Designation: D7211 – 13

Standard Specification for Parts Machined from Polychlorotrifluoroethylene (PCTFE) and Intended for General Use[1]

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 (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 finished machined parts ready for commercial use.

1.2 This specification establishes requirements for parts machined from unplasticized, 100 % polychlorotrifluoroethylene (PCTFE) homopolymers.

1.3 This specification does not cover parts machined from PCTFE copolymers, PCTFE film or tape less than 0.25-mm (0.010-in.) thick, or modified PCTFE (containing pigments or plasticizers).

1.4 This specification allows for parts containing regrind and recycled material.

1.5 The specification does not cover PCTFE parts used in aerospace applications involving storage and handling of oxygen media, air media, inert media, and certain reactive media (specifically ammonia, gaseous hydrogen, and liquid hydrogen), in which dimensional stability, high molecular weight, molecular weight retention, and crystallinity control are important considerations. For aerospace grade, machined PCTFE parts, use Specification D7194.

1.6 *Application*—PCTFE parts covered by this specification are made of 100 % PCTFE resin, free of plasticizers, fillers, or other additives. The parts meet specific physical characteristics appropriate for their end use, and are typically used in applications requiring good electrical properties or resistance to aggressive chemical media. General purpose PCTFE parts include seals, gaskets, valve and pump parts (cryogenic and noncryogenic), translucent tubing, sight glasses, flowmeter tubes, heavy-walled solid pipes and fittings, gears, cams, bearings, laboratory ware, circuit boards, electrical connector covers and switches, radome covers, and a variety of other stock shapes. They are removed and replaced during normal maintenance procedures. The parts also experience static or dynamic mechanical loading, and temperatures ranging from cryogenic to temperatures at or above the glass transition temperature, T_g = 55°C (131°F).

NOTE 1—Quick-quenched PCTFE will potentially exhibit dimensional relaxation in the vicinity of T_g.

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°C (259°F).

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

1.8 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 and health practices and determine the applicability of regulatory limitations prior to use.*

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

2. Referenced Documents

2.1 *ASTM Standards:*[2]

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)[3]

D4591 Test Method for Determining Temperatures and Heats of Transitions of Fluoropolymers by Differential Scanning Calorimetry

[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.

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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.

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

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 *oxygen media, n*—liquid oxygen and gaseous oxygen.

3.1.3 *air media, n*—liquid air and pressurized air (including breathing air).

3.1.4 *inert media, n*—for example, gaseous helium and gaseous nitrogen.

3.1.5 *reactive media, n*—for example, ammonia, gaseous hydrogen, and liquid hydrogen, nitrous oxide, and nitrogen trifluoride.

3.1.6 *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.

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 Parts shall be made from virgin, unfilled, unplasticized, 100 % polychlorotrifluoroethylene (PCTFE) homopolymer and up to 30 percent (by volume) regrind or recycled polymer.

6.3 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_{stock}) 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, ΔZST, 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 ± 2°C (73 ± 4°F) before and after being held for 48 ± 5 h at 70 ± 5°C (158 ± 9°F), as determined in 11.5.

8.8 If so specified in the purchase contract or order, the maximum allowable *ZST* drop, ΔZST, 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 ± 2°C (73 ± 4°F) and 50 ± 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 MΩ cm water) is boiled; then one to two drops of Zonyl fluorosurfactant[4] (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 ± 2°C (73 ± 4°F).

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

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

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

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

where:

ρ = density (specific gravity) of the finished part,
ρ_a = density of pure amorphous phase (ρ_a = 2.0760 g cm^{-3} at 23°C),
ρ_c = density of the pure crystalline phase (ρ_c = 2.1856 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 (3⁄16-in.) wide by 1.58-mm (1⁄16-in.) thick V-notched test strips. The *ZST* will be determined at 250 ± 1°C (482 ± 2°F) using a 7.5 ± 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 (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 (1⁄16 in.) or rod stock that has a diameter equal to or greater than 4.8 mm (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 (1⁄16 in.), or rod stock that has a diameter less than 4.8 mm (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, ΔZST, will be calculated as:

$$\Delta ZST = \frac{ZST_{resin} - ZST_{stock}}{ZST_{resin}} \times 100\,\% \tag{2}$$

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 ± 5°C (248 ± 9°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 ± 5°C (248 ± 9°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 ± 5°C (160 ± 9°F), heated for 48 ± 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, ΔL, calculated as:

$$\Delta L = \frac{L_f - L_i}{L_i} \times 100\,\% \tag{3}$$

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

[4] 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,[1] which you may attend.

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_{stock}

12.2.1.5 ZST_{resin} and ΔZST (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

SUMMARY OF CHANGES

Committee D20 has identified the location of selected changes to this standard since the last issue (D7211 – 06) that may impact the use of this standard. (May 1, 2013)

(1) Deleted withdrawn standard from 2.1.
(2) Changed relative humidity to new requirements of Practice D618.
(3) Renumbered sections throughout.