

Electronics

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Specification This Issue: Date: Replaces:

RT-1171 Issue 7 December 5, 2001 Issue 6

#### Thermofit<sup>®</sup> 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 ( $194^{\circ}F$ ).

#### 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

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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.

#### 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 <u>Acceptance Tests</u>

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.

#### <u>Size Range</u>

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

#### 4.2.2 <u>Acceptance Test Samples</u>

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  $200 \pm 5^{\circ}$ C ( $392 \pm 9^{\circ}F$ ) oven. Condition the test specimens (and measurement gauges, when applicable) for 3 hours at  $23 \pm 3^{\circ}$ C ( $73 \pm 5^{\circ}F$ ) and  $50 \pm 5$  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 ( $\pm$  1 mm), and inside diameter in accordance with ASTM D 2671. Condition the specimens for 3 minutes in a 200  $\pm$  5°C (392  $\pm$  9°F) oven, cool to 23  $\pm$  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:

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

Where:

C = Longitudinal Change [percent] L<sub>0</sub> = Length Before Conditioning [inches (mm)] L<sub>1</sub> = Length After Conditioning [inches (mm)]

#### 4.3.2 <u>Tensile Strength and Ultimate Elongation</u>

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  $20 \pm 2$  inches ( $500 \pm 50$  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 -  $55 \pm 3^{\circ}$ C (-67  $\pm 5^{\circ}$ 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  $10 \pm 2$  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.

[	1									
	As S	upplied	As Recovered							
	Inside Diameter Inside Diameter Wall Thickness									
Size	Size Minimum		Maximum		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 1 Tubing Dimensions

## TABLE 2Mandrel Dimensions for Bend Testing

Tubing Size	Mandrel Diameter		
	in.	mm.	
3/64 to 1/4 inclusive	$5/16 \pm 0.002$	$7.9 \pm 0.05$	
3/8 to $1/2$ inclusive	$3/8 \pm 0.003$	$9.5\pm0.08$	
3/4 to 2 inclusive	$7/16 \pm 0.004$	$11.1 \pm 0.10$	
3 to 4	$7/8 \pm 0.005$	$22.2 \pm 0.13$	

<b>PHYSICAL</b> DimensionsInches/(mm)In accordance with Table 1Section 4.3.1Longitudinal ChangePercent $+0, -5$ ASTM D 2671Tensile Strengthpsi/(MPa)1500 minimum (10.3)Section 4.3.2Ultimate FloragationPercent200 minimumASTM D 2671Secant Modulus (Expanded)Percent200 minimumASTM D 2671Concentricity (Expanded)Percent70 minimumASTM D 2671Restricted ShrinkageNo CracksASTM D 2671You minutes at 175 $\pm$ 2°CNo CracksASTM D 2671Proof Voltage 2000 V/a-c1.35 maximumASTM D 2671Specific Gravity (Recovered)No crackingSection 4.3.3Low Temperature FlexibilityNo crackingSection 4.3.34 hours at 250 $\pm$ 3°CNo dripping, flowing or crackingASTM D 2671Heat ShockNo dripping, flowing or crackingASTM D 2671( $42\pm \pm$ 5°F)No dripping, flowing or crackingASTM D 2671Heat ResistanceMIL-STD-104MIL-STD-104ColorMIL-STD-104ASTM D 2671Ultimate ElongationPercent200 minimum (10.3)ASTM D 2671ColorMIL-STD-104ASTM D 2671ColorMIL-STD-104ASTM D 2671Color( $347 \pm 4^{o}F$ )S00 minimum (19,680)Note 1Orlor StabilityNon-CorrosiveASTM D 2671Volume ResistivityOhm-cm10	PROPERTY	UNIT	REQUIREMENT	TEST METHOD	
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	Tensile Strength	psi/(MPa)	1500 minimum (10.3)	Section 4.3.2	
$ \begin{array}{c c c c c c c c c c c c c c c c c c c $	Ultimate Elongation	Percent	200 minimum	ASTM D 2671	
$ \begin{array}{c c c c c c c c c c c c c c c c c c c $	Secant Modulus (Expanded)	psi/(MPa)	$2.5 \times 10^4$ maximum (172)	ASTM D 2671	
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$ \begin{array}{ c c c c c c c c c c c c c c c c c c c$	30 minutes at $175 \pm 2^{\circ}C$			Procedure A	
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$ \begin{array}{ c c c c c c } \hline Specific Gravity (Recovered) & & 1.35 maximum & ASTM D 2671 \\ \hline Low Temperature Flexibility & & No cracking & Section 4.3.3 \\ \hline 4 hours at -55 \pm 3^{\circ}C & & No dripping, flowing or cracking & ASTM D 2671 \\ \hline Heat Shock & & No dripping, flowing or cracking & ASTM D 2671 \\ \hline (482 \pm 5^{\circ}F) & & No dripping, flowing or cracking & ASTM D 2671 \\ \hline (482 \pm 5^{\circ}F) & & No dripping, flowing or cracking & ASTM D 2671 \\ \hline (482 \pm 5^{\circ}F) & & No dripping, flowing or cracking & ASTM D 2671 \\ \hline (482 \pm 5^{\circ}F) & & 1500 minimum (10.3) & ASTM D 2671 \\ \hline (482 \pm 5^{\circ}F) & & MIL-STD-104 & MIL-STD-104 \\ \hline Color & & MIL-STD-104 & MIL-STD-104 \\ \hline Color Stability & & MIL-STD-104 & ASTM D 2671 \\ \hline 24 hours at 175 \pm 2^{\circ}C & & MIL-STD-104 & ASTM D 2240 \\ \hline ELECTRICAL \\ Dielectric Strength & Volts/mil & 500 minimum (19,680) & Note 1 \\ \hline (volts/mm) & Volts/mil & S00 minimum & ASTM D 2671 \\ \hline ChemicAL \\ Copper Mirror Corrosion & & No pitting or blackening of \\ \hline (47 \pm 4^{\circ}F) & & No fitting or blackening of \\ \hline Copper Contact Corrosion & & No fitting or blackening of \\ \hline (347 \pm 4^{\circ}F) & & No fitting or blackening of \\ \hline Copper Contact Corrosion & & No pitting or blackening of \\ \hline (347 \pm 4^{\circ}F) & & No fitting or blackening of \\ \hline (347 \pm 4^{\circ}F) & & No fitting or blackening of \\ \hline Copper Contact Corrosion & & No pitting or blackening of \\ \hline (347 \pm 4^{\circ}F) & & No fitting or blackening of \\ \hline (347 \pm 4^{\circ}F) & & No fitting or blackening of \\ \hline (347 \pm 4^{\circ}F) & & No fitting or blackening of \\ \hline (347 \pm 4^{\circ}F) & & No fitting or blackening of \\ \hline (347 \pm 4^{\circ}F) & & No fitting or blackening of \\ \hline (347 \pm 4^{\circ}F) & & No fitting or blackening of \\ \hline (547 \pm 4^{\circ}F) & & No fitting or blackening of \\ \hline (547 \pm 4^{\circ}F) & & No fitting or blackening of \\ \hline (547 \pm 4^{\circ}F) & & No fitting or blackening of \\ \hline (547 \pm 4^{\circ}F) & & No fitting or blackening of \\ \hline (547 \pm 4^{\circ}F) & & No fitting or blackening of \\ \hline $	Proof Voltage 2000 V/a-c				
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(347 ± 4°F)        1) No flaming or glowing longer than 1 minute from any flame application       ASTM D 2671         Flammability        1) No flaming or glowing longer than 1 minute from any flame application       Procedure C         3) No burning of cotton.       Self-extinguishing within 15       ASTM D 2671	16 hours at $175 \pm 2^{\circ}C$		copper.	Procedure B	
Flammability        1) No flaming or glowing longer than 1 minute from any flame application       ASTM D 2671         Procedure C       2) 25% maximum flag burn       Procedure C         3) No burning of cotton.       Self-extinguishing within 15       ASTM D 2671	$(34/\pm 4^{\circ}F)$				
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any flame application2)25% maximum flag burn3)No burning of cotton.Self-extinguishing within 15ASTM D 2671			longer than 1 minute from	Procedure C	
2) 25% maximum flag burn 3) No burning of cotton. Self-extinguishing within 15 ASTM D 2671			any flame application		
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	<u> </u>		charming of indicator	1	

TABLE 3Requirements

# TABLE 3Requirements(continued)

PROPERTY	UNIT	REQUIREMENT	<b>TEST METHOD</b>
Chemical (continued)			
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	500 minimum (19,700)	ASTM D 2671
	(volts per mm)		
Water Absorption (Recovered)		0.5 maximum	ASTM D 2671
24 hours at $23 \pm 3^{\circ}C$			
$(73 \pm 5^{\circ}F)$			
Fluid Resistance			ASTM D 2671
24 hours at $23 \pm 3^{\circ}$ C			
$(73 \pm 5^{\circ}F)$ 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:			
Dielectric Strength	Volts/mil	400 minimum (15,760)	
	(volts/mm)		
Tensile Strength	psi (MPa)	1000 minimum (6.9)	

\*Trademark of the Monsanto Company

**NOTE 1**: Recover the specimens on metal mandrels for 10 minutes, minimum, at  $150 \pm 3^{\circ}C$  ( $302 \pm 5^{\circ}F$ ) or until the tubing is completely shrunk on the mandrels.

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 FP301-1/4-48"-Black

 FP301-1/4-48"-White-Hdr
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 FP301-18-48"-Black-Hdr
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 121 

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 121-127-09BK

 912229N002
 120-126-16BL
 121-001-09
 121-018-32
 121-018-40
 121-123-1-1-32BTC
 121