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TTMS MARKER SYSTEM TTMS

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1 SCOPE

This specification covers the requirements and performance of TTMS heat shrinkable tubing. The tubing is designed to be marked using thermal transfer techniques and is to be used in conjunction with recommended printers and ribbons. The tubing shall be fabricated from radiation crosslinked modified polyolefin and shall be supplied as a flattened tube.

2 APPLICABLE DOCUMENTS

This document takes precedence over documents referenced herein. Unless otherwise stated the latest issue of the referenced document shall apply.

2.1 Referenced Documents

Mil-Std-202F Test Methods for Electronic and Electrical Components
UL 224 Extruded Insulated Tubing
SAE-AS-81531 Marking of Electrical Insulating Materials
ASTM D 570 Test Method for Water Absorption of Plastics
ASTM D 2671 Testing Heat Shrinkable Tubing for Electrical Use
ASTM G 21 Determining Resistance of Polymeric Materials to Fungi

3 REQUIREMENTS

3.1 Material

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

3.2 Colour

The tubing shall be white or yellow (other colours may be available on special request).

3.3 Form

The tubing shall conform to the dimensions given in Table 2 and shall be supplied as continuous lengths.

3.4 Properties

The tubing shall meet the requirements defined in Table 3.

4 QUALITY ASSURANCE PROVISIONS

4.1 Classification of Tests

4.1.1 Qualification Tests

Qualification tests are those performed on either printed or unprinted tubing, as defined in the requirements and shall consist of all the tests listed in this specification.

4.1.2 Acceptance Tests

Acceptance tests are those performed on tubing and shall consist of the following:

Dimensions
Longitudinal Change

4.2 Sampling Instructions

4.2.1 Qualification Test Samples

Qualification shall consist of the appropriate length of marked and unmarked tubing to allow completion of all the tests. Qualification of any one size shall qualify all sizes.

4.2.2 Acceptance Test Samples

Acceptance test samples shall consist of the appropriate length of tubing required to conduct the defined tests.

4.3 Test Procedures

Unless otherwise specified, tests shall be performed on specimens which have been fully recovered by conditioning in accordance with 4.3.1. Prior to all testing, the test specimen (and measurement gauges, when applicable) shall be conditioned for 3 hours at $23 \pm 3^{\circ}\text{C}$ ($73 \pm 5^{\circ}\text{F}$) and 50 ± 5 percent relative humidity. All ovens shall be of the mechanical convection type in which air passes the specimens at a velocity of 100 to 200 feet ($30 - 60 \text{ m.}$) per minute.

4.3.1 Dimensions and Longitudinal Change

Three 6 inch (150mm) specimens of tubing, as supplied, shall be measured for length, to an accuracy of $\pm 1/32$ inch ($\pm 1\text{mm}$), and inside diameter in accordance with ASTM D 2671. The specimens then shall be conditioned for 3 minutes in a $200 \pm 3^{\circ}\text{C}$ ($392 \pm 5^{\circ}\text{F}$) oven, removed from the oven, cooled to $23 \pm 3^{\circ}$ ($73 \pm 5^{\circ}\text{F}$), remeasured for length, inside diameter and wall thickness in accordance with ASTM D 2671. The longitudinal change shall be calculated 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])

4.3.2 Tensile Strength and Ultimate Elongation

The tensile strength and ultimate elongation of the tubing shall be determined in accordance with ISO 37 using a 2 inch (50mm) initial jaw separation. The speed of jaw separation shall be 20 ± 2 inches ($50 \pm 5\text{mm}$) per minute.

4.3.3 Low Temperature Flexibility

Recover three 6 inch (150mm) specimens sizes 25.4mm and smaller over a stranded AWG wire (nearest gauge which is larger than the sleeving maximum ID nominal after unrestricted shrinkage). Condition the specimens for 4 hours at $-55 \pm 1^\circ\text{C}$ ($-67 \pm 2^\circ\text{F}$). While at this temperature, bend the specimens 90 degrees in approximately 2 seconds, over a similarly conditioned mandrel selected in accordance with Table 1. Examine the specimen for cracks.

4.3.4 Heat Shock

Print three 2 inch (50mm) long specimens per Section 4.3.6. Condition the specimens for 4 hours at $250^\circ \pm 3^\circ\text{C}$ ($482 \pm 5^\circ\text{F}$) in a forced air oven with an air velocity of from 100 to 200 feet (30 to 60 m) per minute passed the specimens. Remove the specimens from the oven, cool to room temperature and bend through 90 degrees, in approximately 2 seconds, over a mandrel selected in accordance with Table 1. Visually examine the specimens for evidence of dripping, flowing or cracking. Disregard any side cracking caused by flattening of the specimens of the mandrel. Examine specimens for legibility at a distance of 14 inches.

TABLE 1
Mandrel Dimensions for Bend Testing

Tubing Size	Diameter of Mandrel	
	(inches)	(mm)
1/8 through 3/8	5/16	7.9
1/2 through 3/4	3/8	9.5
1	7/16	11.1

4.3.5 Heat Ageing**4.3.5.1 Mandrel Bend**

Shrink three 2 inch (50mm) long specimens, size 1/2 or smaller on a stranded wire selected in accordance with Table 1. For tubing sizes larger than 1/2, cut three 6 x 1/4 inch strips, longitudinally from recovered tubing. Condition the specimens for 168 hours at $175 \pm 2^\circ\text{C}$ ($347 \pm 4^\circ\text{F}$) in a convection oven with an air velocity of 100 to 200 ft (30 to 60 m) per minute passed the specimens. Remove the specimens from the oven and cool to room temperature. Bend the specimens shrunk on the stranded wire 90 degrees around a mandrel specified in Table 1. Bend the strips 360 degrees around a 7/16 inch diameter mandrel. Examine the specimens for cracks.

4.3.5.2 Print Performance

Print three 2 inch (50mm) long specimens accordance with Section 4.3.6 and shrink on mandrels approximately equal to the recovered diameter of the specimens. Condition the specimens in the oven for 168 hours at $175 \pm 2^\circ\text{C}$ ($347 \pm 4^\circ\text{F}$). Cool to room temperature and test for print performance in accordance with 4.3.6.

4.3.6 Print Performance

Print six 2 inch (50mm) long specimens in length using a recommended TMS Marker System thermal transfer printer and ribbon. The print shall be of random characters. The characters shall be between 0.08 (2mm) and 0.2 inches (5mm) and the line thickness shall be at least 0.15 inches (0.4mm) and shall not exceed 0.3 inches (0.8mm). The legend shall extend to within 1/4 inch (6mm) of the end of each 2 inch specimen. The specimens shall be tested in accordance with paragraph 4.6.2 of SAE-AS-81531. 50 rubs shall be applied and the specimens shall be examined for legibility at a distance of 14 inches.

4.3.7 Flammability

Tubing shall be tested in accordance with UL 224, VW-1.

4.3.8 Fungus Resistance

Tubing shall be tested in accordance with ASTM G 21.

4.3.9 Copper Contact Corrosion

Tubing shall be tested in accordance with ASTM D 2671 Procedure B. Three specimens shall be conditioned for 168 hours at 158°C.

After conditioning the specimens shall be visually examined for evidence of corrosion.

4.3.10 Copper Mirror Corrosion

Tubing shall be tested in accordance with ASTM D 2671 Procedure A. Three specimens shall be conditioned for 16 hours at 175°C. After conditioning the mirrors shall not be corroded.

4.3.11 Dielectric Strength

Tubing shall be tested in accordance with IEC 60243 (Short Time test).

4.3.12 Print Adherence after Fluid Immersion

Completely immerse three 2 inch (50mm) long specimens (unrecovered) printed in accordance with Section 4.3.6 in each fluid at the specified temperature using fluid specified in Table 3. After immersion lightly wipe the specimens and allow to air dry for 30-60 minutes at 23°C). The specimens are tested in accordance with Section 4.6.2 of SAE-AS-81531 using 20 rubs and examined for legibility at a distance of 14 inches.

4.3.13 Print Permanence after Fluid Immersion

Three specimens each 2 inches (50mm) in length and printed in accordance with Section 4.3.6 are tested in accordance with Mil-Std-202F Method 215. 30 strokes shall be applied and the specimens shall then be examined for legibility at a distance of 14 inches.

4.3.14 Taber Abrasion

Three 2 inch (50mm) long specimens of tubing size 25.4mm are printed in accordance with 4.3.6. The specimens are recovered at 200°C for 3 minutes onto an Aluminium plate of dimensions 2 inches (50mm) length, 1.2 inches (30mm) width and 0.08 inches (2mm) thickness. 1 hour after recovery the samples are mounted on a Taber Abrasion apparatus equipped with a CS10 wheel. The test run is 250 cycles with a load of 500g.

Following the test the samples are examined for legibility at a distance of 14 inches.

TABLE 2 : DIMENSIONS

Size	Internal dia as supplied mm (min)	Internal dia after Full Recovery mm (max)	Wall Thickness Full Recovery mm \pm 0.08
2.4	2.4(3/32" <i>in</i>)	0.79(0.031" <i>in</i>)	0.58 (0.023 \pm 003" <i>in</i>)
3.2	3.2(1/8" <i>in</i>)	1.06 (0.042 <i>in</i>)	0.58 (0.023 \pm 003" <i>in</i>)
4.8	4.8(3/16" <i>in</i>)	1.57 (0.062 <i>in</i>)	0.58 (0.023 \pm 003" <i>in</i>)
6.4	6.4(1/4" <i>in</i>)	2.11 (0.083 <i>in</i>)	0.58 (0.023 \pm 003" <i>in</i>)
9.5	9.5(3/8" <i>in</i>)	3.17 (0.125 <i>in</i>)	0.61 (0.023 \pm 003" <i>in</i>)
12.7	12.7(1/2" <i>in</i>)	4.21 (0.166 <i>in</i>)	0.61 (0.024 \pm 003" <i>in</i>)
19.0	19.0(3/4" <i>in</i>)	6.35 (0.250 <i>in</i>)	0.61 (0.024 \pm 003" <i>in</i>)
25.4	25.4(1" <i>in</i>)	8.45 (0.333 <i>in</i>)	0.64 (0.025 \pm 003" <i>in</i>)
38.1	38.1(1.5" <i>in</i>)	19.0 (0.750 <i>in</i>)	0.51 (0.020 \pm 003" <i>in</i>)
50.8	50.8(2" <i>in</i>)	25.4 (1.000 <i>in</i>)	0.64 (0.025 \pm 003" <i>in</i>)

TABLE 3 : REQUIREMENTS

Property	Unit	Requirement	Test Method
PHYSICAL			
As supplied Dimensions	mm	In accordance with Table 2	Section 4.3.1 ASTM D 2671
Recovered Dimensions	mm	In accordance with Table 2	Section 4.3.1 ASTM D 2671
Longitudinal Change	%	20 maximum	Section 4.3.1 ASTM D 2671
Tensile Strength	MPa	10 minimum	Section 4.3.2 ISO 37
Ultimate Elongation	%	200 minimum	
Specific Gravity	-	1.35 maximum	ISO 1183 (Method A)
Low Temperature Flexibility 4 Hrs at -55°C		No cracking	Section 4.3.3
Heat Shock 4 Hrs at 250°C Followed by print performance		No dripping, flowing or cracking Legible after 50 rubs	Section 4.3.4 Section 4.3.6
Heat Ageing 168 Hrs at 175°C Followed by print performance		No cracking Legible after 50 rubs	Section 4.3.5.1 Section 4.3.5.2
Print Performance (SAE-AS-81531)	-	Legible after 50 rubs	Section 4.3.6
ELECTRICAL			
Dielectric Strength	MV/m	20 minimum	IEC 60243
CHEMICAL			
Corrosive Effect 16 Hrs at 175°C Copper Mirror Copper Contact 168 Hrs at 158°C		Non Corrosive No pitting or blackening of Copper	ASTM D 2671 Procedure A ASTM D 2671 Procedure B
Flammability		Pass	UL 224, VW-I
Fungus Resistance	-	1 maximum	ASTM G 21
Water Absorption	%	0.5 maximum	ASTM D 570
FLUID RESISTANCE			
PRINT ADHERENCE			
JP 8 (F34) 24 Hrs at 23°C Print Performance	-	Legible after 20 rubs	Section 4.3.12
Skydrol 500 B4 24 Hrs at 23°C Print Performance	-	Legible after 20 rubs	Section 4.3.12
Methyl Ethyl Ketone 24 Hrs at 23°C Print Performance	-	Legible after 20 rubs	Section 4.3.12
Hydraulic Fluid H515 24 Hrs at 23°C Print Performance	-	Legible after 20 rubs	Section 4.3.12
Petrol (4 Star) 24 Hrs at 23°C Print Performance	-	Legible after 20 rubs	Section 4.3.12
OX 38 Lub Oil 24 Hrs at 50°C Print Performance	-	Legible after 20 rubs	Section 4.3.12

Property	Unit	Requirement	Test Method
Print Performance (Continued) (SAE-AS-81531)			
Diesel Fuel 24 Hrs at 23°C Print Performance	-	Legible after 20 rubs	Section 4.3.12
Water 1 Hr at 100°C Print Performance	-	Legible after 20 rubs	Section 4.3.12
Water 168 hrs at 23°C Print Performance	-	Legible after 20 rubs	Section 4.3.12
PRINT PERFORMANCE (SAE-AS-81531) (Mil - Std - 202)	Rubs Strokes	50 Minimum, legible after 50 rubs 30 Minimum, legible after 30 rubs	Section 4.3.6 Section 4. 3.13
ABRASION			
Dry 250 cycles	-	Legible	Section 4.3.14

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