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Standard Specification for Crosslinked Poly(Vinylidene Fluoride) Heat-Shrinkable Tubing for Electrical Insulation[1]

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 (ε) indicates an editorial change since the last revision or reapproval.

ε[1] NOTE—Editorial changes were made throughout in January 2013.

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.

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D910 Specification for 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

E176 Terminology of Fire Standards

2.2 *Military Standards:*[3]

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

2.3 *Federal Standards:*

SS-S-550 Sodium Chloride, Technical, for Water-Softening Units[4]

2.4 *IEC Standards:*

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[5]

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.

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.

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.

[1] 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 Insulating 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] Available from Standardization Documents Order Desk, Bldg. 4 Section D, 700 Robbins Ave., Philadelphia, PA 19111-5094, Attn: NPODS.

[4] Available from Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402.

[5] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036.

TABLE 1 Chemical Property Requirements

Property	Requirement
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 D910	
Deicing fluid, MIL-A-8243	
Followed by tests for:	
Dielectric strength, min, V/mil [kV/mm]	500 [19.7]
Tensile strength, min, psi [MPa] at 2 in. [50 mm]/min	5000 [34.5]
Flammability, Procedure A, max, s	15
Water absorption, 24 h at 23 ± 3 °C [73 ± 6 °F], max %	0.5

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.

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.

TABLE 2 Physical Property Requirements

Property	Requirement
Restricted shrinkage, Procedure A, 175± 3 °C [347 ± 6 °F] 2000 V	no cracking, no dielectric breakdown
Dielectric strength, min, V/mil [kV/mm]	600 [23.6]
Heat shock, 300 ± 4 °C [572± 7 °F]	no cracking, flowing, or dripping
Low-temperature flexibility, –55± 2 °C [–67 ± 4 °F] (see Table 4 for mandrels)	no cracking
Use Procedure A of Methods D2671 for sizes 3⁄64 through ½	
Use Procedure C of Methods D2671 for sizes ¾ through 1	
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 2in. [50 mm]/min	150
Heat resistance, 168 h at 250 ± 3 °C [482 ± 6 °F] Elongation, min, %	50
Volume resistivity, min, Ω-cm	10^{13}
Secant modulus, min, psi [MPa]	10^5 [690]
Specific gravity, max	1.8

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.

11.2 If the results of any test, except for attributes listed in Table 3, do not conform to the requirements prescribed in this specification, perform two additional tests on different specimens from the same lot. Nonconformance to Table 3 requirements on first inspection shall be cause for rejection.

11.3 If either of the two additional tests result in nonconformance, the purchaser has the option of rejecting the lot of material. Notice of nonconformances observed by the purchaser based on tests made according to this specification shall be reported to the manufacturer within 60 days from receipt of the material.

11.4 Tubing that has been rejected shall be permitted to be replaced or reworked to correct the nonconformances and resubmitted for inspection. Before resubmitting, full particulars concerning previous rejection and action taken to correct the nonconformances shall be furnished to the inspector.

12. Test Methods

12.1 Use the test methods described in Test Methods D2671 unless stated otherwise in Table 1 or Table 2.

12.2 Use a time of 3 min and a temperature of 200 ± 2 °C [392 ± 4 °F] to recover (shrink) tubings in this specification.

13. Inspection

13.1 The manufacturer or purchaser or both shall have available all the facilities to enable the complete testing to this specification.

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]	
3/64	0.046 [1.16]	40	0.023 [0.59]	0.010± 0.002 [0.25± 0.05]	±10
1/16	0.063 [1.60]	40	0.031 [0.76]	0.010± 0.002 [0.25 ± 0.05]	±10
3/32	0.093 [2.34]	40	0.046 [1.16]	0.010± 0.002 [0.25 ± 0.05]	±10
1/8	0.125 [3.18]	40	0.062 [1.60]	0.010± 0.002 [0.25 ± 0.05]	±10
3/16	0.187 [4.75]	40	0.093 [2.34]	0.010 ± 0.002 [0.25 ± 0.05]	±10
1/4	0.250 [6.35]	40	0.125 [3.18]	0.012± 0.003 [0.31 ± 0.08]	±10
3/8	0.375 [9.50]	40	0.187 [4.75]	0.012± 0.003 [0.31 ± 0.08]	±10
1/2	0.500 [12.7]	40	0.250 [6.35]	0.012± 0.003 [0.31 ± 0.08]	±10
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 4 Mandrel Sizes

Heat-Shrinkable Tubing Inside Diameter As Supplied, in.	Mandrel Diameter, in. [mm]
3/64 to 1/4	0.312 [7.94]
3/8 to 1/2	0.375 [9.53]
3/4 to 1	0.438 [11.1]

TABLE 5 Sampling Table for Lot Acceptance Tests

Property	Requirement	Inspection Level	AQL	Sampling Unit, ft [m]
Inside diameter as supplied	Table 3	S-3	1.0	4 [1.2]
Inside diameter after unrestricted shrinkage	Table 3	S-3	1.0	4 [1.2]
Wall thickness after shrinkage	Table 3	S-3	1.0	4 [1.2]
Longitudinal change	Table 3	S-2	1.0	4 [1.2]
Straight length size, min	15.1 herein	S-3	1.0	single straight length
Workmanship	9.1 herein	I	2.5	4 [1.2]

14. Certification

14.1 When specified in the purchase order or contract, the manufacturer's or supplier's certification shall be furnished to the purchaser stating that samples representing each lot have been manufactured, tested, and inspected in accordance with this specification and the requirements have been met. When specified in the purchase order or contract, a report of the test results shall be furnished.

15. Packaging, Marking, and Shipping

15.1 The tubing shall be supplied in lengths of 48 + 1, –0 in. [1219 + 25, –0 mm] unless otherwise specified.

15.2 The tubing shall be packaged in conformance with standard commercial practice unless otherwise specified. Individual sizes shall be neatly bundled or boxed. The exterior shipping container shall be acceptable by parcel post or common carrier.

15.3 Each bundle or container of tubing shall be distinctly identified by a tag or label. The name of the manufacturer, the expanded and recovered dimension of the tubing, the length, quantity, and other appropriate information shall be shown thereon.

16. Keywords

16.1 crosslinked poly(vinylidene fluoride) heat-shrinkable tubing; electrical insulation; heat-shrinkable tubing; poly(vinylidene fluoride)