



# Standard Specification for Filled Compounds of Polytetrafluoroethylene (PTFE) Molding and Extrusion Materials<sup>1</sup>

This standard is issued under the fixed designation D 4745; 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 polytetrafluoroethylene (PTFE) filled molding compounds made with virgin PTFE resins defined in Specification D 4894, except Types I, IV, V, and VI.

NOTE 1—This specification can be used as a model for other PTFE compounds having particulate fillers that can survive the sintering temperatures of PTFE as can those listed in this specification. This specification is restricted to virgin PTFE for technical reasons. Recycled material cannot be processed successfully.

NOTE 2—The properties measured on commercially fabricated parts may differ from the listed values for samples prepared by the procedures given in this specification, depending on part geometry and processing parameters.

NOTE 3—There is no ISO equivalent to this specification.

1.2 The values stated in SI units as detailed in Practice E 380 are to be regarded as the standard and the practices of E380 incorporated herein.

1.3 The following statement applies to the test method portion, Section 12, 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 and health practices and determine the applicability of regulatory limitations prior to use.* See 9.5 and Note 4 for a specific warning statement.

## 2. Referenced Documents

### 2.1 ASTM Standards:

- D 618 Practice for Conditioning Plastics and Electrical Insulating Materials for Testing<sup>2</sup>
- D 638 Test Method for Tensile Properties of Plastics<sup>2</sup>
- D 792 Test Methods for Specific Gravity (Relative Density) and Density of Plastics by Displacement<sup>2</sup>
- D 883 Terminology Relating to Plastics<sup>2</sup>
- D 1600 Terminology for Abbreviated Terms Relating to Plastics<sup>2</sup>

<sup>1</sup> 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.

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<sup>2</sup> Annual Book of ASTM Standards, Vol 08.01.

- D 1895 Test Methods for Apparent Density, Bulk Factor, and Pourability of Plastic Materials<sup>2</sup>
- D 1898 Practice for Sampling of Plastics<sup>2</sup>
- D 3892 Practice for Packaging/Packing of Plastics<sup>3</sup>
- D 4894 Specification for Polytetrafluoroethylene (PTFE) Granular Molding and Extrusion Materials<sup>4</sup>
- E 11 Specification for Wire-Cloth Sieves for Testing Purposes<sup>5</sup>
- E 380 Practice for the Use of the International System of Units (SI)<sup>5</sup>
- E 691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method<sup>5</sup>

## 3. Terminology

3.1 *Definitions*—The terminology given in Terminology D 883 is applicable to this specification unless otherwise specified.

### 3.2 Definitions of Terms Specific to This Standard:

3.2.1 *bulk density, n*—the mass in kilograms per cubic metre of resin compound measured under the conditions of the test.

3.2.2 *density, n*—the mass per unit volume in air in milligrams per cubic metre (grams per cubic centimetre) of the material at a temperature of  $23 \pm 2^\circ\text{C}$  ( $73.4 \pm 4^\circ\text{F}$ ).

3.2.3 *filled compound, n*—blend of PTFE resin as the matrix and particulate fillers, generally glass, other inorganic, metallic, or polymeric materials that withstand the sintering temperature of PTFE ( $327$  to  $380^\circ\text{C}$ ).

3.2.4 *free-flow resins (pelletized), n*—generally made by treatment of finely divided resins to produce free-flowing agglomerates.

3.2.5 *lot, n*—one continuous production run or a uniform blend of two or more production runs of the compound.

3.2.6 *pigmented compound, n*—a compound in which a pigment is added for colorant purposes only.

3.2.7 *standard flow resins (nonpelletized), n*—finely divided resin with an average particle size less than  $100\ \mu\text{m}$ .

3.3 *Abbreviations*—Abbreviations are in accordance with

<sup>3</sup> Annual Book of ASTM Standards, Vol 08.02.

<sup>4</sup> Annual Book of ASTM Standards, Vol 08.03.

<sup>5</sup> Annual Book of ASTM Standards, Vol 14.02.

Terminology D 1600. PTFE is the acronym for polytetrafluoroethylene.

#### 4. Classification

4.1 This specification covers the following two types of PTFE compounds

4.1.1 *Type I*—Nonpelletized material, for general-purpose compression molding.

4.1.2 *Type II*—Pelletized or free-flowing material, for molding, automatic molding, or ram extrusion.

4.2 Thirteen grades of each type distinguished by the nature of the filler(s) are listed in Tables 1-3.

4.3 A one-line system may be used to specify materials covered by this specification. The system uses predefined cells to refer to specific aspects of this specification, as the following illustrates:

| Specification                      |      |       |       |         |
|------------------------------------|------|-------|-------|---------|
| Standard Number                    | Type | Grade | Class | Special |
| Block                              | :    | :     | :     | Notes   |
| Example: Specification D 4745 – 97 | II   | 2     |       |         |

4.3.1 For this example, the line callout would be Specification D 4745 – 97, II 2, and would specify a pelletized or free-flowing filled composition of polytetrafluoroethylene that has all of the properties listed for that type, and grade 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>6</sup> A provision for special notes is included so that other information can be provided when required. An example would be in Specification D 3295 – 81a where dimensions and tolerances are specified for each AWG size within type and class. When special notes are used, they should be preceded by a comma.

#### 5. Ordering Information

5.1 The filled compounds of PTFE may be ordered using the type, (see 4.1) and the grade (see reference Table 1 and Table 3), or they may be ordered using the designation of the suppliers.

<sup>6</sup> See the *ASTM Form and Style Manual*, available from ASTM Headquarters.

#### 6. Requirements

6.1 The PTFE compounds covered by this specification shall be uniform (filler and resin particles evenly distributed) and shall contain no foreign material.

6.2 The PTFE compounds shall conform to the requirements prescribed in Tables 1-3 when tested by the procedures specified herein. Table 1 and Table 3 list requirements for Type I. Table 2 and Table 3 reference requirements for Type II.

6.3 Other PTFE compounds are commercially available, but are not described in this specification.

#### 7. Sampling

7.1 Sample the resin in accordance with the Sections covering General Sampling Procedures in Practice D 1898. Adequate statistical sampling prior to packaging shall be considered an acceptable alternative.

7.2 The producer shall take (and test) sufficient within-lot samples to ensure adequate in-process quality control and continuing conformance to the property requirements of this specification.

#### 8. Number of Tests

8.1 Routine lot inspection tests shall consist of those carried out to determine the requirements specified in Table 1 or Table 3 depending on type. Periodic tests shall include using all the tests to determine the requirements in Table 3, depending on type.

8.2 The requirements listed in Tables 1-3, as they apply, are sufficient to establish conformity of a material to this specification. When the number of test specimens is not stated in the test method, single determinations may be made. If more than single determinations are made on specimens from separate portions of the same sample, the results shall be averaged. The single or average result shall conform to the requirements prescribed in this specification.

#### 9. Test Specimens

9.1 Test specimens shall be cut from billets molded in accordance with the following procedures. An acceptable alternate procedure for molding the test plaque is described in Specification D 4894.

##### 9.2 Test Billets:

**TABLE 1 TFE Compounds, Type I, Standard Flow (Nonpelletized)**

| Type | Grade                                     | Raw Resin Bulk Density, min, g/L | Molded Parts (Molded and Sintered) |                             |                  |          |                    |
|------|---|----------------------------------|------------------------------------|-----------------------------|------------------|----------|--------------------|
|      |   |                                  | Density, min, g/cm <sup>3</sup>    | SPG, max, g/cm <sup>3</sup> | Tensile Strength |          | Elongation, min, % |
|      |   |                                  |                                    |                             | min, MPa         | min, psi |                    |
| 1    | 15 % glass fiber                          | 400                              | 2.150                              | 2.25                        | 19.6             | 2840     | 250                |
| 2    | 25 % glass fiber                          | 425                              | 2.150                              | 2.250                       | 15.7             | 2270     | 200                |
| 3    | 35 % glass fiber                          | 450                              | 2.200                              | 2.300                       | 10.3             | 1500     | 150                |
| 4    | 5 % glass fiber and 5 % MoS <sub>2</sub>  | 350                              | 2.150                              | 2.300                       | 20.7             | 3000     | 250                |
| 5    | 15 % glass fiber and 5 % MoS <sub>2</sub> | 375                              | 2.150                              | 2.300                       | 17.2             | 2500     | 200                |
| 6    | 10 % graphite                             | 350                              | 2.100                              | 2.220                       | 17.9             | 2600     | 225                |
| 7    | 15 % graphite                             | 300                              | 2.100                              | 2.200                       | 16.6             | 2400     | 100                |
| 8    | 25 % carbon and graphite                  | 350                              | 1.950                              | 2.100                       | 11.0             | 1600     | 80                 |
| 9    | 32 % carbon and graphite                  | 325                              | 1.900                              | 2.100                       | 6.9              | 1000     | 50                 |
| 10   | 40 % bronze                               | 500                              | 2.900                              | 3.200                       | 17.2             | 2500     | 175                |
| 11   | 60 % bronze                               | 650                              | 3.800                              | 4.000                       | 13.8             | 2000     | 140                |
| 12   | 55 % bronze and 5 % MoS <sub>2</sub>      | 700                              | 3.500                              | 4.000                       | 10.3             | 1500     | 80                 |
| 13   | 50 % stainless steel                      | 500                              | 3.200                              | 3.600                       | 17.2             | 2500     | 150                |

TABLE 2 TFE Compounds, Type II, Free-Flow (Pelletized)

| Type | Grade                                     | Raw Resin Bulk Density, min, g/L | Molded Parts (Molded and Sintered) |                             |                  |          |                    |
|------|---|----------------------------------|------------------------------------|-----------------------------|------------------|----------|--------------------|
|      |   |                                  | Density, min, g/cm <sup>3</sup>    | SPG, max, g/cm <sup>3</sup> | Tensile Strength |          | Elongation, min, % |
|      |   |                                  |                                    |                             | min, MPa         | min, psi |                    |
| 1    | 15 % glass fiber                          | 625                              | 2.150                              | 2.25                        | 17.2             | 2500     | 200                |
| 2    | 25 % glass fiber                          | 625                              | 2.150                              | 2.250                       | 12.4             | 1800     | 180                |
| 3    | 35 % glass fiber                          | 650                              | 2.200                              | 2.300                       | 8.3              | 1200     | 100                |
| 4    | 5 % glass fiber and 5 % MoS <sub>2</sub>  | 575                              | 2.150                              | 2.300                       | 17.2             | 2500     | 220                |
| 5    | 15 % glass fiber and 5 % MoS <sub>2</sub> | 600                              | 2.150                              | 2.300                       | 13.8             | 2000     | 180                |
| 6    | 10 % graphite                             | 600                              | 2.100                              | 2.220                       | 13.8             | 2000     | 180                |
| 7    | 15 % graphite                             | 550                              | 2.100                              | 2.200                       | 10.3             | 1500     | 100                |
| 8    | 25 % carbon and graphite                  | 500                              | 1.950                              | 2.100                       | 8.3              | 1200     | 20                 |
| 9    | 32 % carbon and graphite                  | 500                              | 1.900                              | 2.100                       | 6.9              | 1000     | 20                 |
| 10   | 40 % bronze                               | 750                              | 2.900                              | 3.200                       | 13.8             | 2000     | 100                |
| 11   | 60 % bronze                               | 900                              | 3.800                              | 4.000                       | 10.3             | 1500     | 100                |
| 12   | 55 % bronze and 5 % MoS <sub>2</sub>      | 900                              | 3.500                              | 4.000                       | 6.9              | 1000     | 50                 |
| 13   | 50 % stainless steel                      | 850                              | 3.200                              | 3.600                       | 13.8             | 2000     | 100                |

TABLE 3 Required Filler Content

|   | Mass, %  | Tolerance, ±, % |
|---|----------|-----------------|
| 1 | 0 to 3   | 1               |
| 2 | 4 to 25  | 2               |
| 3 | 26 to 60 | 3               |
| 4 | 61 to 75 | 5               |

9.2.1 Prior to molding, screen the material through a 2.0-mm hand sieve.

9.2.2 Preform solid test billets in a mold (see Fig. 1) having a cross-sectional area not greater than 25.8 cm<sup>2</sup> (4 in.<sup>2</sup>) and of sufficient height to contain the sample. Clearance should be sufficient to ensure escape of entrapped air during pressing. The billet length may be varied in accordance with the amount of testing to be done. A mold length of 250 mm (9.8 in.) produces a billet approximately 75 mm (2 to 3 in.) long. Powder-charge weight may be varied according to the density of the material. The billet length should not exceed 75 mm (3 in.).

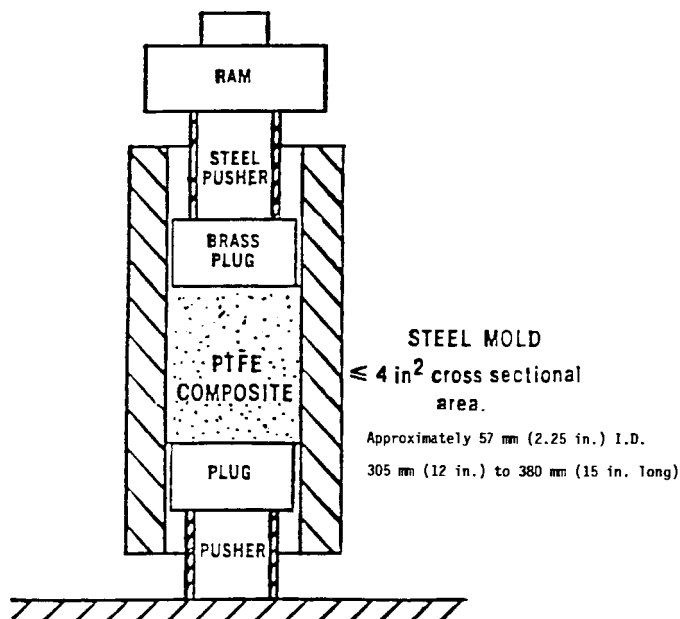


FIG. 1 Preforming of PTFE Composite Test Billet

9.2.3 Assemble the mold. Add the resin to the mold, taking care not to fill within 13 mm (0.5 in.) of the top of the cavity. Insert the top plug and apply hand pressure, making certain that the pusher is centered in the mold. Place the mold in a hydraulic press and remove the support ring or spacers. Do not allow the two end plugs to bottom on the mold shell. Apply an initial load to the mold of 3.45 MPa (500 psi) ± 10 % and hold for 1 to 2 min. Increase the loading smoothly to the final preforming pressure in 3 to 5 min. Use 35 MPa (5100 psi) for compounds containing 15 % by weight or less filler and 70 MPa (10150 psi) for composite compounds containing more than 15 % filler. For compounds containing bronze filler, use 60 MPa (8500 psi), and hold under maximum pressure for 2 to 5 min. Release the pressure gradually without apparent movement of the press platens. Then open the press, remove the top pusher from the mold, and force the preform vertically out of the mold, using a continuous, smooth movement.

9.2.4 Place the preform in a sintering oven and sinter in accordance with the procedures in Table 4. Use Procedure B for compounds containing molybdenum disulfide filler.

9.3 Sectioning Test Billet:

9.3.1 Remove and discard the top and bottom 2-mm (1/16 in.) section of the billet. Obtain transverse test specimens from as near the center of the billet as possible.

9.3.2 Prepare five test specimens, 1 ± 0.25 mm (0.040 ± 0.010 in.) in thickness for the determination of tensile strength and elongation and cut a piece of suitable thickness for density measurements. This piece should be approximately cubical in shape, weighing at least 10 g. All surfaces must be smooth. Take care to avoid wedge-shape cuts.

9.4 The alternative test billet is described in Specification D 4894.

TABLE 4 Sintering Procedures for Test Billets

|  | Procedure A        | Procedure B        |
|--|--------------------|--------------------|
| Initial temperature, °C (±) <sup>A</sup> | Ambient            | Ambient            |
| Rate of heating, °C/h (°F/h)             | 60 ± 5 (108 ± 9)   | 60 ± 5 (108 ± 10)  |
| Hold temperature, °C (°F)                | 370 ± 6 (698 ± 10) | 360 ± 6 (680 ± 10) |
| Hold time, min                           | 120 ± 5            | 120 ± 5            |
| Rate of cooling, °C/h (°F/h)             | 60 ± 5 (108 ± 9)   | 60 ± 5 (108 ± 9)   |
| Final temperature, °C (°F) <sup>A</sup>  | 95 ± 6 (203 ± 10)  | 95 ± 6 (203 ± 10)  |
| Time to cool to room temperature, h      | 24                 | 24                 |

<sup>A</sup> Oven can be opened safely at these temperatures.