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# Standard Specification for Parts Machined from Polychlorotrifluoroethylene (PCTFE) and Intended for General Use<sup>1</sup>

This standard is issued under the fixed designation D7211; 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 is intended to be a means of calling out finished machined parts ready for general use.

1.2 This specification establishes requirements for parts machined from polychlorotrifluoroethylene (PCTFE) semifinished parts.

1.3 For aerospace grade, machined PCTFE parts, use Specification [D7194](#).

NOTE 1—Quick-quenched PCTFE will potentially exhibit dimensional relaxation in the vicinity of  $T_g = 55^\circ\text{C}$  ( $131^\circ\text{F}$ ).

NOTE 2—Although no recommendations are made regarding the limiting upper use temperature of PCTFE, the heat deflection temperature of PCTFE as determined by Test Method [D648](#) is  $126^\circ\text{C}$  ( $259^\circ\text{F}$ ).

1.4 The values stated in SI units are to be regarded as standard. The values in parentheses are for information only.

1.5 The following precautionary caveat pertains only to the test methods portion, 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.*

NOTE 3—There is no known ISO equivalent to this standard.

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 [D20](#) on Plastics and is the direct responsibility of Subcommittee [D20.15](#) on Thermoplastic Materials.

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## 2. Referenced Documents

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

[D618 Practice for Conditioning Plastics for Testing](#)

[D648 Test Method for Deflection Temperature of Plastics Under Flexural Load in the Edgewise Position](#)

[D792 Test Methods for Density and Specific Gravity \(Relative Density\) of Plastics by Displacement](#)

[D883 Terminology Relating to Plastics](#)

[D1430 Classification System for Polychlorotrifluoroethylene \(PCTFE\) Plastics](#)

[D1600 Terminology for Abbreviated Terms Relating to Plastics](#)

[D2117 Test Methods for Carbon Black—Surface Area by Nitrogen Adsorption \(Withdrawn 1999\)](#)<sup>3</sup>

[D4591 Test Method for Determining Temperatures and Heats of Transitions of Fluoropolymers by Differential Scanning Calorimetry](#)

[D7194 Specification for Aerospace Parts Machined from Polychlorotrifluoroethylene \(PCTFE\)](#)

## 3. Terminology

3.1 *Definitions*:

3.1.1 Terms are defined in accordance with Terminologies [D883](#) and [D1600](#) unless listed below.

3.1.2 *Zero Strength Time (ZST), n*—time measured in accordance with Section 10 of Classification [D1430](#) to check the relative molecular weight of the PCTFE material.

## 4. Classification

4.1 Part shape and size shall be defined by the applicable purchase order.

<sup>2</sup> For referenced ASTM standards, visit the ASTM website, [www.astm.org](http://www.astm.org), or contact ASTM Customer Service at [service@astm.org](mailto: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> The last approved version of this historical standard is referenced on [www.astm.org](http://www.astm.org).

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

4.2 General purpose grade PCTFE shall be Class 1 homopolymer in accordance Classification **D1430**.

4.3 The grade of product shall be categorized in accordance with Classification **D1430** as follows:

4.3.1 Grade 0 having an undetermined or unspecified *ZST*.

4.3.2 Grade 1 having an as-polymerized *ZST* of 100 to 199 seconds.

4.3.3 Grade 2 having an as-polymerized *ZST* of 200 to 299 seconds.

4.3.4 Grade 3 having an as-polymerized *ZST* of 300 to 450 seconds.

4.4 The finished part shall be received in an unannealed or annealed state as specified in the applicable purchase order. If annealed, annealing shall be accomplished as described in **11.4**.

## 5. Ordering Information

5.1 All parts covered by this specification shall be ordered by grade and annealed state as listed in Section 4.

## 6. Materials and Manufacture

6.1 Annealed and unannealed parts shall be made from polymers meeting all requirements of Classification **D1430**, Group 01, Class 1, Grades 0, 1, 2, or 3.

6.2 The base material shall be free of all defects or contaminants that would be detrimental to final fabrication or performance of the finished parts.

## 7. Property Requirements

7.1 Specification values listed in this specification are minimum specification values or minimum-maximum specification ranges. Any additional requirement for specific tests or data shall be made at the time of the order.

## 8. General Requirements

NOTE 4—If so specified in the purchase contract or order, the molder producing the semifinished article from which finished parts are made will be responsible for insuring the requirement in **8.8** is met. All other requirements listed in this section pertain to the finished part, and therefore, will be the responsibility of the supplier of the finished, machined part.

8.1 Finished parts shall have a natural translucent appearance. The color shall be white or gray with no yellowing or other unnatural color.

8.2 Finished parts shall be free of voids, scratches, fissures, inclusions, or entrapped air bubbles that will affect serviceability. No particles (for example, black specks) shall be visible to the naked eye.

8.3 Depending on commercial resin grade, processing route (for example, extrusion, compression molding, injection molding), quenching method (water or air cooling), and thickness of the starting semifinished article from which the finished part is made, the specific gravity, sp. gr. 23/23°C of finished PCTFE parts when determined by **11.1**, can vary from 2.11 to 2.17. However, to ensure consistent properties and performance in the intended application, the specific gravity of a finished part shall not be allowed to fluctuate freely within the 2.11 to 2.17 range.

8.4 The melting point of finished parts shall be determined to be in the range of 210 to 220°C (410 to 428°F) as determined in **11.2**.

8.5 Finished parts shall be made from semifinished articles having an as-molded zero strength time (*ZST<sub>stock</sub>*) of 300 to 450 s (Grade 3), or 200 to 299 s (Grade 2), or 100 to 199 s (Grade 1), as determined in **11.3**, or shall be undetermined or unspecified (Grade 0).

NOTE 5—To ensure that the process route does not cause excessive thermal degradation and accompanying molecular weight drop, it is recommended that the maximum allowable *ZST* drop,  $\Delta ZST$ , shall not exceed <20 % as determined in **11.3.4**.

8.6 All finished parts are to be supplied in annealed condition in accordance with **11.4**, or in an unannealed condition.

8.7 No dimension of an annealed, finished part shall change more than 0.003 mm/mm (0.003 in./in.) measured at  $23 \pm 2^\circ\text{C}$  ( $73 \pm 4^\circ\text{F}$ ) before and after being held for  $48 \pm 5$  h at  $70 \pm 5^\circ\text{C}$  ( $158 \pm 9^\circ\text{F}$ ), as determined in **11.5**.

8.8 If so specified in the purchase contract or order, the maximum allowable *ZST* drop,  $\Delta ZST$ , shall be <20 % as determined in **11.3.4**.

## 9. Number of Tests

9.1 When the number of test specimens is not stated in the test method, a single determination is 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.

## 10. Test Conditions

10.1 *Standard Temperature*—The tests shall be conducted at the standard laboratory temperature of  $23 \pm 2^\circ\text{C}$  ( $73 \pm 4^\circ\text{F}$ ) and  $50 \pm 10$  % relative humidity.

## 11. Test Methods

### 11.1 *Specific Gravity (Sp. Gr.)*

11.1.1 Specific gravity of finished parts shall be determined in accordance with Test Methods **D792**, Method A, with the following modifications: The submersion medium (deionized 18 M $\Omega$  cm water) is boiled; then one to two drops of Zonyl fluorosurfactant<sup>4</sup> (or equivalent) wetting agent is added per 100 mL of water. A magnifying glass is used to ensure further that no air bubbles cling to submerged parts during weighings. Specimens shall also be free of internal voids in accordance with **8.2**. The test temperature shall be  $23 \pm 2^\circ\text{C}$  ( $73 \pm 4^\circ\text{F}$ ).

11.1.2 If desired, the weight percent crystallinity,  $W^c$ , is calculated as:

$$W^c = \frac{\rho_c}{\rho} \left( \frac{\rho - \rho_a}{\rho_c - \rho_a} \right) \times 100 \% \quad (1)$$

$$\rho_c = \frac{1}{0.45563 + 0.8079 \times 10^{-4} T + 0.874 \times 10^{-7} T^2}$$

<sup>4</sup>The sole source of supply of the apparatus known to the committee at this time is E. I. DuPont de Nemours and Co., DuPont Corporate Information Center, Chestnut Run Plaza 705/GS38, Wilmington, DE 19880-0705. If you are aware of alternative suppliers, please provide this information to ASTM International Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee,<sup>1</sup> which you may attend.

$$\rho_a = \frac{1}{0.47884 + 1.186 \times 10^{-4} T + 2.20 \times 10^{-7} T^2}$$

where:

- $\rho$  = density (specific gravity) of the finished part,
- $\rho_a$  = density of pure amorphous phase ( $\rho_a = 2.0760 \text{ g cm}^{-3}$  at 23°C),
- $\rho_c$  = density of the pure crystalline phase ( $\rho_c = 2.1856 \text{ g cm}^{-3}$  at 23°C), and
- $T$  = analysis temperature (°C).

11.2 *Melting Point (MP)*—Purity shall be evaluated by determining the melting point at which all spherulitic order disappears as determined by polarized light microscopy in accordance with Test Method **D2117** or, alternatively, by determining the peak crystal melting temperature,  $T_{m,peak}$ , using DSC in accordance with Test Method **D4591**.

### 11.3 Zero Strength Time (ZST)

11.3.1 The ZST apparent molecular weight of the as-molded semifinished article, denoted  $ZST_{stock}$ , shall be determined by procedures in Classification **D1430** using 50-mm (2-in.) long by 4.8-mm ( $\frac{3}{16}$ -in.) wide by 1.58-mm ( $\frac{1}{16}$ -in.) thick V-notched test strips. The ZST will be determined at  $250 \pm 1^\circ\text{C}$  ( $482 \pm 2^\circ\text{F}$ ) using a  $7.5 \pm 0.1$ -g weight.

11.3.2 When determining the ZST of the as-molded semifinished article,  $ZST_{stock}$ , the molding method used to fabricate the semifinished article from which the finished part is made shall be used. Several options exist for sample preparation:

11.3.2.1 For 1.58-mm ( $\frac{1}{16}$ -in.) thick sheet stock, ZST specimens are to be die cut, and

11.3.2.2 For sheet stock that is thicker than 1.58 mm ( $\frac{1}{16}$  in.) or rod stock that has a diameter equal to or greater than 4.8 mm ( $\frac{3}{16}$  in.), it will be necessary to machine the ZST specimens directly from the stock.

11.3.2.3 For sheet stock that is thinner than 1.58 mm ( $\frac{1}{16}$  in.), or rod stock that has a diameter less than 4.8 mm ( $\frac{3}{16}$  in.), standard V-notched ZST test strips will be obtained by reprocessing the semifinished article in accordance with 9.1.2 in Classification **D1430**.

11.3.3 If desired, the ZST of the as-polymerized resin,  $ZST_{resin}$ , will be determined using V-notched test strips cut from compression-molded sheet prepared in accordance with 9.1.2 of Classification **D1430**.

11.3.4 If desired, the ZST drop,  $\Delta ZST$ , will be calculated as:

$$\Delta ZST = \frac{ZST_{resin} - ZST_{stock}}{ZST_{resin}} \times 100 \% \quad (2)$$

11.4 Both unannealed and annealed PCTFE parts are covered by this specification. If an annealed condition is specified, two annealing routes are possible:

11.4.1 *Annealing—Method A*. For the best dimensional stability, parts shall be machined to final dimensions with appropriate allowances for contraction or expansion during annealing, annealed at  $120 \pm 5^\circ\text{C}$  ( $248 \pm 9^\circ\text{F}$ ) for 2 h, cooled to room temperature, after which dimensional stability shall be determined (see **11.5**).

11.4.2 *Annealing—Method B*. For closest tolerances on a finished part, parts shall be machined to approximate dimensions, annealed at  $120 \pm 5^\circ\text{C}$  ( $248 \pm 9^\circ\text{F}$ ) for 2 h, cooled

to room temperature, finished to final dimensions, after which dimensional stability shall be determined (see **11.5**).

### 11.5 Dimensional Stability

11.5.1 Linear dimensional change shall be determined by comparing selected dimensions measured before and after oven heating to simulate accelerated use. Pre- and post-heating dimensional measurements will be made at several reference locations, or at multiple locations distributed equidistantly about the specimen, or both. After the initial dimensions have been measured at 20 to 30°C (68 to 86°F), specimens will be placed in a preheated oven at  $71 \pm 5^\circ\text{C}$  ( $160 \pm 9^\circ\text{F}$ ), heated for  $48 \pm 5$  h, after which the specimens will be removed and allowed to cool. After resting for 16 to 24 h (overnight), the final dimensions will be measured at 20 to 30°C (68 to 86°F), and the percent dimensional change,  $\Delta L$ , calculated as:

$$\Delta L = \frac{L_f - L_i}{L_i} \times 100 \% \quad (3)$$

where:

$L_i$  and  $L_f$  = initial and final dimensions before and after heating.

11.5.2 Measurement of dimensions will always be made with respect to a known direction such as the machine or transverse direction, or alternatively, parallel or perpendicular to the sealing surface, for example.

NOTE 6—Conventional metrological methods (coordinate measuring machines and dial micrometers) do not always have the requisite sensitivity to detect dimensional changes in small parts of the order of 0.3 %. For example, a precision micrometer with 0.013-mm (0.0005-in.) sensitivity will not be able to detect dimensional changes smaller than 0.3 % if the original dimension is less than 4.3 mm (0.17 in.). An example would be PCTFE gaskets with thicknesses of the order of 0.50 mm (0.020 in.). In such cases, dimensional stability shall be indeterminate and shall not constitute grounds for nonprocurement.

## 12. Packaging and Package Marking

12.1 Finished parts shall be individually packaged in sealed envelopes, pouches, bags, or other containers in accordance with the manufacturer's commercial practice.

### 12.2 Marking for Shipment

12.2.1 Each container shall be legibly and permanently labeled with the following information:

12.2.1.1 *Material*—General Purpose Grade PCTFE parts,

12.2.1.2 *Grade 0, 1, 2, or 3*

12.2.1.3 *Annealed Condition*: Unannealed, Annealed Method A, or Annealed Method B

12.2.1.4 *ZST<sub>stock</sub>*

12.2.1.5 *ZST<sub>resin</sub>* and  $\Delta ZST$  (if performed)

12.2.1.6 *Specification number* D7211.

12.2.1.7 *Part manufacturer's name*

12.2.1.8 *Molder's name*

12.2.1.9 *Processing route and date*

12.2.1.10 *Lot number*

12.2.1.11 *Purchase order number*

## 13. Keywords

13.1 annealing; dimensional stability; finished parts; PCTFE; polychlorotrifluoroethylene