



Standard Specification for Extruded and Compression Molded Rod and Heavy-Walled Tubing Made from Polytetrafluoroethylene (PTFE)¹

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^{e1} NOTE—Editorially corrected Footnote 1 to reflect a jurisdiction change in April 2002.

1. Scope

1.1 This specification is intended to be a means of calling out plastic product used in the fabrication of end items or parts.

1.2 This specification covers requirements and test methods for the material, dimensions, and workmanship, and the properties of extruded- and compression-molded rod, and heavy-walled tube manufactured from granular unfilled PTFE resin in accordance with Specification D 4894.

1.3 This specification covers rod and heavy-walled tubing made wholly from polytetrafluoroethylene and produced in accordance with good commercial practice.

1.4 The properties included in this specification are those required for the compositions covered. Requirements necessary to identify particular characteristics important to specialized applications may be described by using the classification system given in Section 4.

1.5 This specification allows for the use of recycled plastics as defined in Guide D 5033.

1.6 The values stated in inch-pound units are to be regarded as the standard in all property and dimensional tables.

1.7 *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.*

NOTE 1—There are similar ISO standards, such as ISO 13000-1 and 13000-2.

2. Referenced Documents

2.1 ASTM Standards:

D 374 Test Methods for Thickness of Solid Electrical Insulation²

D 638 Test Method for Tensile Properties of Plastics³

D 790 Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials³

D 792 Test Methods for Density Specific Gravity (Relative Density) of Plastics by Displacement³

D 883 Terminology Relating to Plastics³

D 1505 Test Method for Density of Plastics by the Density-Gradient Technique³

D 1600 Terminology for Abbreviated Terms Relating to Plastics³

D 1708 Test Method for Tensile Properties of Plastics by Use of Microtensile Specimens³

D 1710 Specification for Polytetrafluoroethylene (PTFE) Basic Shapes, Rod, and Heavy-Walled Tubing²

D 1898 Practice for Sampling of Plastics³

D 3892 Practice for Packaging/Packing of Plastics⁴

D 4000 Classification System for Specifying Plastic Materials⁴

D 4591 Test Method for Determining Temperatures and Heats of Transitions of Fluoropolymers by Differential Scanning Calorimetry⁵

D 4894 Specification for Polytetrafluoroethylene (PTFE) Granular Molding and Ram Extrusion Materials⁵

D 5033 Guide for the Development of Standards Relating to the Proper Use of Recycled Plastics⁵

E 94 Guide for Radiographic Testing⁶

IEEE/ASTM SI-10 Standard for Use of the International System of Units (SI): The Modern Metric System⁷

2.2 *ISO Standard:*⁸

ISO 13000-1 Plastics—Polytetrafluoroethylene (PTFE) Semi-Finished Products—Part I: Requirements and Designation

ISO 13000-2 Plastics—Polytetrafluoroethylene (PTFE)

¹ This specification is under the jurisdiction of ASTM Committee D-20 on Plastics and is the direct responsibility of Subcommittee D20.15 on Thermoplastic Materials (D20.15.12 on Fluoropolymers).

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² *Annual Book of ASTM Standards*, Vol 10.01.

³ *Annual Book of ASTM Standards*, Vol 08.01.

⁴ *Annual Book of ASTM Standards*, Vol 08.02.

⁵ *Annual Book of ASTM Standards*, Vol 08.03.

⁶ *Annual Book of ASTM Standards*, Vol 03.03.

⁷ *Annual Book of ASTM Standards*, Vol 14.04.

⁸ Available from American National Standards Institute, 11 W. 42nd St., 13th Floor, New York, NY 10036.

Semi-Finished Products—Part II: Preparation of Test Specimens and Determination of Properties

3. Terminology

3.1 *Definitions*—Terms are defined in accordance with Terminology D 883 unless otherwise specified.

3.1.1 *heavy-walled tubing, n*—an annular shape with a minimum wall thickness of 1/16 in.

3.1.2 *lot, n*—one production run or a uniform blend of two or more production runs.

3.1.3 *rod, n*—a solid cylindrical shape.

3.2 *Abbreviations*—Abbreviations are in accordance with Terminology D 1600 unless otherwise indicated.

3.2.1 *PTFE*—polytetrafluoroethylene

4. Classification

4.1 Product shape and size is defined in the applicable purchase order.

4.2 This specification covers product-extruded and compression-molded as listed in Tables 1 and 2.

4.2.1 The type of PTFE shape product may be categorized by type, class, and grade as defined in Tables 1 and 2.

4.2.2 Each type of PTFE shape may be categorized into one of the following grades:

4.2.2.1 *Grade 1*—Virgin-extruded or compression-molded product made using only 100 % virgin PTFE resin.

4.2.2.2 *Grade 2*—Recycled-extruded or compression-molded product made using any amount up to 100 % recycled PTFE plastic.

4.2.3 Products can be further differentiated by property requirements, as defined for three classes of PTFE products in Tables 1 and 2.

4.2.3.1 *Class 1*—A type of rod or heavy-walled tubing having maximum physical and electrical properties to meet rigid requirements.

4.2.3.2 *Class 2 (General Purpose)*—A type of rod or heavy-walled tubing having properties required of general electrical, mechanical, and chemical applications.

4.2.3.3 *Class 3*—A type of rod or heavy-walled tubing for noncritical chemical, electrical, and mechanical applications.

4.3 The type, class, and grade is further differentiated based on dimensional stability (elevated temperature excursion test) and internal defect requirements.

4.4 Classification D 4000 also may be used to describe extruded or compression molded products not included in Tables 1 and 2 via a cell callout that includes the applicable table of suffixes using type and specific properties.

4.5 To facilitate the incorporation of future or special materials not covered by Tables 1 and 2, the “as specified” category (00) for type, class, and grade is shown in the table with the basic properties to be obtained from Classification D 4000 as they apply.

4.6 *Callout Designation*—A one-line system shall be used to specify materials covered by this specification. The system uses pre-defined cells to refer to specific aspects of this specification illustrated as follows:

4.6.1 *Examples*:

TABLE 1 Mechanical and Electrical Requirements of PTFE Rod

Type	Description	Grade	Description	Class	Description	Size Range (in.) ^A	Specific Gravity (min) ^B	Ultimate Tensile Strength, psi (min) ^C	Tensile Elongation, % (min) ^D	Dielectric Strength, volts/mil (min) ^D	Dimensional Stability ^E	Internal Examination ^F		
01	Unfilled PTFE	1	virgin	1	premium	less than 1/2	2.14	2000	150	700	A or B	C or D		
						1/2 to 1 1/2	2.15	2100	175	750	A or B	C or D		
						over 1 1/2	2.15	2200	200	800	A	C or D		
					2	general purpose	less than 1/2	2.12	1700	100	600	A or B	C or D	
						1/2 to 1 1/2	2.13	1800	125	650	A or B	C or D		
						less than 1/2	2.14	1900	150	700	A	C or D		
			3	noncritical	less than 1/2	2.12	1400	50	250	A or B	C or D			
				1/2 to 1 1/2	2.13	1500	75	250	A or B	C or D				
				over 1 1/2	2.14	1600	75	250	A	C or D				
				0	as specified	-	-	-	-	-	-	A or B	C or D	
		01	Unfilled PTFE	2	recycled	1	premium	less than 1/2	TBD	TBD	TBD	TBD	A or B	C or D
								1/2 to 1 1/2	TBD	TBD	TBD	TBD	A or B	C or D
	over 1 1/2						TBD	TBD	TBD	TBD	A	C or D		
	2					general purpose	less than 1/2	TBD	TBD	TBD	TBD	A or B	C or D	
						1/2 to 1 1/2	TBD	TBD	TBD	TBD	A or B	C or D		
						less than 1/2	TBD	TBD	TBD	TBD	A	C or D		
	3			noncritical	less than 1/2	TBD	TBD	TBD	TBD	A or B	C or D			
				1/2 to 1 1/2	TBD	TBD	TBD	TBD	A or B	C or D				
				over 1 1/2	2.14	1600	75	250	A	D				
				0	other	none	-	-	-	-	-	A or B	C or D	
00	Other PTFE			1	virgin	0	as specified	none	-	-	-	-	A or B	C or D
					recycled	0	as specified	none	-	-	-	-	-	A or B
		as specified	0		as specified	none	-	-	-	-	-	A or B	C or D	
		as specified	0		as specified	none	-	-	-	-	-	A or B	C or D	

^AOne inch equals 25.4 mm.

^BSee 12.2.

^CSee 12.3.

^DSee 12.4.

^ESee 12.5. “A” indicates that the product has no dimensional stability requirements. “B” indicates that product must comply with dimensional stability requirements in 7.3. This requirement applies only to rod that is under 25.4 mm (1 in.) in diameter.

^FSee 12.6. “C” indicates that the product has no internal inspection requirements. “D” indicates that product must comply with the inspection requirements given in 8.3.

TABLE 2 Mechanical and Electrical Requirements of PTFE Heavy-Walled Tubing

Type	Description	Grade	Description	Class	Description	Specific Gravity (min) ^A	Ultimate Tensile Strength, psi (min) ^B	Tensile Elongation, % (min) ^B	Dielectric Strength, volts/mil (min) ^C	Dimensional Stability ^D	Internal Examination ^E
01	Unfilled PTFE	1	virgin	1	premium	2.15	2000	150	750	A or B	C or D
				2	general purpose	2.15	1800	130	650	A or B	C or D
				3	noncritical	2.14	1600	100	325	A or B	C or D
		2	recycled	0	as specified	-	-	-	-	A or B	C or D
				1	premium	2.14	1500	140	700	A or B	C or D
				2	general purpose	2.14	1400	120	600	A or B	C or D
				3	noncritical	2.13	1300	80	250	A or B	C or D
				0	as specified	-	-	-	-	A or B	C or D
				0	as specified	-	-	-	-	A or B	C or D
				0	as specified	-	-	-	-	A or B	C or D
00	As specified	0	as specified	0	as specified	-	-	-	-	A or B	C or D
		1	virgin	0	as specified	-	-	-	-	A or B	C or D
		2	recycled	0	as specified	-	-	-	-	A or B	C or D
		0	as specified	0	as specified	-	-	-	-	A or B	C or D

^ASee 12.2.

^BSee 12.3.

^CSee 12.4.

^DSee 12.5. "A" indicates that the product has no dimensional stability requirements. "B" indicates that product must comply with dimensional stability requirements in 7.3.

^ESee 12.6. "C" indicates that the product has no internal inspection requirements. "D" indicates that product must comply with the inspection requirements given in 8.3.

4.6.1.1 *Example 1*—Product made from unfilled PTFE, virgin, premium (no dimensional stability requirements or internal examination).

Cell Callout: 10111AC

01 = product made from PTFE in accordance with Table 1.

1 = unfilled PTFE type.

1 = grade—virgin.

1 = premium class product.

A = no dimensional stability required.

C = no internal exam required.

4.6.1.2 *Example 2*—Products made from unfilled PTFE, virgin, general purpose properties, 1 in. diameter rod, maximum tolerance of +0.020 in. inspected for internal defect.

Cell Callout: 10112BD

1 = product made from PTFE in accordance with Table 1.

01 = unfilled type.

1 = virgin grade product.

2 = general purpose class requirements.

B = dimensional tolerances in accordance with Table 3.

D = internal inspection required.

TABLE 3 Diameter and Tolerance for PTFE Rod and Heavy-Walled Tubing

Nominal Diameter or Outside Diameter, in. ^{A,B}	Tolerance, in. ^{A,C}
1/16	0.005
1/8	0.007
3/16	0.009
1/4	0.012
3/8	0.012
1/2	0.014
5/8	0.016
3/4	0.017
1	0.020
1 1/4	0.025
1 1/2	0.030
1 3/4	0.035
2	0.035
2 1/4	0.040
2 1/2	0.045
3	0.045

^AOne inch equals 25.4 mm.

^BIntermediate diameters shall conform to the tolerance of the next larger diameter in this table.

^CThe tolerance is plus for outside diameters and minus for inside diameters.

4.6.2 These two examples illustrate how a one-line, alpha-numeric sequence can identify the product composition, commercial parameters and physical characteristics of extruded or compression molded product. A space must be used as a separator between the specification number and the type designation. No separators are needed between type, class, and grade. When special notes are to be included, such information should be preceded by a comma. Special tolerances must be noted at the time of order and are inserted after the grade in parenthesis and preceded by a comma.

5. Ordering Information

5.1 All shapes covered by this specification shall be ordered using the proper callout designation (see 4.6).

6. Physical Property Requirements

6.1 The physical property values listed within this specification's tables are to be considered minimum specification values. Any requirement for specific test data for a given production lot should be specified at the time of order. Physical properties for products not yet included in Table 1 may be specified using Classification D 4000 for extruded or compression-molded products.

6.2 *Melting Point*—The melting point of all types of rod and heavy-walled tubing shall be $327 \pm 10^\circ\text{C}$ when tested in accordance with 12.7.

7. Dimensions, Mass, and Permissible Variations

7.1 The dimensions and tolerances of heavy-walled tubing shall be according to Table 3. Measurements shall be made in accordance with Method A of Test Methods D 374.

7.2 For rod and heavy-walled tubing, it may be necessary to center-less-grind the outside diameter to meet the tolerance given in Table 3.

7.2.1 *Eccentricity*—The eccentricity of the heavy-walled tubing, when measured as one-half of the difference between the maximum and minimum wall thickness at either end of the tube, shall not exceed 10 % of the nominal wall thickness. The

TABLE 4 Precision Summary, Tensile Strength and Elongation at Break

 NOTE 1— $I_r = 2.8 \times CV_r$; $I_R = 2.8 \times CV_R$

Material	Tensile Strength				
	Mean, psi	CV_r , %	CV_R , %	I_r , %	I_R , %
Granular PTFE	4801	2.79	8.85	7.81	24.78
Coagulated Dispersion PTFE	4807	2.71	3.37	7.59	9.46
PFA	4164	3.11	9.03	8.71	25.28
FEP	4144	2.98	7.98	3.34	22.34

TABLE 5 Percentage Elongation at Break

 NOTE 1— $I_r = 2.8 \times CV_r$; $I_R = 2.8 \times CV_R$

Material	Mean, psi	CV_r , %	CV_R , %	I_r , %	I_R , %
Granular PTFE	337	2.83	16.43	7.92	46.00
Coagulated Dispersion PTFE	300	2.17	13.74	6.08	38.47
PFA	336	3.27	9.66	9.16	27.05
FEP	319	2.21	7.60	6.19	21.28

nominal wall thickness is one-half the difference between the nominal outside diameter and the nominal inside diameter.

7.3 As indicated in Table 1, when tested in accordance with 12.5, products must have maximum change in a sample diameter of 0.5 % or a maximum change in a sample diameter of 3.0 %, or both.

7.4 Products shall be produced within commercial tolerances and with the lowest stress levels for machined parts as delineated in Table 3.

7.5 Tubular bar dimensions shall be supplied in the unfinished condition, unless otherwise specified at time of order, sufficient to finish to the nominal dimension ordered.

8. Workmanship, Finish and Appearance

8.1 *Color*—Class 1 shall be white to translucent but may have occasional spots. Class 2 typically are white but may vary to light gray or light brown. For Class 3, occasional small gray, brown, or black spots shall not be considered cause for rejection.

8.2 *Finish*—The rod or heavy-walled tubing shall be free from surface blisters, cracks, wrinkles, and other surface defects that might impair it for general use.

8.3 *Internal Defects*—Classes C and D either shall be free of all macroscopic voids, cracks, and foreign inclusions, or the location of such defects shall be marked or identified clearly. The examination for internal defects shall be made in accordance with Guide E 94.

9. Sampling

9.1 Sampling shall be statistically adequate to satisfy the requirements of this specification.

9.2 For purposes of sampling, an inspection lot for examination and tests shall consist of all material of the same type, class, grade, and nominal size submitted for inspection at one time.

10. Number of Tests

10.1 Routine lot inspection shall consist of all the criteria specified in the applicable product tables.

10.2 The criteria listed in these product tables and definitions are sufficient to establish conformity of the sheet, plate, rod, or tubular bars to this specification. When the number of test specimens is not stated in the test method, a single determination may be made. If more than single determinations and separate portions of the same sample are made, the results shall be averaged. The final result shall conform to the requirements prescribed in this specification.

11. Test Conditions

11.1 *Conditioning of Specimens*—The specification values and dimensions are based on conditioning techniques outlined in Procedure A of Practice D 618.

11.2 *Standard Temperature*—The tests shall be conducted at the standard laboratory temperature of $23 \pm 1^\circ\text{C}$ ($73.4 \pm 1.8^\circ\text{F}$). Since the rod or heavy-walled tubing does not absorb water, the maintenance of constant humidity during testing is not important.

12. Test Methods

12.1 *Visual Inspection*—Visually inspect each sample of PTFE rod or heavy-walled tubing selected in accordance with Section 9 to verify its compliance with the requirements of this specification. Occasional superficial flaws in PTFE rod or heavy-walled tubing should be interpreted as not affecting the physical and electrical properties, however, if there is an appearance of a transverse discontinuity or “poker chip,” testing for tensile strength and elongation is imperative.

12.2 *Specific Gravity*—Determine the specific gravity of the rod or heavy-walled tubing in accordance with Method A of Test Methods D 792. Two drops of wetting agent should be added to the water in order to reduce the surface tension and ensure complete wetting of the specimens. Test two specimens representative of the cross-section of the rod or heavy-walled tubing and average the results.

12.2.1 The gradient tube method of Test Method D 1505 may be used as an alternate on three specimens.

12.3 Tensile Strength and Elongation:

12.3.1 Determine the tensile strength and elongation of rods in accordance with Test Method D 638 as modified in 12.3.1.1 through 12.3.2.

12.3.1.1 Use sample geometry from Test Method D 1708 unless it is too small.

12.3.1.2 Rods of 6.35-mm ($1/4$ -in.) and smaller may be tested in full cross-section.

12.3.2 For the tensile strength and elongation of heavy-walled tubing, test five specimens in accordance with Test Method D 638 using specimens conforming to Type IV of that test method. (See Fig. 1.) The speed of testing shall be 50.8 mm (2 in.)/min.

12.4 Dielectric Strength:

12.4.1 Determine the dielectric strength of the rod in accordance with the short-timed test of Test Method D 149. Test five specimens and average the results.

12.4.2 *Dielectric Strength of Heavy-Walled Tubing*—Test three specimens prepared in accordance with 12.4.2.1 or 12.4.2.2, as applicable, in accordance with Test Method D 149 using the short-time test under oil. For flat specimens, the

constructed to ensure acceptance by common carriers for safe transportation at the lowest rate to the point of delivery, unless otherwise specified in the contract or order.

16.2 All packing, packaging, and marking provisions of Practice D 3892 shall apply to this specification.

17. Keywords

17.1 heavy-walled tubing; polytetrafluoroethylene; polytetrafluoroethylene, recycled plastic; polytetrafluoroethylene, shape; rod, polytetrafluoroethylene

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