



Designation: D3294 – 22

# Standard Specification for Polytetrafluoroethylene (PTFE) Resin Molded Sheet and Molded Basic Shapes<sup>1</sup>

This standard is issued under the fixed designation D3294; 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 establishes requirements and methods of test for the material, dimensions, and workmanship, and the physical and electrical properties of molded sheet in minimum thicknesses of 0.794 mm ( $\frac{1}{32}$  in.) manufactured from PTFE resin molding materials defined in Specification D4894.

1.2 This specification also establishes requirements for molded basic shapes made from molding materials. This specification is for products 300 mm (12 in.) or less in a dimension parallel to and 12.7 mm (0.5 in.) or greater in the dimension perpendicular to the direction of the applied molding pressure.

1.3 The values stated in SI units are to be regarded as the standard.

1.4 The following precautionary caveat pertains only to the test method portion, Section 7, 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.* Special attention is called to 13.2, 13.3, 13.6, 13.8, and A1.

NOTE 1—There is no known ISO equivalent to this standard.

1.5 *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 D20 on Plastics and is the direct responsibility of Subcommittee D20.15 on Thermoplastic Materials (Section D20.15.12).

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## 2. Referenced Documents

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

D149 Test Method for Dielectric Breakdown Voltage and Dielectric Strength of Solid Electrical Insulating Materials at Commercial Power Frequencies

D374/D374M Test Methods for Thickness of Solid Electrical Insulation

D618 Practice for Conditioning Plastics for Testing

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

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

D5947 Test Methods for Physical Dimensions of Solid Plastics Specimens

E94/E94M Guide for Radiographic Examination Using Industrial Radiographic Film

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

## 3. Terminology

3.1 *Definitions*:

3.1.1 Definitions are in accordance with Terminology D883 unless otherwise specified.

<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.

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

3.1.2 *lot, n*—one continuous production run or a uniform blend of two or more production runs of one size sheet or molded basic shape.

3.2 *Abbreviations:*

3.2.1 Abbreviations are in accordance with Terminology D1600.

4. Classification

4.1 This specification covers the following four types of molded basic sheets and shapes:

4.1.1 *Type I*—Premium; normally used for exacting electrical, mechanical, or chemical applications.

4.1.2 *Type II*—General purpose; for electrical, mechanical, and chemical applications not requiring premium material.

4.1.3 *Type III*—Mechanical Grade; for non-critical chemical, electrical, and mechanical applications.

4.1.4 *Type IV*—Utility; having no electrical requirements and with mechanical properties at a lower level.

4.2 Types I, II, and III shall be subdivided into two grades as follows:

4.2.1 *Grade 1*—made only from virgin resin.

4.2.2 *Grade 2*—made using reprocessed resin.

4.3 The grades shall be further subdivided into four classes as follows:

4.3.1 *Class A*—resistant to thermal dimensional change not exceeding 0.5 %.

4.3.2 *Class B*—thermal dimensional change not exceeding 5.0 %.

4.3.3 *Class C*—no requirement for thermal dimensional change.

4.3.4 *Class D*—as agreed by the processor and customer.

4.4 A one-line system shall be used to specify materials covered by this specification. The system uses predefined cells to refer to specific aspects of this specification, as illustrated below.

Specification				
Standard Number	Type	Grade	Class	Special
Block	:	:	:	Notes
:	:	:	:	:

Example: Specification D3294 – 03, I I A

For this example, the line callout would be Specification D3294 – 03, 11A and would specify premium virgin form of polytetrafluoroethylene that has all of the properties listed for that Type, Grade, and Class in the appropriate specified properties, tables, or both, in the specification identified. A comma is used as the separator between the standard Number and the Type. Separators are not needed between the Type, Grade, and Class.<sup>3</sup> Provision for Special Notes is included so that other information shall be provided when required. An example would be in Specification D3295 where dimensions and tolerances are specified for each AWG size within Type and Class. When Special Notes are used, they shall be preceded by a comma.

<sup>3</sup> See the ASTM Form and Style Manual. Available from ASTM International Headquarters.

5. Ordering Information

5.1 The molded sheet or basic shapes covered in this specification shall be ordered stating the type, grade, and class and that they meet the requirements of this specification.

6. Materials

6.1 The sheet or molded basic shape from Types I, II, III, or IV shall be made from unpigmented PTFE as free of foreign matter as commercially practical.

7. Requirements

7.1 The sheet covered by this specification shall meet the physical and electrical requirements specified in Table 1 when tested by the methods given in Section 13.

7.2 The molded basic shapes covered by this specification shall meet the physical and electrical requirements specified in Table 2 when tested by the test methods given in Section 13.

7.2.1 *Melting Point*—the melting point of all types of sheet and molded basic shapes shall be 327 ± 10°C when tested in accordance with paragraph 13.8.

8. Dimensions

8.1 The size, shape, dimensional tolerances, and dimensional stability shall be as specified in the contract or order.

8.2 The tolerance on length and width shall be plus 6.3 mm (¼ in.), minus 0 mm (0 in.).

9. Workmanship, Finish, and Appearance

9.1 *Color*—Type I shall be white to translucent. Types II, III, and IV are typically white, but vary to off white or light gray. For Types II, III, and IV occasional small gray, brown, or black spots shall not be considered as cause for rejection.

9.2 *Finish*—The material shall be as free as is commercially practical from surface blisters, wrinkles, cracks and other surface defects that might affect its serviceability. It shall also be commercially free of macroscopic voids, cracks, and foreign inclusions.

9.3 *Internal Defects*—The moldings shall be as free as is commercially practical of microscopic voids, cracks, and foreign inclusions.

TABLE 1 Physical and Electrical Requirements for PTFE Sheets<sup>A</sup>

Types	Tensile Strength <sup>A</sup> (min) psi	Elongation <sup>A</sup> (min) Percent	Dielectric Strength <sup>B</sup> (min) Volts Per Mill	Specific Gravity <sup>C</sup>	Porosity <sup>D</sup>
I	4500	300	600	2.15 to 2.18 <sup>E</sup>	Zero penetration
II	3000	225	500	2.14 to 2.19	Not required
III	2000	150	300	2.13 to 2.19	Not required
IV	1300	75	Not required	2.13 to 2.20	Not required

<sup>A</sup>See 13.2.

<sup>B</sup>See 13.3.

<sup>C</sup>See 13.4.

<sup>D</sup>See 13.6.

<sup>E</sup>PTFE sheet used for tank lining shall be Type I but shall have a specific gravity of 2.19 to 2.22.

**TABLE 2 Physical and Electrical Requirements for Basic Shapes**

Types	Tensile Strength psi (min)	Elongation % (min)	Dielectric Strength Volts per mil (min)	Specific Gravity
I	4800	325	1200	2.14 to 2.18
II	3200	240	850	2.14 to 2.19
III	1500	75	250	2.13 to 2.20
IV	1500	75	Not required	2.13 to 2.20

## 10. Sampling

10.1 Sampling shall be statistically adequate to satisfy the requirements of 15.1

## 11. Number of Tests

11.1 Routine lot inspection tests shall consist of all the tests specified in Table 1, Table 2, or Table 3.

11.2 The tests listed in Table 1 and Table 2, as they apply, are sufficient to establish conformity of the PTFE sheet or basic shapes to this specification. When the number of test specimens is not stated in the test method, single determination shall be made. If more than single determinations and separate portions of the same sample are made, the results shall be averaged. The single or average result shall conform to the requirements prescribed in this specification.

11.3 The properties listed in the Appendix X1 provide additional information. The data shown are informational only and shall not be used for specification purposes.

## 12. Test Conditions

12.1 *Conditioning of Specimens*—Unless otherwise specified in this specification, the test specimens shall be conditioned in accordance with Procedure A of Practice D618 for a period of at least four h prior to test.

12.2 *Standard Temperature*—Unless otherwise specified, the tests shall be conducted at the standard laboratory temperature of 23°C ± 2°C (73.4°F ± 3.6°F). Since the sheet or molded basic shape does not absorb water, the maintenance of constant humidity during testing is not important.

## 13. Test Methods

13.1 *Visual and Dimensional Inspection*—Each of the sample PTFE sheets or molded basic shapes selected in accordance with Section 10 shall be visually and dimensionally

inspected to verify their compliance with the requirements of the standard. Occasional superficial flaws in PTFE sheet or molded basic shapes shall be interpreted as neither affecting the porosity nor soundness of the molding. Such flaws are scratches, edge cracks, and the adherence of resin flakes. Such indications shall not be cause for rejection.

13.2 *Tensile Strength and Elongation*—Determine the ultimate tensile strength and elongation in accordance with Test Method D638 except as follows:

13.2.1 Cut five micro-specimens with the steel rule die and the dimensions shown in Fig. 1 using a hydraulic or mechanical press. When cutting a specimen, back it by a hard surface board such as masonite or equal with a piece of thin cardboard between said hard surface and sample.

13.2.2 Testing shall be at a speed of 50.8 mm (2 in.)/min.

13.2.3 Determine elongation by using an initial jaw separation of 22.2 mm (0.875 in.) and expressed as a percentage of the initial jaw separation.

13.2.4 *Alternative Specimens*—When the shape of the sample does not permit making the micro-specimen as specified in 13.2.1 prepare specimens by turning a 0.8-mm (1/32-in.) thick-walled tube from the shape, and cutting dumbbells from the tube wall in a direction perpendicular to the applied molding pressure, that is, with the long axis of the dumbbell parallel to the circumference of the tube. Lathe-turn the tube in such a manner that the specimen is taken from the center of the original wall thickness. In the case of a rod, remove the outer 1.6 mm (1/16 in.) before finish turning the outer diameter of the tube. Turn both inside and outside surfaces with a fine lathe feed and sharp tools to permit the smoothest possible finish.

13.2.5 Cut sheets 1.6 mm (1/16 in.) or under in thickness, five micro-specimens with the steel rule die and the dimensions shown in Fig. 1 using a hydraulic or mechanical press. Machine sheets thicker than 1.6 mm (1/16 in.) and thinner than 15.9 mm (5/8 in.) to a thickness of 1.6 ± 0.25 mm (1/16 ± 0.010 in.) and five specimens from these reduced portions. From sheets 15.9 mm (5/8 in.) and over in thickness, a slice somewhat thicker than 1.6 mm (1/16 in.) shall be cut from one edge but not less than 12.7 mm (1/2 in.) distance from that edge and both faces machined to a thickness of 1.6 ± 0.25 mm (1/16 ± 0.010 in.). In all cases of specimens reduced to 1.6 mm (1/16 in.) by machining, tool marks shall be removed by light sanding in a longitudinal direction.

13.3 *Dielectric Strength*—Determine the dielectric strength in accordance with Test Method D149 using five specimens and the short-time test under oil, except as follows:

13.3.1 When 25.4 mm (1 in.) specimens are used, the electrodes shall be 63.5 mm (1/4 in.) in diameter, with edges rounded to a 0.8 mm (1/32 in.) radius.

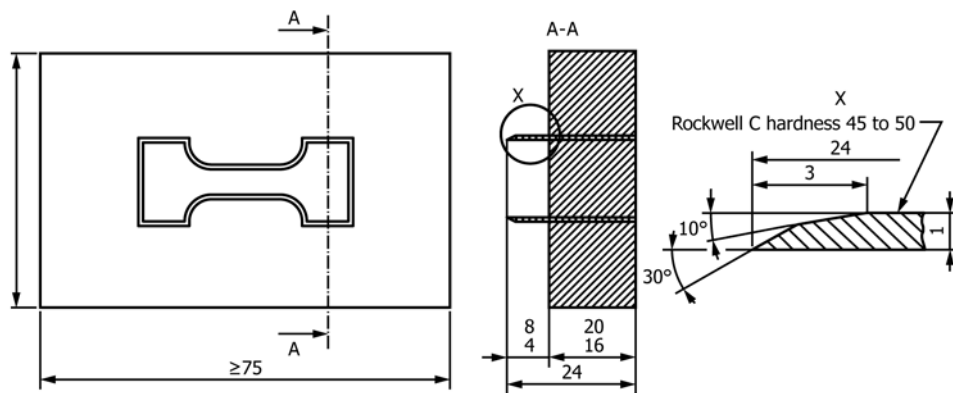
13.3.2 If the size of the molding does not permit 25.4 mm (1 in.) wide specimens, 12.7 mm (1/2-in.) discs or strips 0.5 ± 0.05 mm (0.020 ± 0.002 in.) thick shall be used with 1.6-mm (1/16-in.) diameter electrodes with rounded edges.

13.3.3 The specimen must extend sufficiently far beyond the electrode edge so that a flash-over does not occur.

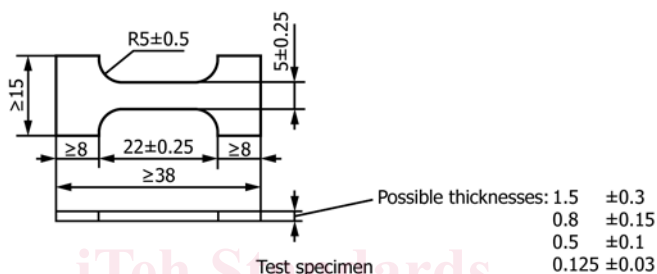
13.4 *Specific Gravity*—Determine the specific gravity on two specimens in accordance with Method A of Test Methods

**TABLE 3 Nominal Thickness and Tolerances for PTFE Sheets**

Thickness Inch	Tolerance Inch	Thickness Inch	Tolerance Inch	Thickness Inch	Tolerance Inch
1/32	+0.015 -0.005	1/4	+0.030 -0.015	1/4	+0.102 -0.051
1/16	+0.015 -0.005	3/8	+0.038 -0.019	1/2	+0.118 -0.059
3/32	+0.020 -0.005	1/2	+0.046 -0.022	3/4	+0.134 -0.067
1/8	+0.016 -0.008	5/8	+0.054 -0.027	2	+0.150 -0.075
5/32	+0.018 -0.009	3/4	+0.070 -0.035	Over 2	+10 % -10 %
3/16	+0.022 -0.011	1	+0.087 -0.043		



Steel-rule die  
(inside dimensions for die are the same as test specimen)  
Die to be sharpened on outside edge only (as shown in A-A)



NOTE 1—Dimensions in millimetres.

FIG. 1 Microtensile Die—ISO

D792. Add two drops of a wetting agent (liquid detergent)<sup>4</sup> to the water in order to reduce the surface tension and insure complete wetting of the sample.

13.5 Porosity—Determine the porosity of Type I sheet or molded shape by the penetrant test.

13.5.1 Scope—The test for porosity is to determine that the molding has received adequate pressure and temperature throughout.

13.5.2 Significance and Use—The significance of this test for porosity is to indicate if the molding has been properly manufactured.

13.5.3 Use one full size sheet or molding for the porosity test. Degrease the entire surface on the molding with folded paper wiping tissues wet with a suitable cleaner.<sup>5</sup> Remove the excess cleaner and permit the surface to dry for at least 5 min.

13.5.4 Deposit a film of penetrant<sup>5</sup> on the entire surface of the molding and allow to stand for 5 min. If the penetrant appears to dry prematurely, rewet the surface with penetrant and allow to dry for 1 min longer. Then, remove the penetrant by wiping with a tissue and scrub the entire surface thoroughly with tissues wet with cleaner.

13.5.5 When dry, inspect entire surface for indication of discoloration caused by the penetrant. Retained areas of penetrant that appear cloudy or hazy indicate porosity. Occasional superficial flaws in PTFE sheet or moldings shall not be interpreted as porosity.

13.5.6 Precision and Bias—The precision and bias for this penetrant-die test will be determined.

13.6 Dimensional Stability—Determine the thermal dimensional change of each lot of material using the method in 13.6.1 – 13.6.10.

13.6.1 Scope—The test for dimensional stability is specific to determine the amount of change of dimension when the molding is heated.

13.6.2 Significance and Use—The significance of this test is to indicate if the molding has been adequately stress relieved.

13.6.3 Measure the entire molding to the nearest 0.025 mm (0.001 in.) in directions of length, width, and depth of sheets and blocks, length and diameter of cylinders, and length, diameter, and wall thickness of tubes. Measurements shall be made in accordance with Method A of Test Methods D374/D374M or Test Method D5947.

13.6.4 Mark the points of original measurement so that measurement after heating and cooling is made at the same points.

13.6.5 Place the molded shape or sheet in a heating chamber at a temperature of  $290 \pm 3^\circ\text{C}$  ( $554 \pm 5.4^\circ\text{F}$ ). The heating medium is either oil or air.

<sup>4</sup> Examples of suitable wetting agents are “Joy” detergent, Proctor and Gamble, Inc.; and “Triton” X-100, Dow Chemical Company.

<sup>5</sup> Spotcheck cleaner and penetrant, available from Magnaflux Corp., 7300 W. Lawrence Ave., Chicago, IL 60656 has been found satisfactory for this purpose. Spotcheck developer is not required.