



Standard Specification for Unmodified Poly(Vinylidene Fluoride) (PVDF) Molding Extrusion and Coating Materials¹

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This standard has been approved for use by agencies of the U.S. Department of Defense.

1. Scope

1.1 This specification covers melt processable molding and extrusion materials, as well as coating materials of poly(vinylidene fluoride) fluoroplastic, commonly abbreviated PVDF (or PVF₂ in scientific literature). This specification covers thermoplastic resin materials supplied in pellet or powder form.

1.2 This specification applies only to the virgin homopolymer prepared from vinylidene fluoride, not copolymers, reinforced, filled grades or special grades with additives or treatments for modification of attributes.

1.3 The tests involved are intended to provide information for specification of unmodified PVDF homopolymer resins. It is not the purpose of this specification to provide engineering data for design purposes.

1.4 PVDF fluoroplastics melt between 156 and 180°C (312 and 356°F) and are thermally stable up to about 370°C (698°F). (**Warning**—Evolution of corrosive and toxic hydrogen fluoride can occur under certain conditions.)

1.5 The values stated in SI units, as detailed in **IEEE/ASTM S-10**, are to be regarded as the standard. The values given in parentheses are for information only.

NOTE 1—PVDF exhibits polymorphism.² The type and extent of crystalline structure varies with the thermomechanical history of the sample. Specimens prepared by techniques different than prescribed in this specification can have properties that vary from the values specified.

1.6 *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.* Specific precautionary statements are given in Section 10.

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 Lovinger, A. J., "Poly(Vinylidene Fluoride)" *Developments in Crystalline Polymers*, Vol 1, Chapter 5, D. C. Bassett, Ed., Applied Science, London, 1982.

NOTE 2—There is no equivalent ISO standard for this specification. Information in this specification is technically equivalent to related information in ISO 12086-1 and ISO 12086-2.

2. Referenced Documents

2.1 ASTM Standards:³

- D149 Test Method for Dielectric Breakdown Voltage and Dielectric Strength of Solid Electrical Insulating Materials at Commercial Power Frequencies
- D150 Test Methods for AC Loss Characteristics and Permittivity (Dielectric Constant) of Solid Electrical Insulation
- D256 Test Methods for Determining the Izod Pendulum Impact Resistance of Plastics
- D257 Test Methods for DC Resistance or Conductance of Insulating Materials
- D542 Test Method for Index of Refraction of Transparent Organic Plastics
- D618 Practice for Conditioning Plastics for Testing
- D638 Test Method for Tensile Properties of Plastics
- D790 Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials
- D792 Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement
- D883 Terminology Relating to Plastics
- D1238 Test Method for Melt Flow Rates of Thermoplastics by Extrusion Plastometer
- D2863 Test Method for Measuring the Minimum Oxygen Concentration to Support Candle-Like Combustion of Plastics (Oxygen Index)
- D3418 Test Method for Transition Temperatures and Enthalpies of Fusion and Crystallization of Polymers by Differential Scanning Calorimetry
- D3835 Test Method for Determination of Properties of Polymeric Materials by Means of a Capillary Rheometer
- D3892 Practice for Packaging/Packing of Plastics
- IEEE/ASTM S-10 Use of the International System of Units

³ 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.

TABLE 1 Classification of PVDF Resins

Property		Typical Values or Ranges		
		Type I		Type II
		Grade 1	Grade 2	
Specific Gravity	Gms/cc	1.75-1.79	1.75-1.79	1.76-1.79
Peak Melting Endotherm	°C	156-162	162-170	164-180
Melt Flow Rate	g/10 min (wt in Kg)			
	Ultra High Viscosity	0.5-10 ^A
	High Viscosity	0.5-8 ^A	5-8 ^B	0.5-10 ^C
	Medium Viscosity	4-18 ^A	5-36 ^B	0.5-30 ^D
	Low Viscosity	...	3.5-45 ^E	0.5-60 ^F
Apparent Melt Viscosity	Pa's: ^G			
	High Viscosity	2800-3800	2800-3700	2500-4000
	Medium Viscosity	2300-2800	1300-2800	1300-2500
	Low Viscosity	...	350-1300	250-1300

Note: For measuring MFR values of PVDF, the load must be selected based on the viscosity as follows:

- ^A= 21.6 Kg
- ^B= 12.5 Kg
- ^C= 10.0 Kg
- ^D= 5 Kg
- ^E= 3.8 Kg
- ^F= 2.16 Kg

^G Reported for a shear rate of 100 s⁻¹ determined by capillary rheometry at 232°C (450°F) using 0.027 radian (60°) entrance angle die with L/D of 15 and in accordance with procedures of Test Method [D3835](#). Multiply the pascal second values by ten to obtain poise values.

(SI): The Modern Metric System

2.2 IEC and ISO Standards:

ISO 12086-1 Plastics—Fluoropolymer Dispersion and Moulding and Extrusion Materials—Part 1: Designation and Basis for Specification⁴

ISO 12086-2 Plastics—Fluoropolymer Dispersion and Molding and Extrusion Materials—Part 2: Preparation of Test Specimens and Determination of Properties⁴

3. Terminology

3.1 Definitions:

3.1.1 For definitions of plastics terms used in this specification, see Terminology [D883](#).

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

4. Classification

4.1 This specification covers two types⁵ of natural, unmodified PVDF fluoroplastics supplied in pellet form for molding and extrusion, and in powder form for solutions, dispersions, or coatings.

4.1.1 *Type I*—PVDF fluoroplastics are polymerized in emulsion. Depending upon the polymerization conditions, the peak melting point of the resin can be varied between 156 and 170°C. The diameter of the primary particle isolated from the emulsion is typically less than 1 µm; the dried powder has an average agglomerate diameter range of 3 to 15 µm.

4.1.1.1 Two distinctly different Type I emulsion PVDF resins are available commercially. These are differentiated by peak melting endotherm values, as shown in [Table 1](#), and this difference is the basis for subdividing Type I resins into Grades 1 and 2. [Table 1](#) shows the melt viscosity ranges encompassing

resin grades available from several sources and are provided for information purposes only.

4.1.2 *Type II*—PVDF fluoroplastics are polymerized in suspension. Peak melting temperatures of these resins range from 164 to 180°C. The particles isolated from suspension are spherical and range typically from 20 to 150 µm in diameter.

4.1.2.1 Type II resins are available commercially, and the data of [Table 1](#) reflect ranges encompassing values typical for the properties of available grades.

4.2 The system uses predefined cells to refer to specific aspects of this specification, as illustrated below.

Specification				
Standard Number Block	Type	Grade	Class	Special Notes
Example: Specification				
D3222 – 05	1	2

For this example (D3222 – 05, I2), the line callout describes a PVDF resin polymerized in emulsion, having a specific gravity between 1.75 and 1.79, and a peak melting endotherm between 162 to 170°C. A comma is used as the separator between the Standard Number and the Type. Separators are not needed between the Type, Grade, and Class.⁶ Provision for Special Notes is included so that other information, such as a preferred viscosity range, can be provided when required. When special notes are used, they shall be preceded by a comma.

5. General Requirements

5.1 The material shall be of uniform composition and free of foreign matter.

6. Detail Requirements

6.1 *General Attributes:*

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

⁵ Dohany, J. E., and Robb, L. E., "Poly(Vinylidene Fluoride)" *Kirk-Othmer Encyclopedia of Chemical Technology*, Vol 11, 3rd Edition, 1980, pp. 64–74.

⁶ See the *ASTM Form and Style for ASTM Standards*, available from ASTM Headquarters.

6.1.1 *Peak Melting Endotherm*—The material covered by this specification shall have a minimum peak melting endotherm for the type and class as shown in **Table 1** when tested in accordance with Test Method **D3418**. For Type I resins, this shall involve heating a solid specimen of 5 ± 1 mg from room temperature to 200°C at 10°C/min, maintaining the temperature at 200°C for 5 min, followed by cooling at a controlled rate of 10°C/min to about 30°C, then reheating at 10°C/min to 200°C. Record the peak melting endotherm during the second melting cycle.

6.1.1.1 *Temperature*—Test Type II resins likewise except that the maximum is 250°C.

6.1.2 *Specific Gravity*—A solid specimen of the material covered by this specification shall have the minimum specific gravity indicated in **Table 1** (1.75 for Type I, Class 1 and 1.76 for all others) when tested in accordance with Test Method **D792**.

NOTE 3—Test attached to the specimen upon immersion. Dipping the specimens in a very dilute solution (less than 0.1 weight percent) of an ammonium perfluorooctanoate surfactant minimizes this problem.

6.1.3 *Refractive Index*—The material covered in this specification shall have a refractive index of 1.42 when measured at the sodium D line at 25°C (77°F) in accordance with the refractometer procedure in Test Methods **D542**, using specimens that have not been subjected to any processes which induce orientation of the polymer chains or crystal-lites. Compression-molded specimens at least 2-mm (0.079-in.) thick that have been quenched rapidly in water are preferred.

6.1.4 *Limiting Oxygen Index*—The material covered in this specification shall have a minimum limiting oxygen index of 42 when tested in accordance with Test Method **D2863**.

NOTE 4—If a column with a restricted opening is used, position the top of the specimen 40 mm below the opening.

6.2 Processing Related Attributes:

6.2.1 *Flow Rate*—Materials conforming to this specification shall be tested for melt flow rate in accordance with Test Method **D1238** using loads shown in parentheses in **Table 1**.

6.2.2 *Rheological Properties*—The apparent melt viscosity of these materials shall be tested in accordance with Test Method **D3835** at 231 ± 1 °C (450°F) using a die with an entrance angle of 60° (cone angle of 120°) and a minimum capillary L/D of 15. See **Table 1**.

6.3 Mechanical Properties:

6.3.1 *Tensile Properties*—The material covered in this specification shall have a tensile yield strength exceeding 36 MPa (5200 psi) at 23°C (74°F) and a minimum elongation at break of 10 % when tested in accordance with Test Method **D638** at 51 mm (2 in.)/min, using Type I specimens 3.2-mm (0.125-in.) thick as specified in Test Method **D638**. Preferably, compression-molded samples are used (see Section 8), but injection molded specimens also are used, providing that the samples yield and rupture in the gage region and not near the heel. Specimens shall be molded under conditions specified by the resin suppliers. Generally, injection molded specimens show low and variable elongation values compared to compression-molded specimens. Typically, the melt tempera-

ture is 30 to 60°C higher than the upper peak melting endotherm value depending on the grade. Mold temperature is 120 ± 10 °F.

6.3.2 *Flexural Properties*—The material covered in this specification shall have a minimum flexural modulus of 1.38 GPa (190×10^3 psi) when tested in accordance with Method I of Test Methods **D790**, using 6.4-mm (0.25-in.) thick specimens prepared by injection molding under conditions specified by the resin supplier. Alternatively, compression-molded samples are used (see Section 8) and tested after the 16-h conditioning period.

6.3.3 *Impact Resistance*—Type I material covered in this specification shall have a minimum impact strength of 80.0 J/m (1.50 ft-lbf/in.) determined by Test Methods **D256** using 6.4-mm (0.25-in.) thick specimens prepared by injection molding under conditions specified by the manufacturer. Alternatively, specimens are compression-molded and tested after the conditioning period as specified above. For Type II material, impact testing is not required.

6.4 Electrical Properties:

6.4.1 *D-C Resistance*—The material covered in this specification shall have a d-c volume resistivity greater than $1.2\Omega\text{-m}$ (1.2×10^{14} Ω-cm) when tested as a 0.76-mm (0.030-in.) compression-molded specimen (see Section 8) in accordance with Test Methods **D257**.

6.4.2 *Dielectric Strength*—The material covered in this specification shall have a dielectric strength in air no less than 57 kV/mm (1280 V/0.001 in.) by the “short-time” method of Test Methods **D149** with 0.13-mm (0.05-in.) thick compression-molded specimens (see Section 8) tested in air using 25.4-mm (1-in.) Type 3 electrodes.

6.4.3 *Dielectric Constant*—The material covered in this specification shall have a dielectric constant less than 11.0 at 100 Hz and greater than 5.8 at 1 MHz when tested as a 3.2-mm (0.125-in.) thick compression-molded specimen (see Section 8) in accordance with Test Methods **D150** at 23°C (73°F).

6.4.4 *Dissipation Factor*—The material covered in this specification shall have a dissipation factor of less than 0.045 at 100 Hz and less than 0.24 at 1 MHz when tested as 3.2-mm (0.125-in.) compression-molded specimens (see Section 8) in accordance with Test Methods **D150** at 23°C (73°F).

NOTE 5—Since this material has very low water-absorption characteristics, maintenance of constant humidity during testing or specimen preparation is not necessary except as required for a specific test method. However, no moisture shall be present in the resin when preparing specimens for testing. Heat the resin sample at 110°C (230°F) in an air-circulating oven until the adventitious moisture is removed.

7. Sampling

7.1 Sampling shall be statistically adequate to satisfy the requirements of **12.4**.

8. Preparation of Compression Molded Specimens

8.1 Equipment:

8.1.1 Press with approximately 180 kN (20 ton) capacity and heating capability for maintaining platens between 220 and 240°C (428 to 464°F).

8.1.2 Two smooth chromium-finished plates with approximate dimensions 150 by 250 by 5 mm (10 by 10 by 0.02 in.), or, if more appropriate to the press type, 150 by 150 by 5 mm (6 by 6 by 0.02 in.).

8.1.3 Flat open-cavity steel molds, that is, frames, to provide the shape and thicknesses requisite for the specific tests.

8.1.4 Timing device.

8.1.5 Appropriate equipment to handle the hot mold assembly when removed from the press.

8.1.6 Balance and containers for weighing the resin samples.

8.1.7 Water-filled container to quench-cool the samples in the mold frame.

8.1.8 Aluminum foil approximately 0.1-mm thick (0.004-in.).

8.2 *Compression Molding Specimens Less Than 2 mm (0.08 in.):*

8.2.1 For the given mold cavity establish, by initial trial preparations, the amount of material necessary to overfill slightly and yield a minimum flash after forming.

8.2.2 Place the appropriate amount of material in the center of the mold between thin sheets of polished aluminum foil.

8.2.3 Place the assembly between the chrome-finished plates.

8.2.4 Place the mold assembly in the press so that it is in contact with the hot platens, using a ram force that barely registers on the force gage and hold for a 5-min period at a temperature of $230 \pm 2^\circ\text{C}$ ($446 \pm 4^\circ\text{F}$).

8.2.5 After the preheat period, slowly increase the ram force to 130 kN (30 000 lbf) and hold for 1 min.

8.2.6 Remove the sandwiched material and immediately quench in cold water.

8.2.7 After standing for 1 min, disassemble and remove the molded plaque from the frame.

NOTE 6—The alternative method of allowing the assembly to cool at ambient room temperature under a heavy weight, or under pressure in a cold press, results in specimens having properties that vary from values in specification tests.

8.2.8 If the mold shape is not appropriate for the test, cut test specimens from the molded sample.

NOTE 7—The edges of the specimen affect performance in mechanical tests. Die-cutting is the preferred method to prepare such specimens; the cutting edges shall be leveled and sharp.

8.3 *Compression Molding Specimens Thicker Than 2 mm (0.08 in.):*

8.3.1 Pellets of PVDF can be compression-molded directly in thick sections without difficulty.

8.3.2 Powdered PVDF samples tend to entrap air when thick sections are molded under compression. Such specimens are not suitable for any tests in this specification. The preferred method to obtain bubble-free thick moldings involves preparation of thin compression-molded sheets, as described in 8.2, and a subsequent second molding cycle filling the thick section mold with several layers of the thin sheet specimens cut to fill

the mold dimension. To assure complete filling, the stack of thin samples must be slightly higher than the mold cavity thickness.

9. Test Conditions

9.1 *Specific Gravity, Mechanical Properties, and Electrical Properties:*

9.1.1 Condition the molded test specimens in accordance with Procedure A of Practice D618, except that the period shall be at least 16 h prior to test.

9.1.2 Conduct tests at the standard laboratory temperature of $23 \pm 2^\circ\text{C}$ ($73.4 \pm 3.6^\circ\text{F}$).

NOTE 8—PVDF is a partially crystalline polymer. Unless molded and conditioned equivalently for a sufficient period to assure consistent crystallinity, samples prepared by any other method give variable results.

10. Handling

10.1 As is the case with any synthetic resin, it is advisable to wear a dust mask when handling large quantities of powder grades to prevent ingestion.

11. Packaging

11.1 The packing, packaging, and marking provisions of Practice D3892 shall apply to this specification.

12. Inspection and Certification

12.1 Inspection and certification of the material supplied with reference to this specification shall be for conformance to the requirements specified herein.

12.2 Lot-acceptance inspection shall be the basis on which acceptance or rejection of the lot is made. The lot-acceptance inspection shall consist of all the requirements.

12.3 Periodic check inspection with reference to this specification shall consist of the tests for all requirements of the material under this specification.

12.4 Certification shall be that the material was manufactured by a process in statistical control, sampled, tested, and inspected in accordance with this specification, and that the average values for the lot meet the requirements of this specification (line callout).


12.5 A report of test results shall be furnished when requested. The report shall consist of results of the lot-acceptance inspection for the shipment and the results of the most recent periodic-check inspection.

13. Precision and Bias

13.1 The precision and bias statements of ASTM test methods referenced herein apply to the specific tests required in this specification.

14. Keywords

14.1 extrusion materials; fluorohydrocarbon plastics; fluoropolymers; molding materials; polyvinylidene fluoride (PVDF)

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