Designation: D3149 – 06 (Reapproved 2013)

Standard Specification for Crosslinked Polyolefin Heat-Shrinkable Tubing for Electrical Insulation[1]

This standard is issued under the fixed designation D3149; 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 covers flexible and semirigid crosslinked polyolefin heat-shrinkable tubing used for electrical insulating purposes. It is supplied in an expanded form and will shrink to its extruded diameter when heated.

NOTE 1—This standard is similar to but not identical to IEC 60684–3–209, –211 and –212.

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-STD-104 Limits for Electrical Insulation Color
MIL-H-5606 Hydraulic Fluid, Petroleum Base, Aircraft, Missile, and Ordnance
MIL-T-5624 Turbine Fuel, Aviation, Grades JP4 and JP5
MIL-L-7808 Lubricating Oil, Aircraft, Turbine Engine, Synthetic Base
MIL-L-23699 Lubricating Oil, Aircraft, Turbine Engines, Synthetic Base
MIL-A-8243 Anti-Icing and De-Icing Defrosting Fluid

2.3 *Federal Standards:*

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

2.4 *IEC Standards:*

60684–3–209 Flexible insulating sleeving, Part 3, Sheet 209: Heat-shrinkable sleeving, general purpose, flame retarded polyolefin, shrink ratio 2:1[5]
60684–3–211 Flexible insulating sleeving, Part 3, Sheet 211: Heat-shrinkable sleeving, general purpose, semi-rigid polyolefin, shrink ratio 2:1[5]
60684–3–212 Flexible insulating sleeving, Part 3, Sheet 212: Heat-shrinkable polyolefin sleeving, general purpose, flame retarded, 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. Classification

4.1 *Type I*—Flexible, flame-retardant, opaque polyolefin tubing with a secant modulus at 2 % strain less than 25 000 psi (172 MPa).

4.2 *Type II*—Flexible, non-flame-retardant, clear or opaque polyolefin tubing with a secant modulus at 2 % strain less than 25 000 psi (172 MPa).

4.3 *Type III*—Semi-rigid, flame-retardant, opaque polyolefin tubing with a secant modulus at 2 % strain greater than 25 000 psi (172 MPa).

4.4 *Type IV*—Semi-rigid, non-flame-retardant, clear or opaque polyolefin tubing with a secant modulus at 2 % strain greater than 25 000 psi (172 MPa).

[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] May be obtained 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.

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

5. Ordering Information

5.1 When tubing is ordered to this specification, the purchaser should define the type, size, and color of the required tubing.

6. Materials and Manufacture

6.1 The compound used in the manufacture of heat-shrinkable tubing shall be modified polyolefin resin, and the finished compound shall be free of all foreign matter other than intended formulation additives as appropriate.

6.2 The tubing shall be extruded, cross-linked, and then expanded to the required dimensions.

7. Chemical Property Requirements

7.1 The material shall conform to the chemical requirements specified in Table 1.

7.2 Every lot of Type I and Type III material manufactured shall be tested for flammability. Other chemical requirements may be tested less frequently or at a frequency agreed upon by the purchaser and supplier.

8. Physical Property Requirements

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

8.2 Every lot of material manufactured shall be tested for restricted shrinkage, heat shock, tensile strength, elongation, low-temperature flexibility and color. Other physical property requirements may be tested less frequently or at a frequency agreed upon by purchaser and seller.

9. Dimensional Requirements

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

9.2 Tubing with non-standard dimensions may 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 4 in. shall be at least as thick as that of the 4-in. size.

10. Workmanship

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

11. Sampling

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

11.2 Properties may be tested at any stage in processing when they are unaffected by subsequent processing.

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

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

12. Number of Tests and Retests

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

12.2 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.

12.3 If either of the two additional tests results in a nonconformance, the lot of material may be rejected at the option of the purchaser. Notice of nonconformance determined 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.

12.4 Tubing that has been rejected may be replaced or reworked to correct the nonconformance and resubmitted for

TABLE 1 Chemical Property Requirements

Property	Type I	Type II	Type III	Type IV
Corrosion (as measured by copper removal), 16 h at 150 ± 2 °C (302 ± 4 °F), Procedure A	noncorrosive	noncorrosive	noncorrosive	noncorrosive
Fluid resistance, 24 h at 24 ± 3 °C (75 ± 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 Gas Grade 100, min octane 130, Specification D910				
De-icing Fluid, MIL-A-8243				
Followed by tests for:				
Dielectric strength, min, V/mil (kV/mm)	400 (15.75)	400 (15.75)	400 (15.75)	400 (15.75)
Tensile strength, min, psi (MPa)	1000 (6.9)	1000 (6.9)	1600 (11.0)	1600 (11.0)
Flammability, max, s	60, <25 % paper indicator burned.	N/A[A]	60, <25 % paper indicator burned.	N/A
Procedure B	No dripping or flowing.		No dripping or flowing.	
Water absorption, 24 h at 23 ± 2 °C (73 ± 4 ° F) max, %	0.5	0.2	0.5	0.2

[A] N/A = not applicable.

TABLE 2 Physical Property Requirements

Property	Type I	Type II	Type III	Type IV
Restricted shrinkage, Procedure A, 30 min at 175 ± 3 °C (347 ± 6 °F), voltage proof 2000 V	no cracking, no dielectric breakdown	no cracking, no dielectric breakdown	no cracking, no dielectric breakdown	no cracking, no dielectric breakdown
Dielectric strength, min, V/mil (kV/mm)	500 (19.7)	500 (19.7)	500 (19.7)	500 (19.7)
Heat shock; 250 ± 3 °C (482 ± 6 °F)	no cracking, flowing, or dripping	no cracking, flowing, or dripping	no cracking, flowing, or dripping	no cracking, flowing, or dripping
Low-temperature flexibility, – 55± 2 °C (–67 ± 2 °F) (see Table 4 for mandrels)	no cracking	no cracking	no cracking	no cracking
Procedure A of Methods D2671 for sizes 3/64 through 1/2				
Procedure C of Methods D2671 for sizes 3/4 through 4				
Tensile strength, min, psi (MPa):				
Types I and II, 20 in./min (50 cm/min)	1500 (10.3)	1500 (10.3)		
Types III and IV, 2 in./min (5 cm/min)			2000 (13.8)	2000 (13.8)
Elongation, min, %:				
Types I and II, 20 in./min (50 cm/min)	200	200		
Types III and IV, 2 in./min (5 cm/min)			200	200
Heat resistance, 168 h at 175 ± 3 °C (347 ± 6 °F), elongation, min, %	150	150	100	100
Color	MIL-STD-104	MIL-STD-104	MIL-STD-104	MIL-STD-104
Color stability, 24 h at 175 ± 3 °C (347 ± 6 °F)	MIL-STD-104	MIL-STD-104 N/A for clear	MIL-STD-104	MIL-STD-104 N/A for clear
Specific gravity, max	1.35	1.0	1.35	1.0
Volume resistivity, min, Ω·cm	10^{14}	10^{16}	10^{14}	10^{16}
Secant modulus, psi (MPa)	25 000 (172) max	25 000 (172) max	25 000 (172) min	25 000 (172) min
Copper contact corrosion and copper stability, Procedure B 168 h at 160 ± 3 °C (320 ± 6 °F)				
Copper stability, ultimate elongation, min, % followed by:				
visual examination	no blackening or pitting of copper	no blackening or pitting of copper	no blackening or pitting of copper	no blackening or pitting of copper
ultimate elongation, min,%	150	150	150	150

TABLE 3 Dimensional Requirements

	As Supplied		After Heat Shrinking			
Nominal Size, in.	Types I, II, III, IV Inside Diameter, min, in. (mm)	Types I, II, III, IV Eccentricity, max, %	Types I, II, III, IV Inside Diameter, min, in. (mm)	Types I and II Wall Thickness, in. (mm)	Types III and IV Wall Thickness, in. (mm)	Longitudinal Change, %
3/64	0.046 (1.16)	40	0.023 (0.59)	0.016 ± 0.003 (0.41± 0.08)	0.020 ± 0.003 (0.56± 0.08)	±5
1/16	0.063 (1.60)	40	0.031 (0.76)	0.017 ± 0.003 (0.43 ± 0.08)	0.020 ± 0.003 (0.51 ± 0.08)	±5
3/32	0.093 (2.34)	40	0.046 (1.16)	0.020 ± 0.003 (0.51 ± 0.08)	0.020 ± 0.003 (0.51 ± 0.08)	±5
1/8	0.125 (3.18)	40	0.062 (1.60)	0.020 ± 0.003 (0.51 ± 0.08)	0.020 ± 0.003 (0.51 ± 0.08)	±5
3/16	0.187 (4.75)	40	0.093 (2.34)	0.020 ± 0.003 (0.51 ± 0.08)	0.025 ± 0.003 (0.63 ± 0.08)	±5
1/4	0.250 (6.35)	40	0.125 (3.18)	0.025 ± 0.003 (0.63 ± 0.08)	0.025 ± 0.003 (0.63 ± 0.08)	±5
3/8	0.375 (9.50)	40	0.187 (4.75)	0.025 ± 0.003 (0.63 ± 0.08)	0.030 ± 0.003 (0.76 ± 0.08)	±5
1/2	0.500 (12.7)	40	0.250 (6.35)	0.025 ± 0.003 (0.63 ± 0.08)	0.030 ± 0.003 (0.76 ± 0.08)	±5
3/4[A]	0.750 (19.1)	40	0.375 (9.50)	0.030± 0.003 (0.76 ± 0.08)		±5
1[A]	1.000 (25.4)	40	0.500 (12.7)	0.035 ± 0.005 (0.89 ± 0.13)		±5
1 1/2[A]	1.500 (38.1)	40	0.750 (19.1)	0.040± 0.006 (1.02 ± 0.15)		±5
2[A]	2.000 (50.1)	40	1.000 (25.4)	0.045 ± 0.007 (1.15 ± 0.18)		±5
3[A]	3.000 (76.4)	40	1.500 (38.1)	0.050 ± 0.008 (1.27 ± 0.20)		±5
4[A]	4.000 (101.6)	40	2.000 (50.1)	0.055 ± 0.009 (1.40 ± 0.25)		±5

[A] Types I and II only.

TABLE 4 Mandrel Sizes for Low-Temperature Flexibility Testing

Nominal Tubing Size, in.	Mandrel Diameter, in. (mm)
3/64 to 1/4	5/16 (8)
3/8 to 1/2	3/8 (10)
3/4 to 2	7/16 (11)
3 to 4	7/8 (22)

TABLE 5 Sampling Table for Lot Acceptance Tests

Property	Require-ment	Inspec-tion Level	AQL	Sampling Unit, ft (m)
Inside diameter as supplied	Table 3	S-3	1.0	4 (1.2)
Inside diameter after unre-stricted recovery	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)

inspection. Before resubmitting, full particulars concerning previous rejection and action taken to correct the nonconformance shall be furnished to the inspector.

13. Test Methods

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

13.2 Use a time of 3 min and a temperature of 175 ± 5 °C (347 ± 9 °F) to recover (shrink) heat-shrinkable tubing described in this specification.

14. Inspection

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

15. Certification

15.1 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.

15.2 When original identity cannot be established, certification shall only be based on the sampling procedure as defined in Section 10.

16. Packaging, Marking, and Shipping

16.1 The tubing shall be supplied in lengths of 48 + 1, -0 in. (1220 + 25, -0 mm) unless otherwise specified.

16.2 The tubing shall be packaged in conformance with good commercial practice unless otherwise specified. Individual types, sizes, and colors shall be neatly bundled or boxed. The exterior shipping container shall be acceptable by parcel post or common carrier.

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

17. Keywords

17.1 crosslinked polyolefin heat-shrinkable tubing; electrical insulation; heat-shrinkable tubing; polyolefin

SUMMARY OF CHANGES

Committee D09 has identified the location of selected changes to this specification since the last issue, D3149 – 00, that may impact the use of this specification. (Approved April 1, 2006)

(*1*) Revised paragraph 6.1.

(*2*) Revised paragraph 15.2.