



Designation: F1504 – 21

# Standard Specification for Folded Poly(Vinyl Chloride) (PVC) Pipe for Existing Sewer and Conduit Rehabilitation<sup>1</sup>

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 ( $\epsilon$ ) indicates an editorial change since the last revision or reapproval.

## 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 Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

<sup>1</sup> 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. Referenced Documents

### 2.1 ASTM Standards:<sup>2</sup>

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:<sup>3</sup>

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

### 2.3 Military Standard:<sup>3</sup>

MIL-STD-129 Marking for Shipment and Storage

## 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.

<sup>2</sup> 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.

<sup>3</sup> 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

3.2 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.

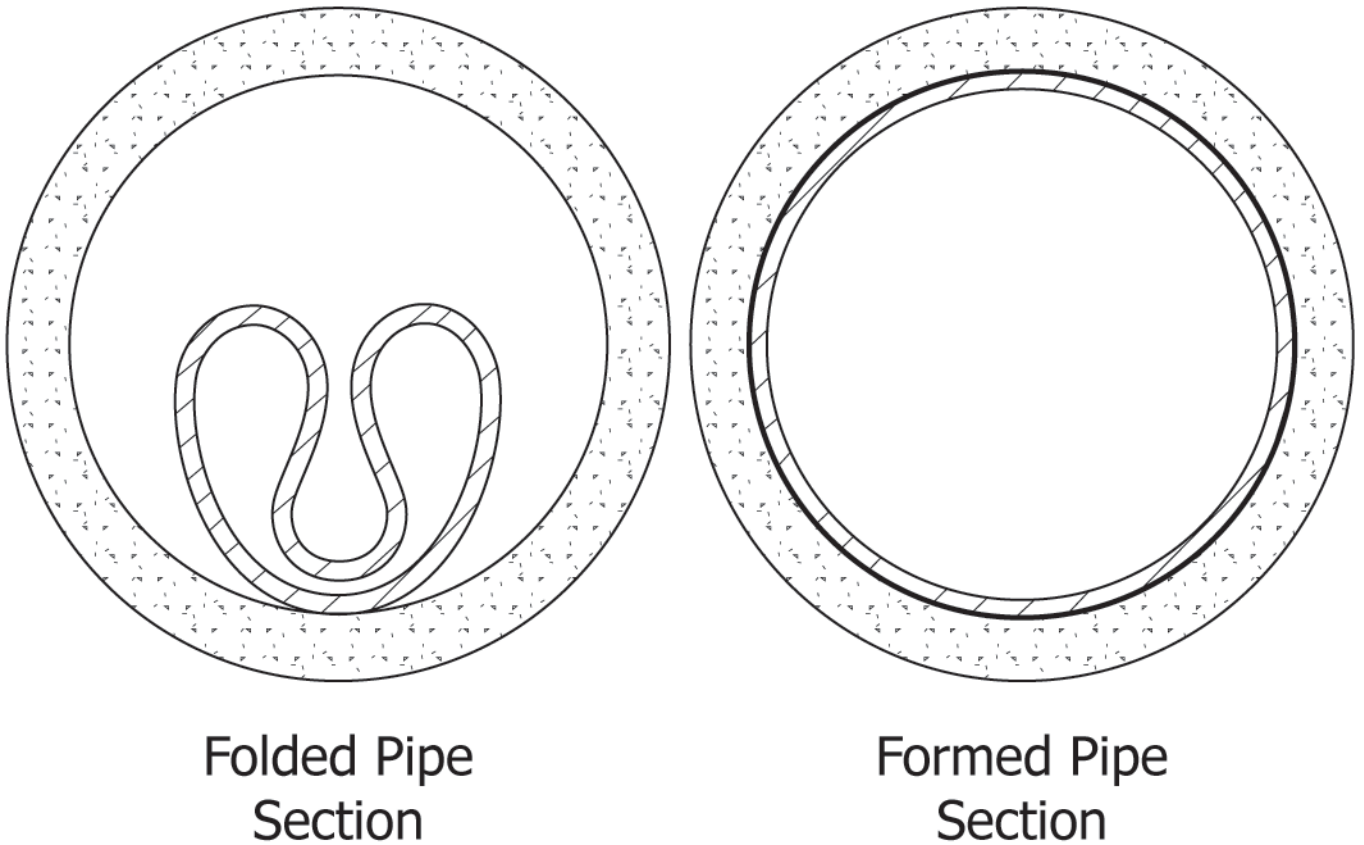
6.2 *Rework Material*—Clean rework material, generated from the manufacturer’s own folded PVC pipe production may be used by the same manufacturer provided that the rework material meets the requirements of 6.1 and that the folded pipe produced meets all the requirements of this specification. Reworked 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.

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.



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

**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 3 Rounded Pipe Sample Flexural Properties**

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

**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	...	...

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 ±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

**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 <sup>B</sup>			
	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 <sup>A</sup>				PS-2 <sup>B</sup>			
	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	...	...	

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

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

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 ± 4 °F (23 °C ± 2 °C) and 50 ± 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 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,

15.1.2 Nominal outside diameter,

15.1.3 The PVC cell classification, for example “12334,” “13223,” “32334” or “33223”

15.1.3.1 All reworked materials shall be labeled as meeting the minimum cell classification of this specification. Reworked material containing any copolymer materials shall be labeled as a copolymer material.

15.1.4 The legend “DR XX Folded PVC Pipe,”

15.1.5 This designation “ASTM F1504,” and

15.1.6 Length marker and linear distance label, for example: “15/yd” or “223/yd” (“15/m”).

## 16. Packaging

16.1 The full length and wall thickness of the folded PVC pipe shall be heated and coiled onto a reel in a continuous

length for storage and shipping. The minimum diameter of the reel drum or core shall meet the manufacturer’s specifications.

## 17. Quality Assurance

17.1 When the product is marked with this designation (ASTM F1504), 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.

## 18. Keywords

18.1 copolymer; homopolymer; installation—underground; plastic pipe—thermoplastic; poly(vinyl chloride) (PVC) plastic pipe; rehabilitation

## SUPPLEMENTARY REQUIREMENTS

### GOVERNMENT/MILITARY PROCUREMENT

These requirements apply only to federal/military procurement, not domestic sales or transfers.

#### S1. Responsibility for Inspection

S1.1 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 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 products shall be packaged in accordance with the supplier’s standard practice in a manner ensuring arrival at destina-

tion in satisfactory condition and that 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.

## SUMMARY OF CHANGES

Committee F17 has identified the location of selected changes to this standard since the last issue (F1504–14(2021)<sup>e1</sup>) that may impact the use of this standard.

(1) Added new sizes to **Table 1**, **Table 2**, and **Table 4** and split those tables into metric and inch/pound units.

(2) Deleted old Table 1 on recommended size changes.

(3) Changed the mold requirement from “split-pipe mold” to “pipe mold”.

(4) Changed the SI conversions of the nominal pipe sizes in **Table 1**, **Table 2**, and **Table 4**, from hard conversions to soft conversions, to reflect actual market practices.

(5) Clarified the terms “folded pipe”, “formed pipe”, and “rounded pipe sample”, for consistency throughout this specification and with Practice **F1947**.

(6) Made other minor changes as follows:

- Changed SI pressure units to MPa, from GPa, for consistency with other Committee F17 standards.

- Made editorial revisions to **10.1**.

- Changed temperature in Fahrenheit to integers, for consistency with other Committee F17 standards.
- Increased relative humidity tolerances to  $\pm 10\%$ , for consistency with other Committee F17 standards.
- Made editorial revisions throughout, for clarity.

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