



Standard Specification for Fluoropolymer Resin Heat-Shrinkable Tubing for Electrical Insulation¹

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1. Scope

1.1 This specification applies to flexible heat-shrinkable extruded tubing made from tetrafluoroethylene resin, copolymer of tetrafluoroethylene and hexafluoropropylene, and from perfluoroalkoxy resin for use as electrical insulation.

NOTE 1—This standard is similar but not identical to IEC 60684–3–240 to –243.

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:

- C 618 Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use as a Mineral Admixture in Portland Cement Concrete²
- D 638 Test Method for Tensile Properties of Plastics³
- D 1711 Terminology Relating to Electrical Insulation⁴
- D 2116 Specification for FEP-Fluorocarbon Molding and Extrusion Materials³
- D 2671 Test Methods for Heat-Shrinkable Tubing for Electrical Use⁵
- D 3307 Specification for PFA-Fluorocarbon Molding and Extrusion Materials⁶
- D 3636 Practice for Sampling and Judging Quality of Solid Electrical Insulating Materials⁵
- D 4895 Specification for Polytetrafluoroethylene (PTFE) Resins Produced from Dispersion⁷
- E 176 Terminology of Fire Standards⁸

2.2 IEC Standards:

- 60684–3–240 to –243 Flexible insulating sleeving, Part 3,

Sheets 240 to 243: Heat-shrinkable PTFE sleeving⁹

3. Terminology

3.1 Definitions:

3.1.1 For definitions pertaining to electrical insulation, refer to Terminology D 1711.

3.1.2 For definitions pertaining to fire standards, refer to Terminology E 176.

4. Classification

4.1 *Type I*—Tubing made from tetrafluoroethylene polymer (TFE) and capable of being heat shrunk at a temperature of 327°C (621°F).

4.2 *Type II*—Tubing made from a copolymer of tetrafluoroethylene and hexafluoropropylene (FEP) and capable of being heat shrunk at a temperature of 150°C (302°F).

4.3 *Type III*—Tubing made from perfluoroalkoxy resin (PFA) and capable of being heat shrunk at a temperature of 175°C (347°F).

5. Ordering Information

5.1 When ordering to this specification, the purchaser must state the size, and type of the required tubing.

6. Materials and Manufacture

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

6.2 Type I tubing is normally made by paste extrusion. Type II and Type III tubings are normally made by melt extrusion. All types are expanded by mechanical means.

7. Chemical and Physical Property Requirements

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

7.2 Every lot of material manufactured should be tested for dimensional requirements and restricted shrinkage. Other requirements may be tested less frequently or with a frequency agreed upon between seller and purchaser.

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 Annual Book of ASTM Standards, Vol 04.02.

³ Annual Book of ASTM Standards, Vol 08.01.

⁴ Annual Book of ASTM Standards, Vol 10.01.

⁵ Annual Book of ASTM Standards, Vol 10.02.

⁶ Annual Book of ASTM Standards, Vol 08.02.

⁷ Annual Book of ASTM Standards, Vol 08.03.

⁸ Annual Book of ASTM Standards, Vol 04.07.

⁹ Available from American National Standards Institute, 11 W. 42nd St., New York, NY 10036.

TABLE 1 Chemical and Physical Property Requirements

Property	Requirement		
	Type I	Type II	Type III
Restricted shrinkage, ^A Procedure B, 2000 V, 10 min	no cracking	no cracking	no cracking
Specific gravity	2.13 to 2.18	2.12 to 2.20	2.13 to 2.20
Longitudinal change, max, %	+ 20	±15	±15
Tensile modulus at 200 % elongation, min, psi (MPa) Test Method D 638 2 in./min (50 mm/min)	2000 (13.8)	1500 (10.3)	2500 (17.3)
Volume resistivity ^B , ohm-cm, at standard laboratory atmosphere, min	10 ¹⁶	10 ¹⁶	10 ¹⁶
Dielectric breakdown voltage, min kV:			
Wall thickness 0.004 to 0.006 in.	8	8	8
0.007 to 0.008 in.	10	10	10
0.009 in.	11.5	11.5	11.5
0.010 to 0.011 in.	12.5	12.5	12.5
0.012 to 0.014 in.	14.6	14.6	14.6
0.015 in.	15	15	15
0.016 to 0.019 in.	16.3	16.3	16.3
0.020 in. and larger	17	17	17
Heat resistance: for 96 h followed by tests for tensile modulus at 200 % elongation, min, psi (MPa)			
Type I—350 ± 4°C (662 ± 7°F)	2000 (13.8)		
Type II—250 ± 3°C (482 ± 6°F)		1500 (10.3)	
Type III—275 ± 4°C (527 ± 7°F)			2500 (17.3)
Low-temperature flexibility, - 55 ± 2°C (-67 ± 4°F)	no cracking	no cracking	no cracking
Melting point:			
Specification D 4895	327 ± 10°C (621 ± 20°F)		
Specification D 2116		270 ± 20°C (518 ± 40°F)	
Specification D 3307 endotherm peak, min			300 ± 2°C (572 ± 7°F)
Specification D 3307			305 ± 3°C (581 ± 5°F)

^A For over-expanded sleeving, use a mandrel equal to the enclosable diameters $(D + d)/2$.

^B See Specification C 618.

8. Dimensional Requirements

8.1 Type I material shall conform to the requirements specified in Table 3.

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TABLE 2 Mandrel Sizes for Low-Temperature Flexibility Testing

Nominal Tubing Inside Diameter (max after unrestricted shrinkage)		Mandrel Diameter,	
in.	(mm)	in.	(mm)
0.015 to 0.125	(0.38 to 3.2)	0.3125 ± 0.002	(7.95 ± 0.06)
0.126 to 0.250	(3.3 to 6.3)	0.375 ± 0.003	(8.06 ± 0.07)
0.251 to 1.000	(6.4 to 26)	0.437 ± 0.004	(11.10 ± 0.10)
1.001 to 2.000	(27 to 50)	0.875 ± 0.005	(16.13 ± 0.13)
2.001 to 3.000	(51 to 75)	1.000 ± 0.005	(25.40 ± 0.13)
3.001 to 4.000	(76 to 101)	1.125 ± 0.005	(28.58 ± 0.13)

TABLE 3 Dimensions, Type I—Lengths for Type I

As Supplied		After Unrestrictive Shrinkage		Stock Lengths	Packaging
Inside Diameter, min, in. (mm)	Inside Diameter, max, in. (mm)	Wall Thickness, in. (mm)			
Heavy Wall					
0.166 (4.22)	0.130 (3.30)	0.030 ± 0.005 (0.76 ± 0.13)		3 ft to 1 ft min	straight lengths
0.250 (6.35)	0.193 (4.90)	0.030 ± 0.005 (0.76 ± 0.13)		3 ft to 1 ft min	straight lengths
0.333 (8.46)	0.257 (6.53)	0.030 ± 0.005 (0.76 ± 0.13)		3 ft to 1 ft min	straight lengths
0.415 (10.54)	0.320 (8.13)	0.030 ± 0.005 (0.76 ± 0.13)		3 ft to 1 ft min	straight lengths
0.498 (12.65)	0.383 (9.73)	0.030 ± 0.005 (0.76 ± 0.13)		3 ft to 1 ft min	straight lengths
0.580 (14.73)	0.448 (11.38)	0.030 ± 0.005 (0.76 ± 0.13)		3 ft to 1 ft min	straight lengths
0.666 (16.92)	0.510 (12.95)	0.030 ± 0.005 (0.76 ± 0.13)		3 ft to 1 ft min	straight lengths
0.748 (19.00)	0.572 (14.53)	0.030 ± 0.005 (0.76 ± 0.13)		3 ft to 1 ft min	straight lengths
0.830 (21.1)	0.637 (16.18)	0.030 ± 0.005 (0.76 ± 0.13)		3 ft to 1 ft min	straight lengths
0.915 (23.2)	0.700 (17.78)	0.032 ± 0.006 (0.81 ± 0.15)		3 ft to 1 ft min	straight lengths
1.000 (25.4)	0.764 (19.41)	0.040 ± 0.007 (1.02 ± 0.18)		3 ft to 1 ft min	straight lengths
1.170 (29.7)	0.891 (22.6)	0.045 ± 0.007 (1.14 ± 0.18)		3 ft to 1 ft min	straight lengths
1.330 (33.8)	1.020 (25.9)	0.050 ± 0.008 (1.27 ± 0.20)		3 ft to 1 ft min	straight lengths
Standard Wall					
0.045 (1.14)	0.027 (0.69)	0.012 ± 0.002 (0.30 ± 0.05)			
0.050 (1.27)	0.032 (0.81)	0.012 ± 0.002 (0.30 ± 0.05)		3 ft min	spools
0.055 (1.40)	0.039 (0.99)	0.016 ± 0.003 (0.41 ± 0.08)		3 ft min	spools
0.060 (1.52)	0.043 (1.09)	0.016 ± 0.003 (0.41 ± 0.08)		3 ft min	spools
0.065 (1.65)	0.049 (1.24)	0.016 ± 0.003 (0.41 ± 0.08)		3 ft min	spools
0.076 (1.93)	0.054 (1.37)	0.016 ± 0.003 (0.41 ± 0.08)		3 ft min	spools
0.085 (2.16)	0.061 (1.55)	0.016 ± 0.003 (0.41 ± 0.08)		3 ft min	spools
0.093 (2.36)	0.067 (1.70)	0.016 ± 0.003 (0.41 ± 0.08)		3 ft min	spools
0.110 (2.79)	0.072 (1.83)	0.016 ± 0.003 (0.41 ± 0.08)		3 ft min	spools
0.120 (3.05)	0.080 (2.03)	0.016 ± 0.003 (0.41 ± 0.08)		3 ft, 2 ft, 1 ft	straight lengths
0.140 (3.56)	0.089 (2.26)	0.016 ± 0.003 (0.41 ± 0.08)		3 ft, 2 ft, 1 ft	straight lengths
0.160 (4.06)	0.101 (2.56)	0.016 ± 0.003 (0.41 ± 0.08)		3 ft, 2 ft, 1 ft	straight lengths
0.180 (4.57)	0.112 (2.84)	0.016 ± 0.003 (0.41 ± 0.08)		3 ft, 2 ft, 1 ft	straight lengths
0.200 (5.08)	0.124 (3.15)	0.020 ± 0.004 (0.51 ± 0.10)		3 ft, 2 ft, 1 ft	straight lengths
0.210 (5.33)	0.130 (3.30)	0.020 ± 0.004 (0.51 ± 0.10)		3 ft, 2 ft, 1 ft	straight lengths
0.230 (5.84)	0.141 (3.58)	0.020 ± 0.004 (0.51 ± 0.10)		3 ft, 2 ft, 1 ft	straight lengths
0.240 (6.10)	0.158 (4.01)	0.020 ± 0.004 (0.51 ± 0.10)		3 ft, 2 ft, 1 ft	straight lengths
0.290 (7.37)	0.178 (4.52)	0.020 ± 0.004 (0.51 ± 0.10)		3 ft, 2 ft, 1 ft	straight lengths
0.310 (7.87)	0.198 (5.03)	0.020 ± 0.004 (0.51 ± 0.10)		3 ft, 2 ft, 1 ft	straight lengths
0.370 (9.40)	0.224 (5.69)	0.020 ± 0.004 (0.51 ± 0.10)		3 ft, 2 ft, 1 ft	straight lengths
0.390 (9.91)	0.249 (6.32)	0.020 ± 0.004 (0.51 ± 0.10)		3 ft, 2 ft, 1 ft	straight lengths
0.410 (10.41)	0.260 (6.60)	0.020 ± 0.004 (0.51 ± 0.10)		3 ft, 2 ft, 1 ft	straight lengths
0.430 (10.92)	0.278 (7.06)	0.020 ± 0.004 (0.51 ± 0.10)		3 ft, 2 ft, 1 ft	straight lengths
0.450 (11.43)	0.311 (7.90)	0.020 ± 0.004 (0.51 ± 0.10)		3 ft, 2 ft, 1 ft	straight lengths
0.470 (11.94)	0.329 (8.36)	0.020 ± 0.004 (0.51 ± 0.10)		3 ft, 2 ft, 1 ft	straight lengths
0.470 (11.94)	0.347 (8.81)	0.020 ± 0.004 (0.51 ± 0.10)		3 ft, 2 ft, 1 ft	straight lengths
0.470 (11.94)	0.334 (8.48)	0.025 ± 0.005 (0.64 ± 0.13)		3 ft, 1 ft min	straight lengths
0.560 (14.22)	0.339 (8.61)	0.025 ± 0.005 (0.64 ± 0.13)		3 ft, 1 ft min	straight lengths
0.655 (16.64)	0.462 (11.73)	0.025 ± 0.005 (0.64 ± 0.13)		3 ft, 1 ft min	straight lengths
0.750 (19.05)	0.524 (13.31)	0.025 ± 0.005 (0.64 ± 0.13)		3 ft, 1 ft min	straight lengths
0.930 (23.6)	0.655 (16.64)	0.030 ± 0.005 (0.76 ± 0.13)		3 ft, 1 ft min	straight lengths
1.125 (28.6)	0.786 (20.0)	0.035 ± 0.006 (0.89 ± 0.15)		3 ft, 1 ft min	straight lengths
1.310 (33.3)	0.911 (23.1)	0.035 ± 0.006 (0.89 ± 0.15)		3 ft, 1 ft min	straight lengths
1.500 (38.1)	1.036 (26.3)	0.035 ± 0.006 (0.89 ± 0.15)		3 ft, 1 ft min	straight lengths
Thin Wall					
0.034 (0.86)	0.015 (0.38)	0.009 ± 0.002 (0.23 ± 0.05)		3 ft min	spools
0.038 (0.97)	0.018 (0.46)	0.009 ± 0.002 (0.23 ± 0.05)		3 ft min	spools
0.046 (1.17)	0.022 (0.56)	0.009 ± 0.002 (0.23 ± 0.05)		3 ft min	spools
0.050 (1.27)	0.027 (0.69)	0.010 ± 0.002 (0.25 ± 0.05)		3 ft min	spools
0.055 (1.40)	0.032 (0.81)	0.010 ± 0.002 (0.25 ± 0.05)		3 ft min	spools
0.060 (1.52)	0.039 (0.99)	0.012 ± 0.003 (0.30 ± 0.08)		3 ft min	spools
0.065 (1.65)	0.043 (1.09)	0.012 ± 0.003 (0.30 ± 0.08)		3 ft min	spools