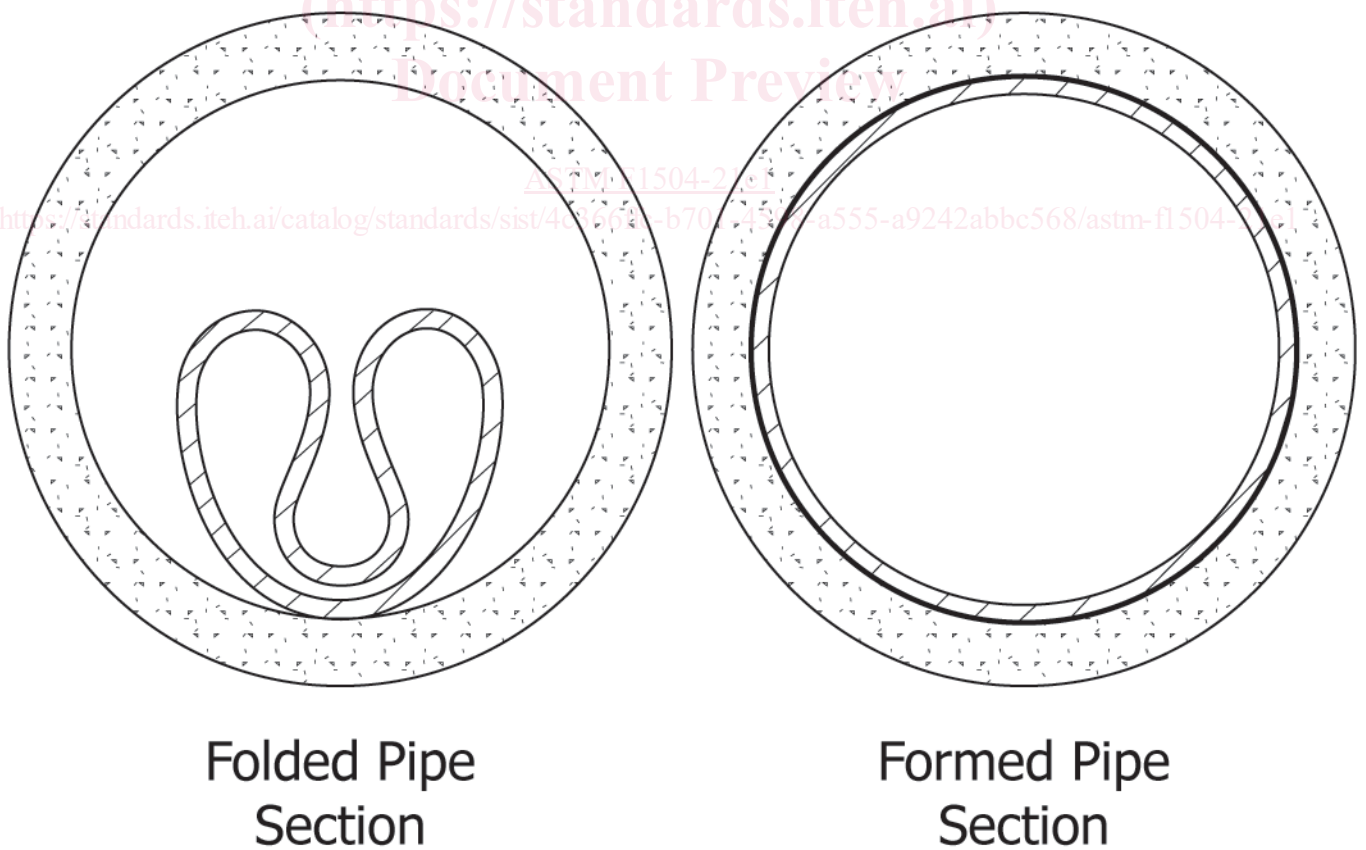
6. Materials and Manufacture

6.1 *Basic Materials*—Folded pipe shall be made from virgin PVC compound meeting all the requirements for cell classifications 12334, 13223, 32334, or 33223 as defined in Specification D1784.

6.2 *Rework Material*—Clean rework material, generated from the manufacturer’s own folded PVC pipe production may be used by the same manufacturer provided that the rework material meets the requirements of 6.1 and that the folded pipe produced meets all the requirements of this specification. Reworked material of intermixed cell classifications shall be labeled as the minimum cell classification of this specification and labeled in accordance with 15.1.3.1. Reworked material containing any copolymer materials shall be labeled as copolymer material.

7. Other Requirements

7.1 *Pipe Flattening*—There shall be no evidence of splitting, cracking, or breaking when the rounded pipe sample is tested in accordance with 11.3.



NOTE 1—This figure is intended only for clarification of terms specific to this specification and shows representative folded and formed pipe shapes. Other folded pipe shapes can meet the requirements of this specification.

FIG. 1 Folded Pipe and Formed Pipe—Clarification of Terms

7.2 *Pipe Impact Strength*—The impact strength of the rounded pipe sample shall not be less than the values specified in **Table 1** when tested in accordance with **11.4**.

NOTE 3—The impact strength test is intended only for use as a quality-control test, not as a simulated service test.

7.3 *Pipe Stiffness*—Pipe stiffness values for the rounded pipe sample shall comply with **Table 2** when tested in accordance with **11.6**.

7.4 *Extrusion Quality*—The extrusion quality of the pipe shall be evaluated by the test methods specified in **7.4.1** and **7.4.2**.

7.4.1 *Acetone Immersion*—The rounded pipe sample shall not flake or disintegrate when tested in accordance with **11.6.1**.

7.4.2 *Heat Reversion*—The extrusion quality shall be estimated by heat reversion method in accordance with **11.6.2**.

7.5 *Flexural Properties*—Flexural modulus of elasticity values for the rounded pipe sample shall comply with **Table 3** when tested in accordance with **11.7**.

8. Dimensions, Mass, and Permissible Variations

8.1 *Outside Diameter*—The average outside diameter of the rounded pipe sample shall meet the requirements specified in **Table 4** with a tolerance of $\pm 1.0\%$ when measured in accordance with **11.2.1**.

8.2 *Wall Thickness*—The minimum wall thickness of the rounded pipe sample, when measured in accordance with **11.2.2**, shall not be less than the values specified in **Table 4**.

9. Workmanship, Finish, and Appearance

9.1 Rounded and folded pipes shall be homogeneous throughout and free from visible cracks, holes, foreign inclusions, or other injurious defects and shall be as uniform as commercially practical in color, opacity, density, and other physical properties.

10. Sampling

10.1 Rounded pipe sample preparation shall involve unfolding and expanding of a folded pipe within a pipe mold with an inside diameter equal to the nominal outside diameter of the folded pipe. A folded pipe of sufficient length (10 ft (3 m) minimum) to complete the testing requirements shall be inserted into the pipe mold and secured at the ends. The assembly shall then be placed in an enclosed chamber for heating. Ambient pressure steam shall be applied to the chamber for at least 15 min at a minimum temperature of

200 °F (93 °C). While maintaining the minimum temperature, the folded pipe shall then be rounded by applying internal steam pressure of at least 8 psig (55 kPa) for at least 2 min. While maintaining the internal pressure, transition to air pressure and cool the sample to 100 °F (38 °C) or less. Remove the rounded pipe sample from the mold for testing.

10.2 The frequency of sampling shall be as agreed upon between the purchaser and the seller.

10.3 Initial and retest samples shall be drawn from the same production shift.

11. Test Methods

11.1 *Test Conditions*—Conduct tests in the standard laboratory atmosphere of 73 °F \pm 4 °F (23 °C \pm 2 °C) and 50 \pm 10 % relative humidity, with test specimens conditioned in accordance with Procedure A of Practice **D618**, unless otherwise specified in the test methods or in this specification.

11.2 Dimensions:

11.2.1 *Diameters*—Measure the outside diameter of the rounded pipe sample in accordance with the applicable section of Test Method **D2122**. Either a tapered sleeve gage or a vernier circumferential wrap tape accurate to ± 0.001 in. (± 0.02 mm) may be used.

11.2.2 *Wall Thickness*—Measure the wall thickness in accordance with the applicable sections of Test Method **D2122**. Make sufficient readings, a minimum of six, to ensure that the minimum thickness is determined. Use a cylindrical anvil tubing micrometer accurate to ± 0.001 in. (± 0.02 mm).

11.3 *Flattening*—Flatten three specimens of rounded pipe samples, 6 in. (150 mm) long, between parallel plates in a suitable press until the distance between the plates is 40 % of the outside diameter of the pipe. The rate of loading shall be uniform and such that the compression is completed within 2 min to 5 min. Remove the load and examine the specimens for evidence of splitting, cracking, or breaking.

11.4 *Impact Resistance*—Determine the impact resistance of rounded pipe samples in accordance with the applicable section of Test Method **D2444**, using a 20 lb (9 kg) Tup A and the flat plate Holder B. Test six specimens each 6 in. (150 mm) long at the impact energies specified in **Table 1**. All specimens shall pass. If one fails, test another six specimens; eleven passes out of twelve tested shall be acceptable.

11.5 *Stiffness*—Determine the pipe stiffness for rounded pipe samples using Test Method **D2412**. Test three specimens, each 6 in. (150 mm) long. The pipe stiffness of each specimen at 5 % deflection shall equal or exceed the minimum value specified in **Table 2**.

11.6 Extrusion Quality:

11.6.1 *Acetone Immersion*—Tests shall be conducted in accordance with Test Method **D2152** on rounded pipe samples. This procedure is used for determining the extrusion quality of extruded PVC plastic pipe as indicated by reaction to immersion in anhydrous acetone. It is applicable only for distinguishing between unfused and properly fused PVC.

11.6.2 *Heat Reversion*—Tests shall be conducted in accordance with Practice **F1057** on rounded pipe samples. The

TABLE 1 Minimum Impact Energy at 73 °F (23 °C)

Inch/Pound Units	
Formed Pipe Nominal Outside Diameter, NPS	Impact Energy, ft·lbf
4	150
6–8	210
9–30	220
SI (Metric) Units	
Formed Pipe Nominal Outside Diameter, DN	Impact Energy, J
100	204
150–200	284
225–750	299

TABLE 2 Minimum Rounded Pipe Sample Stiffness at 5 % Deflection

NOTE 1—Higher stiffness, due to higher moduli or lower DR, may also be available; consult the manufacturer

		Inch/Pound Units						
Folded Pipe Nominal Outside Diameter, NPS		Pipe Stiffness, psi						
		PS-1			PS-2 ^B			
		DR 50	DR 41	DR 35	DR 66	DR 50	DR 41	DR 35
4	...	...	...	31	...	...	...	36
6	...	...	19	31	...	...	22	36
8–15	10	...	19	31	...	12	22	36
18–30	...	...	...	...	6	12	...	...

		SI (Metric) Units						
Folded Pipe Nominal Outside Diameter, DN		Pipe Stiffness, kPa						
		PS-1 ^A			PS-2 ^B			
		DR 50	DR 41	DR 35	DR 66	DR 50	DR 41	DR 35
100	...	...	...	214	...	...	...	248
150	...	...	131	214	...	...	152	248
200–375	69	...	131	214	...	83	152	248
450–750	...	...	...	...	41	83	...	...

^A PS-1 is for material with a minimum cell classification of 13223 or 33223 (280 000 psi (1930 MPa) minimum modulus). B

^B PS-2 is for material with a minimum cell classification of 12334 or 32334 (320 000 psi (2206 MPa) minimum modulus).

TABLE 3 Rounded Pipe Sample Flexural Properties

PVC Cell Classification	Minimum [†] Flexural Modulus of Elasticity, psi (MPa)
13223, 33223	280 000 (1930)
12334, 32334	320 000 (2206)

[†] Editorially corrected in August 2022.

TABLE 4 Rounded Pipe Sample Dimensions

		Inch/Pound Units			
Formed Pipe Nominal Outside Diameter, NPS		Minimum Wall Thickness, in.			
		DR 66	DR 50	DR 41	DR 35
4	...	...	...	...	0.114
6	...	...	...	0.146	0.171
8	...	...	0.160	0.195	0.229
9	...	...	0.180	0.219	0.257
10	...	...	0.200	0.243	0.286
12	...	...	0.240	0.292	0.343
15	...	...	0.300	0.365	0.429
18	0.273	...	0.360	...	...
24	0.363	...	0.480	...	...
30	0.454	...	0.600	...	...

		SI (Metric) Units			
Formed Pipe Nominal Outside Diameter, DN		Minimum Wall Thickness, mm			
		DR 66	DR 50	DR 41	DR 35
100	...	...	...	...	2.9
150	...	...	...	3.7	4.3
200	...	...	4.1	5.0	5.8
225	...	...	4.6	5.6	6.5
250	...	...	5.1	6.2	7.3
300	...	...	6.1	7.4	8.7
375	...	...	7.6	9.3	10.9
450	6.9	...	9.1	...	...
600	9.2	...	12.2	...	...
750	11.5	...	15.2	...	...

rounded pipe sample shall not exhibit any of the effects listed in the suggested Interpretation of Results in Practice **F1057**.

11.7 *Flexural Properties*—Tests shall be conducted on rounded pipe samples in accordance with Test Method

I—Procedure A of Test Method **D790**. Test specimens shall be cut in the longitudinal direction and oriented on the test machine with the interior surface of the rounded pipe sample against the loading supports.

12. Inspection

12.1 Inspection of the folded pipe shall be made as agreed upon between the purchaser and the seller as part of the purchase contract.

13. Retest and Rejection

13.1 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. There shall be no agreement to lower the minimum requirement of this specification by such means as omitting tests that are a part of this specification, substituting or modifying a test method, or by changing the specification limits. In retesting, the product requirements of this specification shall be met, and the test methods specified 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.

14. Certification

14.1 When specified in the purchase order or contract, a manufacturer's certification shall be furnished to the purchaser that the product was manufactured, sampled, tested, and inspected in accordance with this specification, and has been found to meet the requirements. When specified in the purchase order or contract, a report of the test results shall be furnished. Each certification so furnished shall be signed by an authorized agent of the manufacturer.

15. Product Marking

15.1 Folded pipe in compliance with this specification shall be clearly marked at intervals of 5 ft (1.5 m) or less as follows:

15.1.1 Manufacturer's name or trademark and code,