



Designation: D3159 – 10

Standard Specification for Modified ETFE-Fluoropolymer Molding and Extrusion Materials¹

This standard is issued under the fixed designation D3159; 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.

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

1. Scope*

1.1 This specification covers melt processible molding and extrusion materials of modified ETFE-fluoropolymer. The ETFE resin is a copolymer of ethylene containing approximately 75 mass % of tetrafluoroethylene.

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

NOTE 1—Although this specification and ISO 12086-1 (1994) and ISO 12086-2 (1994) differ in approach or detail, data obtained using either are technically equivalent.

1.3 The following safety hazards caveat pertains only to the test method 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.*

1.4 Recycled material is not appropriate for this specification because performance requirements cannot be met with recycled material. Therefore, this specification is for virgin material only.

2. Referenced Documents

2.1 ASTM Standards:²

- D150** Test Methods for AC Loss Characteristics and Permittivity (Dielectric Constant) of Solid Electrical Insulation
- D618** Practice for Conditioning Plastics for Testing
- D638** Test Method for Tensile Properties of Plastics

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 (Section D20.15.12).

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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.

- 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
 - D1600** Terminology for Abbreviated Terms Relating to Plastics
 - D3418** Test Method for Transition Temperatures and Enthalpies of Fusion and Crystallization of Polymers by Differential Scanning Calorimetry
 - D3892** Practice for Packaging/Packing of Plastics
 - E177** Practice for Use of the Terms Precision and Bias in ASTM Test Methods
 - IEEE/ASTM SI-10** Use of the International System of Units (SI): The Modern Metric System
- 2.2 ISO Standards:
- ISO 12086-1** (1994) Plastics—Fluoropolymer Dispersions and Moulding and Extrusion Materials—Part 1
 - ISO 12086-2** (1994) Plastics—Fluoropolymer Dispersions and Moulding and Extrusion Materials—Part 2

3. Terminology

3.1 Definitions:

3.1.1 *General*—The terminology given in Terminology **D883** is applicable to this specification.

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

3.1.3 Abbreviated Terms:

3.1.4 *General*—The abbreviated terms given in Terminology **D1600** are applicable to this specification.

4. Classification

4.1 This specification covers five types of modified ETFE-fluoropolymer supplied in pellet form classified according to their specific gravity. The resins of each type are divided into one to three grades according to their melt flow rate.

4.2 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 as follows:

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

TABLE 1 Specific Gravity, Melting Point, and Flow Rate Requirements

Type Grade	I			II			III		IV	V
	1	2	3	1	2	3	1	2	1	1
Specific gravity,										
min:	1.69	1.69	1.69	1.75	1.75	1.75	1.83	1.83	1.74	1.74
max:	1.76	1.76	1.76	1.84	1.84	1.84	1.88	1.88	1.78	1.80
Melting point, °C,										
min:	255	255	250	220	220	220	218	218	220	250
max:	280	280	280	259	259	259	230	230	240	260
Flow rate, g/10 min,										
min:	2.0	8.0	25	2.0	10.1	25	9.0	25.0	10	15
max:	16.0	28.0 ^A	45	10.0	19.0	40	18.0	35.0	40	30

^A Measured with 1.588-mm (0.0625-in.) orifice; other values measured with 2.095-mm (0.0825-in.) orifice.

Specification			
Standard Number	Type	Grade	Special Block
:	:	:	Notes
:	:	:	:
Example: Specification D3159 – 95, I 2			

For this example, the line callout shall be, Specification D3159 – 95,I2 and shall specify a modified ETFE-fluoropolymer that has all of the properties listed for that type and grade in the appropriate specified properties, or 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 and grade.³

5. General Requirements

5.1 The material shall be of uniform composition and so prepared as to conform to the requirements of this specification.

5.2 The material described in this specification shall be free of foreign matter to such a contamination level as shall be agreed upon between the purchaser and the seller.

6. Performance Requirements

6.1 The average test result of the lot shall conform to the requirements prescribed in **Tables 1 and 2** when tested by the procedures specified herein. **Table 2** lists those tests requiring a specimen molded as described in **Section 8**.

7. Sampling

7.1 The materials shall be sampled in accordance with an adequate statistical sampling program.

8. Specimen Preparation

8.1 Prepare a molded sheet 1.5 ± 0.3 mm (0.06 ± 0.01 in.) thick. Use a picture-frame-type chase having a suitable blanked-out section and thickness to produce the desired sheet. Use clean aluminum foil, 0.13 to 0.18 mm (0.005 to 0.007 in.)

thick, in contact with the resin. A high-temperature mold release agent may be sprayed on the aluminum foil to help prevent the foil from sticking to the sheet. Use steel molding plates at least 1.0 mm (0.040 in.) thick and of an area adequate to cover the chase.

8.2 Lay down and smoothly cover one plate with a sheet of aluminum foil. Place the mold chase on top of this assembly. Place within the mold chase sufficient molding material to produce the required sheet in such manner that the polymer charge is a mound in the middle of the chase. Place a second sheet of aluminum foil on top of the granules and add the top mold plate. Place the assembly in a compression molding press having platens that have been heated to $300 \pm 5^\circ\text{C}$ ($572 \pm 10^\circ\text{F}$).

8.3 Bring the press platens to incipient contact with the mold assembly. Hold for 2 to 4 min without pressure. Apply approximately 1 MPa (145 psi) and hold for 1 to 1.5 min. Then apply 2 to 4 MPa (290 to 580 psi) and hold for 1 to 1.5 min. Maintain the press at $300 \pm 5^\circ\text{C}$ ($572 \pm 10^\circ\text{F}$) during these steps. Remove the assembly from the press and place between two 20 ± 7 -mm (0.75 ± 0.25 -in.) steel plates whose temperature is less than 40°C (104°F).

8.4 When the sheet is cool enough to touch (about 50 to 60°C (122 to 140°F)), remove aluminum foil from the sheet. (If the sheet is allowed to cool to room temperature, the aluminum foil cannot be pulled free.)

9. Conditioning

9.1 For tests of specific gravity, tensile properties, and electrical properties, condition the molded test specimen in accordance with Practice **D618**, Condition 4/23/50. The other tests require no conditioning.

9.2 Conduct tests at the standard laboratory temperature of $23 \pm 2^\circ\text{C}$ ($73.4 \pm 3.6^\circ\text{F}$) for determination of specific gravity, tensile properties, and electrical properties only. Since the resin does not absorb water, the maintenance of constant humidity during testing is not necessary. Conduct tests for flow rate and melting endotherm under ordinary laboratory conditions.

³ See the ASTM *Form and Style Manual*, available from ASTM Headquarters.

TABLE 2 Detail Requirements for Molded Test Specimens for All Resins in This Specification

Type Grade	I			II			III		IV	V
	1	2	3	1	2	3	1	2	1	1
Tensile strength, min, psi:	5500	4400	5500	4500	4500	4000	4000	4000	5000	4000
Elongation, min, %:	275	200	300	300	300	350	350	350	350	350
Dielectric constant, 10 ³ Hz, max:	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6
10 ⁶ Hz, max:	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7
Dissipation factor, 10 ³ Hz, max:	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008
10 ⁶ Hz, max:	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009

10. Packaging and Marking

10.1 *Packaging*—The material shall be packaged in standard commercial containers so constructed as to ensure acceptance by common or other carriers for safe transportation to the point of delivery unless otherwise specified in the contract or order.

10.2 *Marking*—Shipping containers shall be marked with the name of the material, type, and quantity therein.

10.3 All packing, packaging, and marking provisions of Practice **D3892** shall apply to this specification.

11. Test Methods

11.1 Melt Flow Rate:

11.1.1 *Principle of Test Method*—Determine the flow rate at $297 \pm 1^\circ\text{C}$ using Procedure A or B or Test Method **D1238**. Use the extrusion plastometer described in Test Method **D1238** and modified in accordance with **11.1.2**. The sample shall be pellets or pieces of approximately the same suitable size cut from molded or extruded forms. Strips about 6 mm wide by 76 mm long (0.25 by 3 in.) shall be conveniently handled. See Table 2 or 3 of Test Method **D1238** for the amount of charge that shall be adjusted accordingly with the melt density of ETFE being used. Usually the charge amount is 5 to 15 g. Measure the flow rate using a load of 49 N for Types I, II, and III. Collect four successive cuts for the manual method.

11.1.2 *Apparatus*—The apparatus shall consist of an extrusion plastometer, described in Test Method **D1238**, modified by use of corrosion-resistant⁴ alloy for the barrel lining, orifice, piston tip, and orifice securing device.⁵ The orifice diameter is 2.095 by 8.000 mm long (0.0825 by 0.315 in.) for all types except 1.588 by 6.070 mm (0.0625 by 0.239 in.) for Type I, Grade 2.

11.1.3 Procedure:

⁴ “Stellite” Grade No. 19, Haynes-Stellite Co., Kokomo, IN, and “Duranickel” No. 301, International Nickel Co., 67 Wall St., New York, NY 10005, have been found resistant to fluorocarbon resins. 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.

⁵ Suitable instruments are available commercially.

11.1.3.1 *Temperature Calibration*—The specified melt temperature of $297 \pm 1^\circ\text{C}$ is the temperature measured in the melt 13 mm (0.5 in.) above the orifice. This temperature shall be obtained by controlling the temperature measured in the thermometer well at approximately 305°C . Prior to making a test, set the plastometer temperature as follows: With the orifice in place, insert a standardized thermocouple (**Note 2**) through the orifice from the bottom of the plastometer to a point 13 mm (0.5 in.) above the top of the orifice. Charge 5 g of resin granules to the plastometer, compact with the piston, and wait 10 ± 0.5 min for the melt temperature to reach equilibrium. Make the necessary adjustment in the temperature controller to bring the melt temperature to $297 \pm 1^\circ\text{C}$. Repeat this calibration procedure and record the temperature versus time at 1-min intervals for the first 10 min. The polymer shall reach the 297°C temperature within 5 min. With polymer in the plastometer for an elapsed time of 10 min for each point measured, determine the melt temperature at 6.4-mm (0.25-in.) intervals from 6.4 mm to 51 mm (2 in.) above the orifice. The entire temperature profile shall be within a range of 2°C . This precision is readily obtained by proper insulation of the sides, bottom, and top of the plastometer.

NOTE 2—Suitable standards for thermocouple calibration are: lead, m.p. 327.5°C , potassium dichromate, m.p. 398.0°C , and zinc, m.p. 419.4°C .

11.1.4 *Precision and Bias*—Precision and bias for this test method are to be determined by round-robin testing.

11.2 *Specific Gravity*—Determine the specific gravity of a specimen approximately 25 by 38 mm (1 by 1.5 in.) blanked or cut from the molded plaque (see Section 8) in accordance with the procedures described in Test Methods **D792**. Add 2 drops of a wetting agent to the water in order to reduce the surface tension and ensure complete wetting of the specimen.

11.3 Melting Endotherm Peak Temperature:

11.3.1 Determine the endotherm melting peak with a differential thermal analyzer (DTA) or with a differential scanning calorimeter (DSC) operated in a DTA mode at $10^\circ\text{C}/\text{min}$ ($18^\circ\text{F}/\text{min}$).

11.3.1.1 If DTA equipment is used, refer to Test Method **D3418** except that the DTA shall be run at $10^\circ\text{C}/\text{min}$ to 325°C (617°F).