**Designation: D2902 – 00(Reapproved 2006)**

An American National Standard

# Standard Specification for
# Fluoropolymer Resin Heat-Shrinkable Tubing for Electrical Insulation[1]

This standard is issued under the fixed designation D2902; 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 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:*[2]

C618 Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete

D638 Test Method for Tensile Properties of Plastics

D1711 Terminology Relating to Electrical Insulation

D2116 Specification for FEP-Fluorocarbon Molding and Extrusion Materials

D2671 Test Methods for Heat-Shrinkable Tubing for Electrical Use

D3307 Specification for Perfluoroalkoxy (PFA)-Fluorocarbon Resin Molding and Extrusion Materials

D3636 Practice for Sampling and Judging Quality of Solid Electrical Insulating Materials

D4895 Specification for Polytetrafluoroethylene (PTFE) Resin Produced From Dispersion

E176 Terminology of Fire Standards

2.2 *IEC Standards:*

60684–3–240 to –243 Flexible insulating sleeving, Part 3, Sheets 240 to 243: Heat-shrinkable PTFE sleeving[3]

## 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*—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.

**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 D638 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 D4895 | 327 ± 10 °C [621± 20 °F] | | |
| Specification D2116 | | 270 ± 20 °C [518 ± 40 °F] | |
| Specification D3307 endotherm peak, min | | | 300 ± 2 °C [572 ± 7 °F] |
| Specification D3307 | | | 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 C618.

## 8. Dimensional Requirements

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

**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**

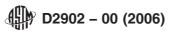| As Supplied | After Unrestrictive Shrinkage | | Stock Lengths | Packaging |
|---|---|---|---|---|
| Inside Diameter, min, in. [mm] | Inside Diameter, max, in. [mm] | Wall Thickness, in. [mm] | | |
| Heavy Wall | | | | |
| 0.166 [4.22] | 0.130 [3.30] | 0.030± 0.005 [0.76 ± 0.13] | 3 ft to 1 ft min | 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 |

**TABLE 3** *Continued*

| As Supplied | After Unrestrictive Shrinkage | | Stock Lengths | Packaging |
|---|---|---|---|---|
| Inside Diameter, min, in. [mm] | Inside Diameter, max, in. [mm] | Wall Thickness, in. [mm] | | |
| 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 |
| 0.076 [1.93] | 0.049 [1.24] | 0.012± 0.003 [0.30 ± 0.08] | 3 ft min | spools |
| 0.085 [2.16] | 0.054 [1.37] | 0.012± 0.003 [0.30 ± 0.08] | 3 ft min | spools |
| 0.093 [2.36] | 0.061 [1.55] | 0.012± 0.003 [0.30 ± 0.08] | 3 ft min | spools |
| 0.110 [2.79] | 0.067 [1.70] | 0.012± 0.003 [0.30 ± 0.08] | 3 ft min | spools |
| 0.120 [3.05] | 0.072 [1.83] | 0.012± 0.003 [0.30 ± 0.08] | 3 ft, 2 ft, 1 ft | straight lengths |
| 0.140 [3.56] | 0.080 [2.03] | 0.012± 0.003 [0.30 ± 0.08] | 3 ft, 2 ft, 1 ft | straight lengths |
| 0.150 [3.81] | 0.089 [2.26] | 0.012± 0.003 [0.30 ± 0.08] | 3 ft, 2 ft, 1 ft | straight lengths |
| 0.170 [4.32] | 0.101 [2.56] | 0.012± 0.003 [0.30 ± 0.08] | 3 ft, 2 ft, 1 ft | straight lengths |
| 0.191 [4.85] | 0.112 [2.84] | 0.012± 0.003 [0.30 ± 0.08] | 3 ft, 2 ft, 1 ft | straight lengths |
| 0.205 [5.21] | 0.124 [3.15] | 0.015± 0.004 [0.38 ± 0.10] | 3 ft, 2 ft, 1 ft | straight lengths |
| 0.215 [5.46] | 0.130 [3.30] | 0.015± 0.004 [0.38 ± 0.10] | 3 ft, 2 ft, 1 ft | straight lengths |
| 0.240 [6.10] | 0.141 [3.58] | 0.015± 0.004 [0.38 ± 0.10] | 3 ft, 2 ft, 1 ft | straight lengths |
| 0.270 [6.86] | 0.158 [4.01] | 0.015± 0.004 [0.38 ± 0.10] | 3 ft, 2 ft, 1 ft | straight lengths |
| 0.302 [7.67] | 0.178 [4.53] | 0.015± 0.004 [0.38 ± 0.10] | 3 ft, 2 ft, 1 ft | straight lengths |
| 0.320 [8.13] | 0.198 [5.03] | 0.015± 0.004 [0.38 ± 0.10] | 3 ft, 2 ft, 1 ft | straight lengths |
| 0.370 [9.40] | 0.224 [5.69] | 0.015± 0.004 [0.38 ± 0.10] | 3 ft, 2 ft, 1 ft | straight lengths |
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| 0.450 [11.43] | 0.311 [7.90] | 0.015± 0.004 [0.38 ± 0.10] | 3 ft, 2 ft, 1 ft | straight lengths |
| 0.470 [11.94] | 0.329 [8.36] | 0.015± 0.004 [0.38 ± 0.10] | 3 ft, 2 ft, 1 ft | straight lengths |
| 0.470 [11.94] | 0.347 [8.81] | 0.015± 0.004 [0.38 ± 0.10] | 3 ft, 2 ft, 1 ft | straight lengths |
| 0.560 [14.22] | 0.399 [10.13] | 0.015± 0.004 [0.38 ± 0.10] | 3 ft, 2 ft, 1 ft | straight lengths |
| 0.560 [14.22] | 0.399 [10.13] | 0.020± 0.005 [0.51 ± 0.13] | 3 ft, 2 ft, 1 ft | straight lengths |
| 0.655 [16.64] | 0.462 [11.73] | 0.018± 0.005 [0.46 ± 0.13] | 3 ft, 2 ft, 1 ft | straight lengths |
| 0.655 [16.64] | 0.462 [11.73] | 0.020± 0.005 [0.51 ± 0.13] | 3 ft, 2 ft, 1 ft | straight lengths |
| 0.750 [19.05] | 0.524 [13.31] | 0.018± 0.005 [0.46 ± 0.13] | 3 ft, 2 ft, 1 ft | straight lengths |
| 0.750 [19.05] | 0.524 [13.31] | 0.020± 0.005 [0.51 ± 0.13] | 3 ft, 2 ft, 1 ft | straight lengths |
| 0.930 [23.6] | 0.655 [16.64] | 0.020± 0.005 [0.51 ± 0.13] | 3 ft, 2 ft, 1 ft | straight lengths |
| 0.930 [23.6] | 0.655 [16.64] | 0.025± 0.005 [0.64 ± 0.13] | 3 ft, 2 ft, 1 ft | straight lengths |
| 1.125 [28.6] | 0.786 [20.0] | 0.025± 0.005 [0.64 ± 0.13] | 3 ft, 2 ft, 1 ft | straight lengths |