Designation: D6457 – 08 (Reapproved 2013)

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

This standard is issued under the fixed designation D6457; 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 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 D4894.

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 are 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 D7209.

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—Although this specification and ISO 13000-1 and ISO 13000-2 differ in approach or detail, data obtained using either are technically equivalent.

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D374 Test Methods for Thickness of Solid Electrical Insulation (Withdrawn 2013)[3]
D638 Test Method for Tensile Properties of Plastics
D792 Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement
D883 Terminology Relating to Plastics
D1600 Terminology for Abbreviated Terms Relating to Plastics
D1708 Test Method for Tensile Properties of Plastics by Use of Microtensile Specimens
D3892 Practice for Packaging/Packing of Plastics
D4000 Classification System for Specifying Plastic Materials
D4591 Test Method for Determining Temperatures and Heats of Transitions of Fluoropolymers by Differential Scanning Calorimetry
D4894 Specification for Polytetrafluoroethylene (PTFE) Granular Molding and Ram Extrusion Materials
D7209 Guide for Waste Reduction, Resource Recovery, and Use of Recycled Polymeric Materials and Products
E94 Guide for Radiographic Examination
IEEE/ASTM SI-10 Standard for Use of the International System of Units (SI): The Modern Metric System

2.2 *ISO Standard:*[4]

ISO 13000-1 Plastics—Polytetrafluoroethylene (PTFE) Semi-Finished Products—Part I: Requirements and Designation
ISO 13000-2 Plastics—Polytetrafluoroethylene (PTFE) Semi-Finished Products—Part II: Preparation of Test Specimens and Determination of Properties

3. Terminology

3.1 *Definitions:*

3.1.1 Terms are defined in accordance with Terminology D883 unless otherwise specified.

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

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

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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] The last approved version of this historical standard is referenced on www.astm.org.

[4] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, http://www.ansi.org.

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

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

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

3.2 *Abbreviations:*

3.2.1 Abbreviations are in accordance with Terminology D1600 unless otherwise indicated.

3.2.2 *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 is categorized by type, class, and grade as defined in Tables 1 and 2.

4.2.2 Each type of PTFE shape is 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 D4000 also is used to describe extruded or compression molded products not included in Tables 1 and 2 by means of 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 D4000 as they apply.

4.6 *Callout Designation*—A line callout system is used to specify materials in this specification. The system uses predefined cells to refer to specific aspects of this specification illustrated as follows:

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 ½	2.14	2000	150	700	A or B	C or D
						½ to 1½	2.15	2100	175	750	A or B	C or D
						over 1½	2.15	2200	200	800	A	C or D
				2	general purpose	less than ½	2.12	1700	100	600	A or B	C or D
						½ to 1½	2.13	1800	125	650	A or B	C or D
						less than ½	2.14	1900	150	700	A	C or D
				3	noncritical	less than ½	2.12	1400	50	250	A or B	C or D
						½ to 1½	2.13	1500	75	250	A or B	C or D
						over 1½	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 ½	TBD	TBD	TBD	TBD	A or B	C or D
						½ to 1½	TBD	TBD	TBD	TBD	A or B	C or D
						over 1½	TBD	TBD	TBD	TBD	A	C or D
				2	general purpose	less than ½	TBD	TBD	TBD	TBD	A or B	C or D
						½ to 1½	TBD	TBD	TBD	TBD	A or B	C or D
						less than ½	TBD	TBD	TBD	TBD	A	C or D
				3	noncritical	less than ½	TBD	TBD	TBD	TBD	A or B	C or D
						½ to 1½	TBD	TBD	TBD	TBD	A or B	C or D
						over 1½	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
		2	recycled	0	as specified	none	-	-	-	-	A or B	C or D
		0	as specified	0	as specified	none	-	-	-	-	A or B	C or D

[A] One inch equals 25.4 mm.
[B] See 12.2.
[C] See 12.3.
[D] See 12.4.
[E] See 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.
[F] See 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
				0	as specified	-	-	-	-	A or B	C or D
		2	recycled	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	0	as specified	-	-	-	-	A or B	C or D
00	As specified	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

[A] See 12.2.
[B] See 12.3.
[C] See 12.4.
[D] See 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.
[E] See 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 *Examples:*

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.

4.6.2 These two examples illustrate how a one-line, alphanumeric sequence identifies 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 must be specified at the time of order. Physical properties for products not yet included in Table 1 are specified using Classification D4000 for xtruded or compression-molded products.

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

[A] One inch equals 25.4 mm.
[B] Intermediate diameters shall conform to the tolerance of the next larger diameter in this table.
[C] The tolerance is plus for outside diameters and minus for inside diameters.

6.2 *Melting Point*—The melting point of all types of rod and heavy-walled tubing shall be 327 ± 10°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 in accordance with Table 3. Measurements shall be made in accordance with Method A of Test Methods D374.

7.2 For rod and heavy-walled tubing, 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

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 with occasional spots. Class 2 typically are white 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 E94.

9. Sampling

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

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, make a single determination. 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 D618.

11.2 *Standard Temperature*—The tests shall be conducted at the standard laboratory temperature of 23 ± 1°C [73.4 ± 1.8°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 will not affect 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 D792. Two drops of wetting agent are 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.

12.3 *Tensile Strength and Elongation:*

12.3.1 Determine the tensile strength and elongation of rods in accordance with Test Method D638 as modified in 12.3.1.1 through 12.3.2.

12.3.1.1 Use sample geometry from Test Method D1708 unless it is too small.

12.3.1.2 Test rods of 6.35-mm [¼-in.] and smaller 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 D638 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:*

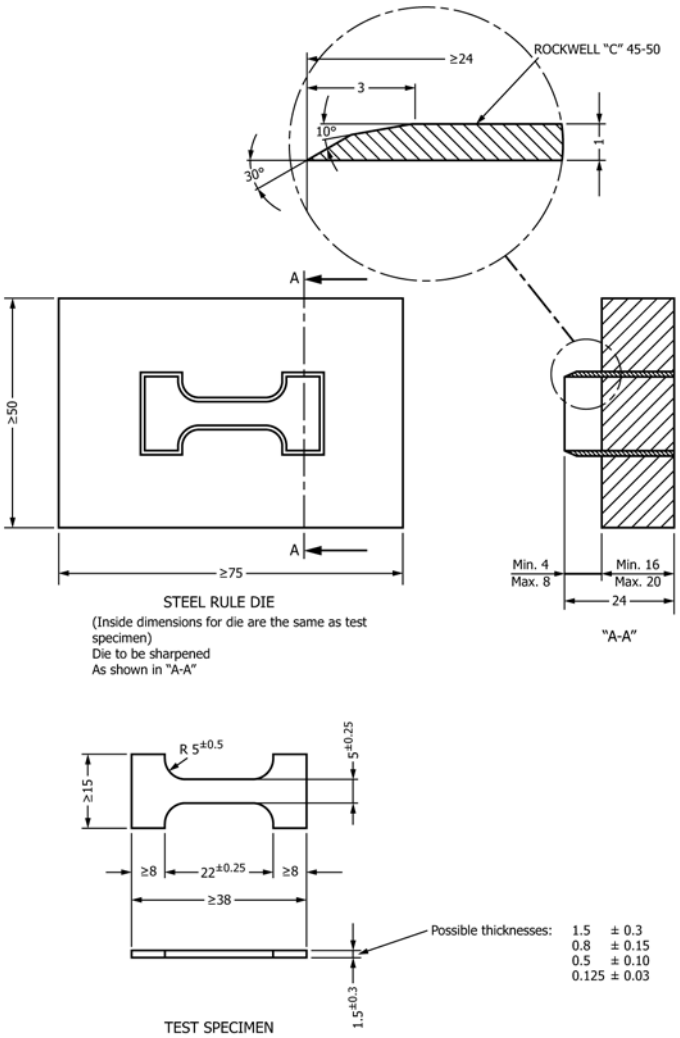
12.4.1 Determine the dielectric strength of the rod in accordance with the short-timed test of Test Method D149. Test five specimens and average the results.

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 D149 using the short-time test under oil. For flat specimens, the electrode shall be as specified in Table 1 of Test Method D149. For tubular specimens, use a straight metal rod for the inner electrode.

12.4.2.1 *Flat Specimens*—Where diameter and wall thickness are sufficient, cut specimens perpendicular to the lengthwise axis as wafers 1 ± 0.02 mm [0.040 ± 0.001 in.] thick and of sufficient size to prevent flashover during the test.

12.4.2.2 *Tubular Specimens*—When tube or tubing dimensions are too small to allow preparation of specimens in accordance with 12.4.2.1, prepare specimens by cutting tubes or tubing into suitable short lengths. Length of specimens shall be sufficient to prevent flash-over.

12.5 *Dimensional Stability*—Determine the dimensional stability of the rod or heavy-walled tubing by cutting two sections of rod from each end 25.4 ± 0.127 mm [1 ± 0.005 in.] in length. Measure (see 7.1) their length and diameter to the nearest 0.0254 mm [0.001 in.] at the center point. Mark these points of original measurements so that measurement after heating and cooling is made at the same points. Place them in a heating chamber that can be elevated to a temperature of 290 ± 3°C [554 ± 5.4°F]. The heating medium is either oil or air. Hold the specimens at this temperature for at least 2 h for each 6.35 mm [0.25 in.] in diameter. Then, lower the temperature at



NOTE 1—Dimensions in millimetres.

FIG. 1 Microtensile Die

a rate not exceeding 30°C [54°F]/h until room temperature is reached. Measure the lengths and diameters of the specimens again to the nearest 0.0254 mm [0.001 in.] at the center point. The change in dimensions shall be calculated by the following formula and the results averaged:

$$D = \frac{L_n - L_i}{L_i} \times 100 \quad (1)$$

where:

D = percent dimensional change,
L_n = initial dimension of sample, and
L_i = dimension of sample after heating.

12.6 *Examination for Internal Defects*—The examination for internal defects in the rod or heavy-walled tubing shall be in accordance with the method described in Guide E94. X-ray the specimen in as many views as necessary to give complete coverage of the piece. Identify all film to correspond with the rod section or view. View the films for defects, such as macroscopic voids, cracks, and inclusions. Films showing apparent defects are checked against the corresponding specimen and position to make sure that such defects are not due to surface damage or surface contamination.

12.7 *Melting Point*—Determine the melting point on one specimen in accordance with Specification D4894. As an alternative, use the procedure given in Test Method D4591.

13. Rejection and Rehearing

13.1 Material that fails to conform to the requirements of this specification is rejected. Report rejections to the producer or supplier promptly and in writing.

13.2 The number of specimens used for any retesting shall be twice that for the original test.

14. Certification

14.1 For all Class 2 rod or heavy-walled tubing, the purchaser shall be furnished certification that this rod or heavy-walled tubing is made from only virgin PTFE and that the sample representing each lot have been either tested or inspected as directed in this specification and the requirements have been met. When specified in the purchase order or contract, a report of the test results shall be furnished.

15. Identification and Product Marking

15.1 *Identification*—Marking of the rod or heavy-walled tubing in bundles shall show the name of the material, grade, type, and class of PTFE rod or heavy-walled tubing and the quantity.

15.2 *Shipping Containers*—Boxes or crates shall be marked with the name of the material, grade, type, class, and lot number, as well as the name and address of the supplier.

16. Packaging and Package Marking

16.1 *Commercial Packing*—The PTFE rod or heavy-walled tubing shall be packed in standard commercial containers, 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 D3892 shall apply to this specification.

17. Keywords

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