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## Standard Specification for Crosslinked Poly(Vinylidene Fluoride) Heat-Shrinkable Tubing for Electrical Insulation<sup>1</sup>

This standard is issued under the fixed designation D3144; 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.

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<sup>ε1</sup> NOTE—Editorial changes were made throughout in January 2013.

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### 1. Scope

1.1 This specification covers semirigid, flame-retardant, crosslinked poly(vinylidene fluoride) heat-shrinkable tubing for electrical insulation purposes. It is supplied in an expanded form and will shrink to its extruded diameter when heated.

NOTE 1—This standard is similar but not identical to IEC 60684–3–228.

1.2 The values stated in inch-pound units are to be regarded as the standard, except temperature which shall be stated in degrees Celsius. Values in parentheses are for information only.

1.3 *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.*

### 2. Referenced Documents

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

- [D910 Specification for Leaded Aviation Gasolines](#)
- [D1711 Terminology Relating to Electrical Insulation](#)
- [D2671 Test Methods for Heat-Shrinkable Tubing for Electrical Use](#)
- [D3636 Practice for Sampling and Judging Quality of Solid Electrical Insulating Materials](#)
- [D8355 Test Methods for Flammability of Electrical Insulating Materials Used for Sleeving or Tubing](#)
- [E176 Terminology of Fire Standards](#)

#### 2.2 Military Standards:<sup>3</sup>

- [MIL-H-5606 Hydraulic Fluid, Petroleum Base, Aircraft, Missile and Ordinance](#)
- [MIL-T-5624 Turbine Fuel, Aviation, Grades JP-4 and JP-5](#)
- [MIL-L-7808 Lubrication Oil, Aircraft, Turbine Engine, Synthetic Base](#)
- [MIL-L-23699 Lubrication Oil, Aircraft, Turbine Engines, Synthetic Base](#)
- [MIL-A-8243 Anti-Icing and Deicing—Defrosting Fluid](#)

<sup>1</sup> This specification is under the jurisdiction of ASTM Committee D09 on Electrical and Electronic Insulating Materials and is the direct responsibility of Subcommittee D09.07 on Flexible and Rigid Electrical Insulating Materials.

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<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> Available from Standardization Documents Order Desk, Bldg. 4 Section D, 700 Robbins Ave., Philadelphia, PA 19111-5094, Attn: NPODS.

2.3 Federal Standards:<sup>4</sup>

SS-S-550 Sodium Chloride, Technical, for Water-Softening Units

2.4 IEC Standards: Standard:<sup>5</sup>

60684-3-228 IEC 60684-3-228 Flexible insulating sleeving, Part 3, Sheet 228: Heat-shrinkable, semi-rigid, polyvinylidene fluoride sleeving, flame retarded, fluid resistant, shrink ratio 2:1

3. Terminology

3.1 Definitions:

3.1.1 For definitions pertaining to electrical insulation, refer to Terminology **D1711**.

3.1.2 For definitions pertaining to fire standards, refer to Terminology **E176**.

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4. Ordering Information

4.1 When tubings are ordered to this specification, it is up to the purchaser to define the size and color of the required tubing.

5. Materials and Manufacture

5.1 The compound used in the manufacture of heat-shrinkable tubing shall be modified poly(vinylidene fluoride), and the finished compound shall be free of all foreign matter other than intended formulation additives as appropriate.

5.2 The tubing shall be extruded, crosslinked, and then expanded to the required dimensions.

6. Chemical Property Requirements

6.1 The material shall conform to the chemical property requirements specified in **Table 1**.

TABLE 1 Chemical Property Requirements

Property	Requirement
Fluid resistance, 24 h at 23 ± 3 °C [73 ± 6 °F]	
Fluid resistance, 24 h at 23 ± 3 °C (73 ± 6 °F)	
JP-4 fuel, MIL-T-5624	
Lubricating oil, MIL-L-7808	
Lubricating oil, MIL-L-23699	
Hydraulic fluid, MIL-H-5606	
5% NaCl, SS-S-550	
Aviation gasoline, Grade 100, min octane 130, Specification <b>D910</b>	
Deicing fluid, MIL-A-8243	
Followed by tests for:	
Dielectric strength, min, V/mil [kV/mm]	500 [19.7]
Dielectric strength, min, V/mil (kV/mm)	500 (19.7)
Tensile strength, min, psi [MPa] at 2 in. (50 mm)/min	5000 [34.5]
Tensile strength, min, psi (MPa) at 2 in. (50 mm)/min	5000 (34.5)
Flammability, Procedure A, max, s	15
Flammability, Test Methods <b>D8355</b> , Test A, max, s	15
Water absorption, 24 h at 23 ± 3 °C [73 ± 6 °F], max %	0.5
Water absorption, 24 h at 23 ± 3 °C (73 ± 6 °F), max %	0.5

<sup>4</sup> Available from Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402; U. S. Government Accountability Office (GAO), 441 G St., NW, Washington, DC 20548, <http://www.gao.gov>.

<sup>5</sup> Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036-10036, <http://www.ansi.org>.

6.2 Every lot of material manufactured shall be tested for flammability (when applicable). Other chemical requirements shall be permitted to be tested less frequently or at a frequency agreed upon between the purchaser and the seller.

## 7. Physical Property Requirements

7.1 The material shall conform to the mechanical, thermal, and electrical requirements of **Table 2**.

7.2 Every lot of material manufactured shall be tested for restricted shrinkage, heat shock, tensile strength, and elongation. Other physical requirements shall be permitted to be tested less frequently or at a frequency agreed upon between the purchaser and seller.

**TABLE 2 Physical Property Requirements**

Property	Requirement
Restricted shrinkage, Procedure A, $175 \pm 3$ °C [ $347 \pm 6$ °F] 2000 V	no cracking, no dielectric breakdown
Dielectric strength, min, V/mil [kV/mm]	600 [23.6]
Heat shock, $300 \pm 4$ °C [ $572 \pm 7$ °F]	no cracking, flowing, or dripping
Low-temperature flexibility, $-55 \pm 2$ °C [ $-67 \pm 4$ °F] (see <b>Table 4</b> for mandrels) — Use Procedure A of Methods <b>D2671</b> for sizes $\frac{3}{64}$ through $\frac{1}{2}$ — Use Procedure C of Methods <b>D2671</b> for sizes $\frac{3}{4}$ through 1	no cracking
Tensile strength, min, psi [MPa], using 1-in. [25 mm] bench marks and 1-in. [25 mm] jaw separation at 2 in. [50 mm]/min	5000 [34.5]
Elongation, min %, using 1-in. [25 mm] bench marks and 1-in. [25 mm] jaw separation at 2 in. [50 mm]/min	150
Heat resistance, 168 h at $250 \pm 3$ °C [ $482 \pm 6$ °F]	50
Elongation, min, %	10 <sup>13</sup>
Volume resistivity, min, Ω-cm	10 <sup>15</sup> [690]
Secant modulus, min, psi [MPa]	1.8
Specific gravity, max	1.8

**TABLE 2 Physical Property Requirements**

Property	Requirement
Restricted shrinkage, Procedure A, $175 \pm 3$ °C ( $347 \pm 6$ °F) 2000 V	no cracking, no dielectric breakdown
Dielectric strength, min, V/mil (kV/mm)	600 (23.6)
Heat shock, $300 \pm 4$ °C ( $572 \pm 7$ °F)	no cracking, flowing, or dripping
Low-temperature flexibility, $-55 \pm 2$ °C ( $-67 \pm 4$ °F) <sup>A</sup> — Use Procedure A of Methods <b>D2671</b> for sizes $\frac{3}{64}$ through $\frac{1}{2}$ — Use Procedure C of Methods <b>D2671</b> for sizes $\frac{3}{4}$ through 1	no cracking
Tensile strength, min, psi (MPa), using 1-in. (25 mm) bench marks and 1-in. (25 mm) jaw separation at 2 in. (50 mm)/min	5000 (34.5)
Elongation, min %, using 1-in. (25 mm) bench marks and 1-in. (25 mm) jaw separation at 2 in. (50 mm)/min	150
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Elongation, min, %	10 <sup>13</sup>
Volume resistivity, min, Ω-cm	10 <sup>15</sup> (690)
Secant modulus, min, psi (MPa)	1.8
Specific gravity, max	1.8

<sup>A</sup> See **Table 4** for mandrels.

## 8. Dimensional Requirements

8.1 The material shall conform to the dimensional requirements of **Table 3**.

8.2 Tubing with non-standard dimensions shall be permitted to be supplied when agreed upon between purchaser and seller. Tubing with non-standard dimensions shall be considered to comply with this specification if the requirements of **Table 1** and **Table 2** are satisfied and the minimum recovered wall thickness equals or exceeds that of the identical or next largest nominal size. The wall for sizes greater than 1 in. shall be at least as thick as that of the 1 in. size.

## 9. Workmanship

9.1 The tubing shall be homogeneous and essentially free of flaws, defects, pinholes, bubbles, seams, cracks, or inclusions.

9.2 Clear tubing shall be transparent to translucent light tan or in a color as agreed between purchaser and seller.

## 10. Sampling

10.1 A lot shall consist of all material which is processed at the same time and under the same conditions and submitted for inspection at one time.

10.2 Properties shall be permitted to be tested at any stage in processing when they are unaffected by subsequent processing.

10.3 Select a quantity of the product at random from each lot in accordance with Practice **D3636** and **Table 5**.

10.4 Statistical process control measurements shall be permitted to be used to demonstrate conformance in lieu of the sampling plan noted herein when the demonstrated process capability is greater than the specified AQL.

## 11. Number of Tests and Retests

11.1 The methods of test define the number of specimens and length required for each test.

**TABLE 3 Dimensional Requirements**

Nominal Size, in.	As Supplied		After Heat Shrinking		Longitudinal Change, %
	Inside Diameter, min. in. [mm]	Eccentricity, max, %	Inside Diameter, max, in. [mm]	Wall Thickness, in. [mm]	
$\frac{3}{64}$	0.046 [1.16]	40	0.023 [0.59]	0.010 ± 0.002 [0.25 ± 0.05]	±10
$\frac{1}{16}$	0.063 [1.60]	40	0.031 [0.76]	0.010 ± 0.002 [0.25 ± 0.05]	±10
$\frac{3}{32}$	0.093 [2.34]	40	0.046 [1.16]	0.010 ± 0.002 [0.25 ± 0.05]	±10
$\frac{1}{8}$	0.125 [3.18]	40	0.062 [1.60]	0.010 ± 0.002 [0.25 ± 0.05]	±10
$\frac{3}{16}$	0.187 [4.75]	40	0.093 [2.34]	0.010 ± 0.002 [0.25 ± 0.05]	±10
$\frac{1}{4}$	0.250 [6.35]	40	0.125 [3.18]	0.012 ± 0.003 [0.31 ± 0.08]	±10
$\frac{3}{8}$	0.375 [9.50]	40	0.187 [4.75]	0.012 ± 0.003 [0.31 ± 0.08]	±10
$\frac{1}{2}$	0.500 [12.7]	40	0.250 [6.35]	0.012 ± 0.003 [0.31 ± 0.08]	±10
$\frac{3}{4}$	0.750 [19.1]	40	0.375 [9.50]	0.017 ± 0.003 [0.43 ± 0.08]	±10
1	1.000 [25.4]	40	0.500 [12.7]	0.019 ± 0.003 [0.48 ± 0.09]	±10

**TABLE 3 Dimensional Requirements**

Nominal Size, in.	As Supplied		After Heat Shrinking		Longitudinal Change, %
	Inside Diameter, min. in. (mm)	Eccentricity, max, %	Inside Diameter, max, in. (mm)	Wall Thickness, in. (mm)	
$\frac{3}{64}$	0.046 (1.16)	40	0.023 (0.59)	0.010 ± 0.002 (0.25 ± 0.05)	±10
$\frac{1}{16}$	0.063 (1.60)	40	0.031 (0.76)	0.010 ± 0.002 (0.25 ± 0.05)	±10
$\frac{3}{32}$	0.093 (2.34)	40	0.046 (1.16)	0.010 ± 0.002 (0.25 ± 0.05)	±10
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