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Specification	**RT-1171**
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Thermofit® MIL-LT Tubing
Low Shrink-Temperature
Polyolefin, Flexible, Heat-Shrinkable

1. SCOPE

This specification covers requirements for flexible electrical insulating, extruded tubing whose diameter will reduce to a predetermined size upon the application of heat in excess of 90°C *(194°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 specifications to the extent specified herein.

2.1 GOVERNMENT-FURNISHED DOCUMENTS

Military

MIL-H-5606	Hydraulic Fluid, Petroleum Base, Aircraft, Missile and Ordnance
Mil-DTL-83133	Turbine Fuels, Aviation, Kerosene Types, NATO F-34 (JP-8), NATO F-35 and JP-8+100
MIL-L-7808	Lubricating Oil, Aircraft Turbine Engine, Synthetic Base
MIL-STD-104	Limits for Electrical Insulation Color
MIL-A-8243	Anti-icing and deicing-Defrosting Fluids
MIL-L-23699	Lubricating Oil, Aircraft Turbine Engines, Synthetic Base

2.2 OTHER PUBLICATIONS

ISO 846	Plastics-Evaluation of the action of microorganisms

American Society for Testing and Materials (ASTM)

D 2240	Standard Test Method for Rubber Property - Durometer Hardness
D 2671	Standard Methods of Testing Heat-Shrinkable Tubing for Electrical Use

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

3. REQUIREMENTS

3.1 MATERIALS

The tubing shall be fabricated form 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 PROPERTIES

The tubing shall meet the requirements of Table 3.

3.3 COLOR

The tubing shall be available in black, white, red, yellow or blue, unless otherwise specified.

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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 consist of the following:

Dimensions
Longitudinal Change
Tensile Strength
Ultimate Elongation
Flammability
Heat Shock
Low Temperature Flexibility

4.2 SAMPLING INSTRUCTIONS

4.2.1 Qualification Test Samples

Qualification test samples shall consist of 50 feet *(125 m)* of black and white tubing. Qualification of black and white shall qualify all colors. Qualification of any size within each size range specified below shall qualify all sizes within that size range.

Size Range
3/64 through 1/8
3/16 through 3/4
1 through 4

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 ± 5°C *(392 ± 9°F)* oven. Condition the test specimens (and measurement gauges, when applicable) for 3 hours at 23 ± 3°C *(73 ± 5°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 ± 1/32 inch *(± 1 mm)*, and inside diameter in accordance with ASTM D 2671. Condition the specimens for 3 minutes in a 200 ± 5°C *(392 ± 9°F)* oven, cool to 23 ± 3°C *(73 + 5°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]
L_0 = Length Before Conditioning [inches *(mm)*]
L_1 = Length After Conditioning [inches *(mm)*]

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4.3.2 Tensile Strength and Ultimate Elongation

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

4.3.3 Low Temperature Flexibility

Test three specimens of tubing for low temperature flexibility as follows: for tubing sizes 3/4-inch expanded and smaller, shrink and condition the tubing as specified in 4.3 onto a stranded AWG wire (nearest AWG which is larger than the tubing maximum I.D. nominal after unrestricted shrinkage). For tubing sizes larger than 3/4-inch, cut a 6 x 1/4-inch *(150 x 6-mm)* longitudinal strip from tubing that has been recovered. Condition the specimens and a mandrel, selected from Table 2, in a cold chamber for 4 hours at -55 ± 3°C *(-67 ± 5°F)*. After completion of the conditioning period and while still in the cold chamber at the specified temperature, bend the specimen around the mandrel through not less than 360 degrees in 10 ± 2 seconds. Visually examine the tubing for cracks.

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 defect and then 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 on spools, unless otherwise specified.

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 size, quantity, manufacturer's identification, specification number, and lot number.

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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.*
3/64	.046	*1.17*	.023	*0.58*	.013	*0.33*	.019	*0.48*	.016	*0.40*
1/16	.063	*1.60*	.031	*0.79*	.014	*0.35*	.020	*0.50*	.017	*0.43*
3/32	.093	*2.36*	.046	*1.17*	.017	*0.43*	.023	*0.58*	.020	*0.50*
1/8	.125	*3.18*	.062	*1.58*	.017	*0.43*	.023	*0.58*	.020	*0.50*
3/16	.187	*4.75*	.093	*2.36*	.017	*0.43*	.023	*0.58*	.020	*0.50*
1/4	.250	*6.35*	.125	*3.18*	.022	*0.56*	.028	*0.71*	.025	*0.64*
3/8	.375	*9.53*	.187	*4.75*	.022	*0.56*	.028	*0.71*	.025	*0.64*
1/2	.500	*12.70*	.250	*6.35*	.022	*0.56*	.028	*0.71*	.025	*0.64*
3/4	.750	*19.05*	.375	*9.53*	.027	*0.68*	.033	*0.84*	.030	*0.76*
1	1.000	*25.40*	.500	*12.70*	.030	*0.76*	.040	*1.01*	.035	*0.88*
1-1/2	1.500	*38.10*	.750	*19.05*	.034	*0.86*	.046	*1.17*	.040	*1.01*
2	2.000	*50.80*	1.000	*25.40*	.038	*0.96*	.052	*1.32*	.045	*1.14*
3	3.000	76.20	1.500	*38.10*	.042	*1.06*	.058	*1.47*	.050	*1.27*
4	4.000	*101.60*	2.000	*50.80*	.046	*1.16*	.064	*1.63*	.055	*1.39*

TABLE 2
Mandrel Dimensions for Bend Testing

Tubing Size	Mandrel Diameter	
	in.	*mm.*
3/64 to 1/4 inclusive	5/16 ± 0.002	*7.9 ± 0.05*
3/8 to 1/2 inclusive	3/8 ± 0.003	*9.5 ± 0.08*
3/4 to 2 inclusive	7/16 ± 0.004	*11.1 ± 0.10*
3 to 4	7/8 ± 0.005	*22.2 ± 0.13*

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TABLE 3
Requirements

PROPERTY	UNIT	REQUIREMENT	TEST METHOD
PHYSICAL			
Dimensions	Inches/*(mm)*	In accordance with Table 1	Section 4.3.1
Longitudinal Change	Percent	+0, -5	ASTM D 2671
Tensile Strength	psi/*(MPa)*	1500 minimum *(10.3)*	Section 4.3.2
Ultimate Elongation	Percent	200 minimum	ASTM D 2671
Secant Modulus (Expanded)	psi/*(MPa)*	2.5 x 10^4 maximum *(172)*	ASTM D 2671
Concentricity (Expanded)	Percent	70 minimum	ASTM D 2671
Restricted Shrinkage 30 minutes at 175 ± 2°C *(347 ± 4°F)* Proof Voltage 2000 V/a-c	---	No Cracks	ASTM D 2671 Procedure A
Specific Gravity (Recovered)	---	1.35 maximum	ASTM D 2671
Low Temperature Flexibility 4 hours at -55 ± 3°C *(-67 ± -5°F)*	---	No cracking	Section 4.3.3 Table 2
Heat Shock 4 hours at 250 ± 3°C *(482 ± 5°F)*	---	No dripping, flowing or cracking	ASTM D 2671
Heat Resistance 168 hours at 175 ± 2°C *(347 ± 4°F)* Followed by test for: Tensile Strength Ultimate Elongation	 psi/(MPa) Percent	 1500 minimum *(10.3)* 200 minimum	ASTM D 2671 ASTM D2671
Color	---	MIL-STD-104	MIL-STD-104
Color Stability 24 hours at 175 ± 2°C *(347 ± 4°F)*	---	MIL-STD-104	ASTM D 2671
Shore A Hardness		85 ± 5	ASTM D 2240
ELECTRICAL			
Dielectric Strength	Volts/mil *(volts/mm)*	500 minimum *(19,680)*	Note 1 ASTM D 2671
Volume Resistivity	Ohm-cm	10^{14} minimum	ASTM D 2671
CHEMICAL			
Copper Mirror Corrosion 16 hours at 175 ± 2°C *(347 ± 4°F)*	---	Non-Corrosive	ASTM D 2671 Procedure A
Copper Contact Corrosion 16 hours at 175 ± 2°C *(347 ± 4°F)*	---	No pitting or blackening of copper.	ASTM D 2671 Procedure B
Flammability	---	1) No flaming or glowing longer than 1 minute from any flame application 2) 25% maximum flag burn 3) No burning of cotton. Self-extinguishing within 15 seconds, no burning or charring of indicator	ASTM D 2671 Procedure C ASTM D 2671 Procedure A

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TABLE 3
Requirements
(continued)

PROPERTY	UNIT	REQUIREMENT	TEST METHOD
Chemical (continued) Fungus Resistance Followed by tests for: Tensile Strength Ultimate Elongation Dielectric Strength	 psi *(Mpa)* percent Volts per mil *(volts per mm)*	 1500 minimum *(10.3)* 200 minimum 500 minimum *(19,700)*	 ISO 846 Method B Section 4.3.2 ASTM D 2671 ASTM D 2671
Water Absorption (Recovered) 24 hours at 23 ± 3°C *(73 ± 5°F)*	---	0.5 maximum	ASTM D 2671
Fluid Resistance 24 hours at 23 ± 3°C *(73 ± 5°F)* in: JP-8 Fuel (Mil-DTL-83133) Skydrol* 500 Hydraulic Fluid (MIL-H-5606) Aviation Gasoline 100/300 Lubricating Oil (MIL-L-7808) Lubricating Oil (MIL-L-23699) Deicing Fluid (MIL-A-8243) 5% NaCl Followed by tests for:	---	---	ASTM D 2671
Dielectric Strength	Volts/mil *(volts/mm)*	400 minimum *(15,760)*	
Tensile Strength	psi *(MPa)*	1000 minimum *(6.9)*	

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NOTE 1: Recover the specimens on metal mandrels for 10 minutes, minimum, at 150 ± 3°C *(302 ± 5°F)* or until the tubing is completely shrunk on the mandrels.

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