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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.

~~ε^1 NOTE—Language was changed editorially in January 2013.~~

1. ~~Scope~~ 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. This specification excludes crosslinked poly(vinylidene fluoride) and poly(vinylidene fluoride) copolymer which are covered under Specification D3144.

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

1.2 The values stated in inch-pound units are to be regarded as ~~the standard~~ standard, except temperature, which shall be stated in degrees Celsius. ~~Values~~ The values given in parentheses are ~~for information only.~~ mathematical conversions to SI units that are provided for information only and are not considered standard.

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:*[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 Resin Molding and Extrusion Materials
D2671 Test Methods for Heat-Shrinkable Tubing for Electrical Use
D3144 Specification for Crosslinked Poly(Vinylidene Fluoride) Heat-Shrinkable Tubing for Electrical Insulation
D3307 Specification for Perfluoroalkoxy (PFA) 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

[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 Electrical 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.

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

2.2 *IEC Standards:*[3]

~~60684-3-240 to -243~~IEC 60684-3-240 Flexible insulating ~~sleeving, Part 3,~~ sleeving - Part 3: Specifications for individual types of sleeving - Sheets 240 to 243: Heat-shrinkable PTFE sleeving

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.~~

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].~~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].~~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].~~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 shall be permitted to be tested less frequently or with a frequency agreed upon between seller and purchaser.

8. Dimensional Requirements

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

8.2 Type II and Type III materials shall conform to the requirements specified in Table 4.

[3] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY ~~10036.~~10036, http://www.ansi.org.

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~~
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~~
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]~~
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}~~
Volume resistivity,[B] -cm, at standard laboratory atmosphere, min	10^{16}	10^{16}	10^{16}
Dielectric breakdown voltage, min kV:			
Wall thickness:			
~~Wall thickness 0.004 to 0.006 in.~~	~~8~~	~~8~~	~~8~~
0.004 to 0.006 in.	8	8	8
~~0.007 to 0.008 in.~~	~~10~~	~~10~~	~~10~~
0.007 to 0.008 in.	10	10	10
~~0.009 in.~~	~~11.5~~	~~11.5~~	~~11.5~~
0.009 in.	11.5	11.5	11.5
~~0.010 to 0.011 in.~~	~~12.5~~	~~12.5~~	~~12.5~~
0.010 to 0.011 in.	12.5	12.5	12.5
~~0.012 to 0.014 in.~~	~~14.6~~	~~14.6~~	~~14.6~~
0.012 to 0.014 in.	14.6	14.6	14.6
~~0.015 in.~~	~~15~~	~~15~~	~~15~~
0.015 in.	15	15	15
~~0.016 to 0.019 in.~~	~~16.3~~	~~16.3~~	~~16.3~~
0.016 to 0.019 in.	16.3	16.3	16.3
~~0.020 in. and larger~~	~~17~~	~~17~~	~~17~~
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]~~			
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 I—350 ± 4 °C (662 ± 7 °F)	2000 (13.8)		
~~Type II—250 ± 3°C [482 ± 6°F]~~		~~1500 [10.3]~~	
Type II—250 ± 3 °C (482 ± 6 °F)		1500 (10.3)	
~~Type III—275 ± 4°C [527 ± 7°F]~~			~~2500 [17.3]~~
Type III—275 ± 4 °C (527 ± 7 °F)			2500 (17.3)
~~Low-temperature flexibility, – 55± 2°C [–67 ± °F]~~	~~no cracking~~	~~no cracking~~	~~no cracking~~
Low-temperature flexibility, –55 ± 2 °C (–67 ± °F)	no cracking	no cracking	no cracking
Melting point:			
~~Specification D4895~~	~~327 ± 10°C [621± 20°F]~~		
Specification D4895	327 ± 10 °C (621 ± 20 °F)		
~~Specification D2116~~		~~270 ± 20 °C [518 ± 40°F]~~	
Specification D2116		270 ± 20 °C (518 ± 40 °F)	
~~Specification D3307 endotherm peak, min~~			~~300 ± 2°C [572 ± 7°F]~~
Specification D3307 endotherm peak, min			300 ± 2 °C (572 ± 7 °F)
~~Specification D3307~~			~~305 ± 3 °C [581± 5°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.

8.3 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 are satisfied and the minimum recovered wall thickness equals or exceeds that of the identical or next largest as supplied size. The wall for sizes greater than the largest specified size shall be at least as thick as that of the largest specified size.

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 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)

9. Workmanship

9.1 The heat-shrinkable tubing shall be homogeneous and free from flaws and defects and from foreign matter that have the potential to compromise its performance.

9.2 Type I tubing shall be furnished in clear (transparent milk white to tan) or in a color as agreed between purchaser and seller.

9.3 Type II tubing shall be furnished in clear (water white to transparent light blue) or in a color as agreed between purchaser and seller.

9.4 Type III tubing shall be furnished in clear (transparent water white) or in a color as agreed between the purchaser and seller.

10. Sampling

10.1 A lot shall consist of all material manufactured from a single lot of resin at the same time and place.

NOTE 2—In view of the batch nature of fluoropolymer resin extrusion involving relatively short runs, single lots of product have the potential to include different sizes or wall thicknesses or both.

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 in accordance with Practice D3636 and Table 5 from each lot as defined in 10.1.

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. Tests and Retests

11.1 If the results of any test, except for attributes listed in ~~Table 3~~Tables 3 and 4 ~~and Table 4~~, do not conform to the requirements prescribed in this specification, perform two additional tests on different specimens from the same lot. Nonconformance to or Table 4 requirements on the first inspection are cause for rejection.

11.2 If either of the two additional tests fail, the purchaser has the option to reject the lot of material. Notice of nonconformance 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.

TABLE 3 Dimensions, Type I—Lengths for Type I

As Supplied	After Unrestrictive Shrinkage		Stock Lengths, ft	Packaging
Inside Diameter, min, in. (mm)	Inside Diameter, max, in. (mm)	Wall Thickness, in. (mm)		
~~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~~
0.166 (4.22)	0.130 (3.30)	0.030 ± 0.005 (0.76 ± 0.13)	3 to 1, 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~~
0.250 (6.35)	0.193 (4.90)	0.030 ± 0.005 (0.76 ± 0.13)	3 to 1, 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~~
0.333 (8.46)	0.257 (6.53)	0.030 ± 0.005 (0.76 ± 0.13)	3 to 1, 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~~
0.415 (10.54)	0.320 (8.13)	0.030 ± 0.005 (0.76 ± 0.13)	3 to 1, 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~~
0.498 (12.65)	0.383 (9.73)	0.030 ± 0.005 (0.76 ± 0.13)	3 to 1, 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~~
0.580 (14.73)	0.448 (11.38)	0.030 ± 0.005 (0.76 ± 0.13)	3 to 1, 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~~
0.666 (16.92)	0.510 (12.95)	0.030 ± 0.005 (0.76 ± 0.13)	3 to 1, 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~~
0.748 (19.00)	0.572 (14.53)	0.030 ± 0.005 (0.76 ± 0.13)	3 to 1, 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~~
0.830 (21.1)	0.637 (16.18)	0.030 ± 0.005 (0.76 ± 0.13)	3 to 1, 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~~
0.915 (23.2)	0.700 (17.78)	0.032 ± 0.006 (0.81 ± 0.15)	3 to 1, 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~~
1.000 (25.4)	0.764 (19.41)	0.040 ± 0.007 (1.02 ± 0.18)	3 to 1, 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~~
1.170 (29.7)	0.891 (22.6)	0.045 ± 0.007 (1.14 ± 0.18)	3 to 1, 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~~
1.330 (33.8)	1.020 (25.9)	0.050 ± 0.008 (1.27 ± 0.20)	3 to 1, min	straight lengths
Standard Wall				
~~0.045 [1.14]~~	~~0.027 [0.69]~~	~~0.012± 0.002 [0.30 ± 0.05]~~		
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~~
0.050 (1.27)	0.032 (0.81)	0.012 ± 0.002 (0.30 ± 0.05)	3, 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~~
0.055 (1.40)	0.039 (0.99)	0.016 ± 0.003 (0.41 ± 0.08)	3, 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~~
0.060 (1.52)	0.043 (1.09)	0.016 ± 0.003 (0.41 ± 0.08)	3, min	spools
~~0.085 [2.16]~~	~~0.061 [1.55]~~	~~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, min	spools
~~0.093 [2.36]~~	~~0.067 [1.70]~~	~~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, min	spools
~~0.110 [2.79]~~	~~0.072 [1.83]~~	~~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, 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~~
0.093 (2.36)	0.067 (1.70)	0.016 ± 0.003 (0.41 ± 0.08)	3, min	spools
0.110 (2.79)	0.072 (1.83)	0.016 ± 0.003 (0.41 ± 0.08)	3, min	spools
~~0.140 [3.56]~~	~~0.089 [2.26]~~	~~0.016± 0.003 [0.41 ± 0.08]~~	~~3 ft, 2 ft, 1 ft~~	~~straight lengths~~
0.120 (3.05)	0.080 (2.03)	0.016 ± 0.003 (0.41 ± 0.08)	3, 2, 1	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~~
0.140 (3.56)	0.089 (2.26)	0.016 ± 0.003 (0.41 ± 0.08)	3, 2, 1	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~~
0.160 (4.06)	0.101 (2.56)	0.016 ± 0.003 (0.41 ± 0.08)	3, 2, 1	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~~
0.180 (4.57)	0.112 (2.84)	0.016 ± 0.003 (0.41 ± 0.08)	3, 2, 1	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~~
0.200 (5.08)	0.124 (3.15)	0.020 ± 0.004 (0.51 ± 0.10)	3, 2, 1	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~~
0.210 (5.33)	0.130 (3.30)	0.020 ± 0.004 (0.51 ± 0.10)	3, 2, 1	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~~
0.230 (5.84)	0.141 (3.58)	0.020 ± 0.004 (0.51 ± 0.10)	3, 2, 1	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~~
0.240 (6.10)	0.158 (4.01)	0.020 ± 0.004 (0.51 ± 0.10)	3, 2, 1	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~~
0.290 (7.37)	0.178 (4.52)	0.020 ± 0.004 (0.51 ± 0.10)	3, 2, 1	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~~
0.310 (7.87)	0.198 (5.03)	0.020 ± 0.004 (0.51 ± 0.10)	3, 2, 1	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~~
0.370 (9.40)	0.224 (5.69)	0.020 ± 0.004 (0.51 ± 0.10)	3, 2, 1	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~~
0.390 (9.91)	0.249 (6.32)	0.020 ± 0.004 (0.51 ± 0.10)	3, 2, 1	straight lengths

TABLE 3 *Continued*

As Supplied	After Unrestrictive Shrinkage		Stock Lengths, ft	Packaging
Inside Diameter, min, in. (mm)	Inside Diameter, max, in. (mm)	Wall Thickness, in. (mm)		
0.430 [10.92]	0.278 [7.06]	0.020± 0.004 [0.51 ± 0.10]	3 ft, 2 ft, 1 ft	straight lengths
0.410 (10.41)	0.260 (6.60)	0.020 ± 0.004 (0.51 ± 0.10)	3, 2, 1	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
0.430 (10.92)	0.278 (7.06)	0.020 ± 0.004 (0.51 ± 0.10)	3, 2, 1	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
0.450 (11.43)	0.311 (7.90)	0.020 ± 0.004 (0.51 ± 0.10)	3, 2, 1	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)	0.329 (8.36)	0.020 ± 0.004 (0.51 ± 0.10)	3, 2, 1	straight lengths
0.470 (11.94)	0.347 (8.81)	0.020 ± 0.004 (0.51 ± 0.10)	3, 2, 1	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
0.470 (11.94)	0.334 (8.48)	0.025 ± 0.005 (0.64 ± 0.13)	3, 1, 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
0.560 (14.22)	0.339 (8.61)	0.025 ± 0.005 (0.64 ± 0.13)	3, 1, 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
0.655 (16.64)	0.462 (11.73)	0.025 ± 0.005 (0.64 ± 0.13)	3, 1, 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
0.750 (19.05)	0.524 (13.31)	0.025 ± 0.005 (0.64 ± 0.13)	3, 1, 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
0.930 (23.6)	0.655 (16.64)	0.030 ± 0.005 (0.76 ± 0.13)	3, 1, 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
1.125 (28.6)	0.786 (20.0)	0.035 ± 0.006 (0.89 ± 0.15)	3, 1, 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
1.310 (33.3)	0.911 (23.1)	0.035 ± 0.006 (0.89 ± 0.15)	3, 1, 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
1.500 (38.1)	1.036 (26.3)	0.035 ± 0.006 (0.89 ± 0.15)	3, 1, 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
0.034 (0.86)	0.015 (0.38)	0.009 ± 0.002 (0.23 ± 0.05)	3, 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
0.038 (0.97)	0.018 (0.46)	0.009 ± 0.002 (0.23 ± 0.05)	3, min	spools
0.055 [1.40]	0.032 [0.81]	0.010± 0.002 [0.25 ± 0.05]	3 ft min	spools
0.046 (1.17)	0.022 (0.56)	0.009 ± 0.002 (0.23 ± 0.05)	3, 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
0.050 (1.27)	0.027 (0.69)	0.010 ± 0.002 (0.25 ± 0.05)	3, min	spools
0.076 [1.93]	0.049 [1.24]	0.012± 0.003 [0.30 ± 0.08]	3 ft min	spools
0.055 (1.40)	0.032 (0.81)	0.010 ± 0.002 (0.25 ± 0.05)	3, min	spools
0.085 [2.16]	0.054 [1.37]	0.012± 0.003 [0.30 ± 0.08]	3 ft min	spools
0.060 (1.52)	0.039 (0.99)	0.012 ± 0.003 (0.30 ± 0.08)	3, min	spools
0.093 [2.36]	0.061 [1.55]	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, min	spools
0.110 [2.79]	0.067 [1.70]	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, 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
0.085 (2.16)	0.054 (1.37)	0.012 ± 0.003 (0.30 ± 0.08)	3, min	spools
0.140 [3.56]	0.080 [2.03]	0.012± 0.003 [0.30 ± 0.08]	3 ft, 2 ft, 1 ft	straight lengths
0.093 (2.36)	0.061 (1.55)	0.012 ± 0.003 (0.30 ± 0.08)	3, min	spools
0.110 (2.79)	0.067 (1.70)	0.012 ± 0.003 (0.30 ± 0.08)	3, min	spools
0.150 [3.81]	0.089 [2.26]	0.012± 0.003 [0.30 ± 0.08]	3 ft, 2 ft, 1 ft	straight lengths
0.120 (3.05)	0.072 (1.83)	0.012 ± 0.003 (0.30 ± 0.08)	3, 2, 1	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
0.140 (3.56)	0.080 (2.03)	0.012 ± 0.003 (0.30 ± 0.08)	3, 2, 1	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
0.150 (3.81)	0.089 (2.26)	0.012 ± 0.003 (0.30 ± 0.08)	3, 2, 1	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
0.170 (4.32)	0.101 (2.56)	0.012 ± 0.003 (0.30 ± 0.08)	3, 2, 1	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
0.191 (4.85)	0.112 (2.84)	0.012 ± 0.003 (0.30 ± 0.08)	3, 2, 1	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
0.205 (5.21)	0.124 (3.15)	0.015 ± 0.004 (0.38 ± 0.10)	3, 2, 1	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
0.215 (5.46)	0.130 (3.30)	0.015 ± 0.004 (0.38 ± 0.10)	3, 2, 1	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
0.240 (6.10)	0.141 (3.58)	0.015 ± 0.004 (0.38 ± 0.10)	3, 2, 1	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
0.270 (6.86)	0.158 (4.01)	0.015 ± 0.004 (0.38 ± 0.10)	3, 2, 1	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
0.302 (7.67)	0.178 (4.53)	0.015 ± 0.004 (0.38 ± 0.10)	3, 2, 1	straight lengths
0.390 [9.91]	0.249 [6.32]	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, 2, 1	straight lengths
0.410 [10.41]	0.260 [6.60]	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, 2, 1	straight lengths

TABLE 3 *Continued*

As Supplied	After Unrestrictive Shrinkage		Stock Lengths, ft	Packaging
Inside Diameter, min, in. (mm)	Inside Diameter, max, in. (mm)	Wall Thickness, in. (mm)		
Thin Wall				
0.430 [10.92]	0.278 [7.06]	0.015± 0.004 [0.38 ± 0.10]	3 ft, 2 ft, 1 ft	straight lengths
0.390 (9.91)	0.249 (6.32)	0.015 ± 0.004 (0.38 ± 0.10)	3, 2, 1	straight lengths
0.450 [11.43]	0.311 [7.90]	0.015± 0.004 [0.38 ± 0.10]	3 ft, 2 ft, 1 ft	straight lengths
0.410 (10.41)	0.260 (6.60)	0.015 ± 0.004 (0.38 ± 0.10)	3, 2, 1	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
0.430 (10.92)	0.278 (7.06)	0.015 ± 0.004 (0.38 ± 0.10)	3, 2, 1	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
0.450 (11.43)	0.311 (7.90)	0.015 ± 0.004 (0.38 ± 0.10)	3, 2, 1	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
0.470 (11.94)	0.329 (8.36)	0.015 ± 0.004 (0.38 ± 0.10)	3, 2, 1	straight lengths
0.470 (11.94)	0.347 (8.81)	0.015 ± 0.004 (0.38 ± 0.10)	3, 2, 1	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
0.560 (14.22)	0.399 (10.13)	0.015 ± 0.004 (0.38 ± 0.10)	3, 2, 1	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
0.560 (14.22)	0.399 (10.13)	0.020 ± 0.005 (0.51 ± 0.13)	3, 2, 1	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
0.655 (16.64)	0.462 (11.73)	0.018 ± 0.005 (0.46 ± 0.13)	3, 2, 1	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
0.655 (16.64)	0.462 (11.73)	0.020 ± 0.005 (0.51 ± 0.13)	3, 2, 1	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
0.750 (19.05)	0.524 (13.31)	0.018 ± 0.005 (0.46 ± 0.13)	3, 2, 1	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
0.750 (19.05)	0.524 (13.31)	0.020 ± 0.005 (0.51 ± 0.13)	3, 2, 1	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
0.930 (23.6)	0.655 (16.64)	0.020 ± 0.005 (0.51 ± 0.13)	3, 2, 1	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
0.930 (23.6)	0.655 (16.64)	0.025 ± 0.005 (0.64 ± 0.13)	3, 2, 1	straight lengths
1.125 [28.6]	0.786 [20.0]	0.030± 0.006 [0.76 ± 0.15]	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, 2, 1	straight lengths
1.125 (28.6)	0.786 (20.0)	0.030 ± 0.006 (0.76 ± 0.15)	3, 2, 1	straight lengths
2.0:1 Shrink Factor				
0.039 [1]	0.020 [0.50]	0.010± 0.002 [0.25 ± 0.05]	4 ft	straight lengths
0.039 (1)	0.020 (0.50)	0.010 ± 0.002 (0.25 ± 0.05)	4	straight lengths
0.059[1.5]	0.030 [0.75]	0.010± 0.002 [0.25 ± 0.05]	4 ft	straight lengths
0.059(1.5)	0.030 (0.75)	0.010 ± 0.002 (0.25 ± 0.05)	4	straight lengths
0.098 [2.5]	0.049 [1.25]	0.010± 0.002 [0.25 ± 0.05]	4 ft	straight lengths
0.098 (2.5)	0.049 (1.25)	0.010 ± 0.002 (0.25 ± 0.05)	4	straight lengths
0.138 [3.5]	0.069 [1.75]	0.010± 0.002 [0.25 ± 0.05]	4 ft	straight lengths
0.138 (3.5)	0.069 (1.75)	0.010 ± 0.002 (0.25 ± 0.05)	4	straight lengths
0.197 [5]	0.098 [2.5]	0.010 ± 0.002 [0.25 ± 0.05]	4 ft	straight lengths
0.197 (5)	0.098 (2.5)	0.010 ± 0.002 (0.25 ± 0.05)	4	straight lengths
0.276 [7]	0.138 [3.5]	0.020 ± 0.004 [0.50 ± 0.10]	4 ft	straight lengths
0.276 (7)	0.138 (3.5)	0.020 ± 0.004 (0.50 ± 0.10)	4	straight lengths
0.394 [10]	0.197 [5.0]	0.020 ± 0.004 [0.50 ± 0.10]	4 ft	straight lengths
0.394 (10)	0.197 (5.0)	0.020 ± 0.004 (0.50 ± 0.10)	4	straight lengths
0.512 [13]	0.256 [6.5]	0.020 ± 0.004 [0.50 ± 0.10]	4 ft	straight lengths
0.512 (13)	0.256 (6.5)	0.020 ± 0.004 (0.50 ± 0.10)	4	straight lengths
0.827 [20]	0.394 [10.0]	0.020± 0.004 [0.50 ± 0.10]	4 ft	straight lengths
0.827 (20)	0.394 (10.0)	0.020 ± 0.004 (0.50 ± 0.10)	4	straight lengths
1.024 [26]	0.512 [13.0]	0.030± 0.004 [0.75 ± 0.10]	4 ft	straight lengths
1.024 (26)	0.512 (13.0)	0.030 ± 0.004 (0.75 ± 0.10)	4	straight lengths
Very Thin Wall				
0.050 [1.27]	0.027 [0.69]	0.006± 0.002 [0.15 ± 0.05]	3 ft	spools
0.055 [1.40]	0.032 [0.81]	0.006± 0.002 [0.15 ± 0.05]	3 ft	spools
0.050 (1.27)	0.027 (0.69)	0.006 ± 0.002 (0.15 ± 0.05)	3	spools
0.060 [1.52]	0.039 [0.99]	0.006± 0.002 [0.15 ± 0.05]	3 ft	spools
0.055 (1.40)	0.032 (0.81)	0.006 ± 0.002 (0.15 ± 0.05)	3	spools
0.065 [1.65]	0.043 [1.09]	0.006± 0.002 [0.15 ± 0.05]	3 ft	spools
0.060 (1.52)	0.039 (0.99)	0.006 ± 0.002 (0.15 ± 0.05)	3	spools
0.076 [1.93]	0.049 [1.24]	0.006± 0.002 [0.15 ± 0.05]	3 ft	spools
0.065 (1.65)	0.043 (1.09)	0.006 ± 0.002 (0.15 ± 0.05)	3	spools
0.085 [2.16]	0.054 [1.37]	0.006± 0.002 [0.15 ± 0.05]	3 ft	spools
0.076 (1.93)	0.049 (1.24)	0.006 ± 0.002 (0.15 ± 0.05)	3	spools
0.093 [2.36]	0.061 [1.55]	0.006± 0.002 [0.15 ± 0.05]	3 ft, 2 ft, 1 ft	straight lengths
0.085 (2.16)	0.054 (1.37)	0.006 ± 0.002 (0.15 ± 0.05)	3	spools
0.110 [2.79]	0.067 [1.70]	0.006± 0.002 [0.15 ± 0.05]	3 ft, 2 ft, 1 ft	straight lengths
0.093 (2.36)	0.061 (1.55)	0.006 ± 0.002 (0.15 ± 0.05)	3, 2, 1	straight lengths
0.120 [3.05]	0.072 [1.83]	0.008± 0.002 [0.20 ± 0.05]	3 ft, 2 ft, 1 ft	straight lengths
0.110 (2.79)	0.067 (1.70)	0.006 ± 0.002 (0.15 ± 0.05)	3, 2, 1	straight lengths
0.140 [3.56]	0.080 [2.03]	0.008± 0.002 [0.20 ± 0.05]	3 ft, 2 ft, 1 ft	straight lengths
0.120 (3.05)	0.072 (1.83)	0.008 ± 0.002 (0.20 ± 0.05)	3, 2, 1	straight lengths
0.150 [3.81]	0.089 [2.26]	0.008± 0.002 [0.20 ± 0.05]	3 ft, 2 ft, 1 ft	straight lengths
0.140 (3.56)	0.080 (2.03)	0.008 ± 0.002 (0.20 ± 0.05)	3, 2, 1	straight lengths