

THERMOFIT® RP-4800 TUBING, HIGH EXPANSION
Polyolefin, Flexible, Heat-Shrinkable, Flame Retarded

1. SCOPE

This specification covers the requirements for one type of flexible electrical insulating, extruded tubing whose diameter will reduce to a predetermined size upon the application of heat in excess of 121°C (250°F).

2. APPLICABLE DOCUMENTS

This specification takes precedence over documents referenced herein. Unless otherwise specified, the latest issue of referenced documents applies. The following documents form a part of this specification to the extent specified herein.

2.1 GOVERNMENT-FURNISHED DOCUMENTS

Military

ASTM D 910 Gasoline, Aviation, Grades 80/87, 100, and 115/145
MIL-PRF-5606 Hydraulic Fluid, Petroleum Base, Aircraft, Missile and Ordnance
MIL-DTL-5624 Turbine Fuel, Aviation, Grades JP-4 and JP-5

2.2 OTHER PUBLICATIONS

American Society for Testing and Materials (ASTM)

D 2671 Standard Methods of Testing Heat-Shrinkable Tubing for Electrical Use
D 910 Standard Spec. for Aviation Gasolines

(Copies of ASTM publications may be obtained from the American Society for Testing and Materials, 1916 Race Street, Philadelphia, Pennsylvania 19103.)

ISO 846 Plastics-Evaluation of the action of microorganisms

3. REQUIREMENTS

3.1 MATERIALS

The tubing shall be fabricated from thermally stabilized, modified polyolefin and shall be crosslinked by irradiation. It shall be homogeneous and essentially free from flaws, defects, pinholes, bubbles, seams, cracks, and inclusions.

3.2 COLOR

Standard color shall be black.

3.3 PROPERTIES

The tubing shall meet the requirements of Table 2.

4. QUALITY ASSURANCE PROVISIONS

4.1 CLASSIFICATION OF TESTS

4.1.1 Qualification Tests

Qualification tests are those performed on tubing submitted for qualification as a satisfactory product and shall consist of all tests listed in this specification.

4.1.2 Acceptance Tests

Acceptance tests are those performed on tubing submitted for acceptance under contract. Acceptance tests shall be: dimensions, longitudinal change, tensile strength, ultimate elongation, secant modulus, flammability and heat shock.

4.2 SAMPLING INSTRUCTIONS

4.2.1 Qualification Test Samples

Qualification test samples shall consist of 50 feet (*15 m*) of tubing of the size specified. Qualification of any size from Table 1 shall qualify all sizes.

4.2.2 Acceptance Test Samples

Acceptance test samples shall consist of not less than 16 feet (*5 m*) of tubing selected at random from each lot. A lot shall consist of all tubing of the same size, from the same production run, and offered for inspection at the same time.

4.3 TEST PROCEDURES

Unless otherwise specified, perform tests on specimens which have been fully recovered by conditioning for 3 minutes in a $200 \pm 5^{\circ}\text{C}$ ($392 \pm 9^{\circ}\text{F}$) oven. Condition the test specimens (and measurement gauges, when applicable) for 3 hours at $23 \pm 3^{\circ}\text{C}$ ($73 \pm 5^{\circ}\text{F}$) and 50 ± 5 percent relative humidity for 3 hours prior to all testing. Use mechanical convection type ovens in which air passes the specimens at a velocity of 100 to 200 feet (*30 to 60 m*) per minute.

4.3.1 Dimensions and Longitudinal Change

Measure three 6-inch (150 mm) specimens of tubing, as supplied, for length $\pm 1/32$ inch (± 1 mm), and inside diameter in accordance with ASTM D 2671. Condition the specimens for 3 minutes in a $200 \pm 5^\circ\text{C}$ ($392 \pm 9^\circ\text{F}$) oven, cool to $23 \pm 3^\circ\text{C}$ ($73 \pm 5^\circ\text{F}$) and then remeasure. Prior to and after conditioning, the dimensions of the tubing shall be in accordance with Table 1 and the longitudinal change shall be in accordance with Table 3. Calculate the longitudinal change as follows:

$$C = \frac{L_1 - L_0}{L_0} \times 100$$

Where: C = Longitudinal Change [Percent]
 L₀ = Length Before Conditioning [Inches (mm)]
 L₁ = Length After Conditioning [Inches (mm)]

4.3.2 Tensile Strength and Ultimate Elongation

The tensile strength and ultimate elongation of the tubing shall be determined in accordance with ASTM D 2671, using 1-inch (25 mm) bench marks and a 1-inch (25 mm) initial jaw separation. The speed of jaw separation shall be 20 ± 2 inches (500 \pm 50 mm) per minute.

4.3.3 Secant Modulus

The secant modulus of the recovered tubing shall be tested in accordance with ASTM D 2671. Initial jaw separation shall be 10 inches (250 mm).

4.3.4 Low Temperature Flexibility

Three 12-inch (300 mm) by 1/4 inch (6 mm) strips cut from the tubing and a 7/16 inch mandrel shall be conditioned for 4 hours at $-55 \pm 2^\circ\text{C}$ ($-67 \pm 4^\circ\text{F}$). While at this same temperature, the specimens then shall be wrapped around the mandrel for not less than 360° in 10 ± 2 seconds. The specimens then shall be visually examined for evidence of cracking.

4.3.5 Heat Shock

Three 12-inch (300 mm) by 1/4 inch (6 mm) strips cut from the tubing shall be conditioned for 4 hours in a $250 \pm 5^\circ\text{C}$ ($482 \pm 9^\circ\text{F}$) oven. After this conditioning, the specimens shall be removed from the oven, cooled to $23 \pm 3^\circ\text{C}$ ($73 \pm 5^\circ\text{F}$), wrapped 180° around a 7/16 inch mandrel in approximately 2 seconds, and then visually examined for evidence of dripping, flowing, or cracking.

4.3.6 Heat Resistance

Three specimens of tubing prepared in accordance with ASTM D 2671, shall be conditioned for 336 hours in a $175 \pm 3^\circ\text{C}$ ($347 \pm 5^\circ\text{F}$) oven. After conditioning, the specimens shall be removed from the oven, cooled to $23 \pm 3^\circ\text{C}$ ($73 \pm 5^\circ\text{F}$) and tested for elongation in accordance with 4.3.2.

4.3.7 Copper Stability

A 6-inch (150 mm) specimen of tubing shall be slid over a snug fitting, straight, clean, bare, solid or tubular copper conductor. The specimens on the conductor shall be conditioned for 24 hours in a dessicator or similar humidity chamber at 90 to 95 percent relative humidity and 25 ± 3 °C (77 ± 5 °F). The specimens on the conductors then shall be conditioned for 168 hours in a 160 ± 3 °C (320 ± 5 °F) oven. After conditioning, the specimens shall be removed from the oven and cooled to 23 ± 3 °C (73 ± 5 °F). The copper conductors then shall be removed from the tubing, and the tubing and conductor shall be examined. Darkening of the copper due to normal air oxidation shall not be cause for rejection. The tubing shall be tested for elongation in accordance with 4.3.2.

4.3.8 Dielectric Strength

The dielectric strength shall be determined by following the ASTM D 2671 procedure for dielectric breakdown. When dielectric breakdown occurs the thickness measurements for calculating dielectric strength shall be made adjacent to the point of breakdown and the dielectric strength shall be calculated in volts per mil.

4.3.9 Corrosive Effect

4.3.9.1 Copper Mirror Corrosion

Two specimens of tubing shall be tested for copper mirror corrosion in accordance with ASTM D 2671, Method A, for 16 hours at 175 ± 3 °C (347 ± 5 °F). Specimens shall consist of 1/4 by 1 inch (6 by 25 mm) strips cut longitudinally. Evidence of corrosion shall be the removal of copper from a mirror, leaving an area of transparency greater than 5 percent of its total area.

4.3.9.2 Corrosion in Contact with Copper

The tubing shall be tested for corrosion in contact with copper in accordance with ASTM D 2671, Method B, for 16 hours at 175 ± 3 °C (347 ± 5 °F).

4.3.10 Flammability

A specimen of tubing shall be recovered to an 18 inch length over a 21-inch metal rod with a diameter equivalent to the maximum recovered diameter specified in Table 1. The specimen then shall be subjected to the vertical test in accordance with ASTM D 2671 Procedure B. Brown scorching or soot on the indicator flag shall not be cause for rejection.

4.3.11 Fluid Resistance

Six specimens of tubing, prepared and measured in accordance with ASTM D 2671, shall be completely immersed in each listed fluid for 24 ± 2 hours at 25 ± 3 °C (77 ± 5 °F). The volume of the fluid shall not be less than 20 times that of the specimens. After immersion, all the specimens shall be lightly wiped and air dried for 30 to 60 minutes at room temperature. Three specimens then shall be tested for dielectric strength and the other three for tensile strength.

4.4 REJECTION AND RETEST

Failure of any sample of tubing to conform to any one of the requirements of this specification shall be cause for rejection of the lot represented. Tubing which has been rejected may be replaced or reworked to correct the defects and resubmitted for acceptance. Before resubmitting, full particulars concerning previous rejection and action taken to correct the defects shall be furnished to the inspector.

5. PREPARATION FOR DELIVERY

5.1 FORM

The tubing shall be supplied in lengths of 48 +1, -0 inches (*1220 +25, -0 mm*) or on spools.

5.2 PACKAGING

Packaging shall be in accordance with good commercial practice.

5.3 MARKING

Each container of tubing shall be permanently and legibly marked with the product designation size, quantity, manufacturer's identification, and lot number.

TABLE 1
Tubing Dimensions

Size	As Supplied		As Recovered							
	Inside Diameter Minimum		Inside Diameter Maximum		Wall Thickness					
					Minimum		Maximum		Nominal	
	in.	mm.	in.	mm.	in.	mm.	in.	mm.	in.	mm.
RP-4800-1	1.000	25.40	.275	6.99	.038	0.96	.052	1.32	.045	1.14
RP-4800-2	2.000	50.80	.550	13.97	.038	0.96	.052	1.32	.045	1.14
RP-4800-3	3.000	76.20	.810	20.57	.038	0.96	.052	1.32	.045	1.14
RP-4800-4	4.000	101.60	1.050	26.67	.038	0.96	.052	1.32	.045	1.14
RP-4800-5	1.000	25.40	.462	11.74	.038	0.96	.052	1.32	.045	1.14
RP-4800-6	2.375	60.33	.680	17.27	.038	0.96	.052	1.32	.045	1.14
RP-4800-7	3.000	76.20	.840	21.34	.038	0.96	.052	1.32	.045	1.14
RP-4800-8	3.750	95.25	.930	23.62	.038	0.96	.052	1.32	.045	1.14
RP-4800-9	4.500	114.30	1.450	36.83	.038	0.96	.052	1.32	.045	1.14
RP-4800-10	1.500	38.10	.375	9.53	.038	0.96	.052	1.32	.045	1.14
RP-4800-11	.750	19.05	.180	4.57	.038	0.96	.052	1.32	.045	1.14

TABLE 2
Requirements

PROPERTY	UNIT	REQUIREMENT	TEST METHOD
PHYSICAL			
Dimensions	Inches (<i>mm</i>)	In accordance with Table 1	Section 4.3.1 ASTM D 2671
Longitudinal Change	Percent	-10 maximum	
Tensile Strength	psi (<i>MPa</i>)	1500 minimum (<i>10.3</i>)	Section 4.3.2 ASTM D 2671
Ultimate Elongation	Percent	200 minimum	
Secant Modulus (Expanded)	psi (<i>MPa</i>)	2.5×10^4 maximum (<i>172</i>)	Section 4.3.3 ASTM D 2671
Specific Gravity	---	1.35 maximum	ASTM D 2671
Low Temperature Flexibility 4 hours at $-55 \pm 1^\circ\text{C}$ ($-67 \pm 2^\circ\text{F}$)	---	No cracking	Section 4.3.4
Heat Shock 4 hours at $250 \pm 3^\circ\text{C}$ ($482 \pm 5^\circ\text{F}$)	---	No dripping, flowing or cracking	Section 4.3.5
Heat Resistance 336 hours at $175 \pm 2^\circ\text{C}$ ($347 \pm 4^\circ\text{F}$) Followed by test for: Ultimate Elongation	---	---	Section 4.3.6 ASTM D 2671
	Percent	150 minimum	Section 4.3.2
ELECTRICAL			
Dielectric Strength	Volts/mil (<i>volts/mm</i>)	500 minimum (<i>19,680</i>)	Section 4.3.8 ASTM D 2671
Volume Resistivity	ohm-cm	10^{14} minimum	ASTM D 2671

TABLE 2
Requirements
(continued)

PROPERTY	UNIT	REQUIREMENT	TEST METHOD
CHEMICAL Corrosive Effect 16 hours at 175 ± 2°C (347 ± 4°F)	- --	No removal of copper	Section 4.3.9
Copper Stability 168 hours at 160 ± 2°C (320 ± 4°F)	---	No brittleness, glazing, cracking, or severe discoloration of tubing	Section 4.3.7
Followed by test for:			
Ultimate Elongation	Percent	200 minimum	Section 4.3.2
Flammability, Average time of burning	seconds	60 maximum 25%maximum flag burn	Section 4.3.10 ASTM D 2671 Procedure B
Water Absorption 24 hours at 23°C (73°F)	Percent	0.5 maximum	ASTM D 2671
Fluid Resistance 24 hours at 23°C (73°F) in: JP-4 Fuel (MIL-DTL-5624) Skydrol* 500 Hydraulic Fluid (MIL-PRF-5606) Aviation Gasoline (100) (ASTM D 910) Water Followed by tests for:	---	---	Section 4.3.11 ASTM D 2671
Dielectric Strength	Volts/mil (volts/mm)	400 minimum (15,760)	
Tensile Strength	psi (MPa)	1000 minimum (6.9)	
Fungus Resistance			ISO 846 Method B
Followed by tests for:			
Tensile Strength	psi (Mpa)	1500 minimum (10.3)	Section 4.3.2
Ultimate Elongation	percent	200 minimum	ASTM D 2671
Dielectric Strength	Volts per mil (volts per mm)	500 minimum (19,700)	ASTM D 2671

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