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Swindon, UK

TTMS MARKER SYSTEM TTMS, TTMS-MP & TTMS-2X

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1 SCOPE

This specification covers the requirements and performance of all formats 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 (details available from TE Connectivity). The product shall be fabricated from radiation cross-linked 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

| | |
|---------------------|--|
| SAE AMS-DTL-23053 | Insulation Sleeving, Electrical, Heat Shrinkable, General Specification for |
| SAE AMS-DTL-23053/5 | Insulation Sleeving, Electrical, Heat Shrinkable. Polyolefin, Flexible, Crosslinked |
| ASTM D 570 | Test Method for Water Absorption of Plastics |
| ASTM D 792 | Test Methods For Density And Specific Gravity (Relative Density) Of Plastics By Displacement |
| ASTM D 876 | Test Methods For Non-rigid Vinyl Chloride Polymer Tubing Used For Electrical Insulation |
| ASTM D 2671 | Testing Heat Shrinkable Tubing for Electrical Use |
| ASTM G 21 | Determining Resistance of Polymeric Materials to Fungi |
| MIL PRF 5606 | Hydraulic Fluid, Petroleum Base, Aircraft, Missile and Ordnance |
| MIL PRF 23699 | Lubricating Oil, Aircraft Turbine Engines, Synthetic Base |
| MIL-STD-202F | Test Methods for Electronic and Electrical Components |
| SAE-AS-81531 | Marking of Electrical Insulating Materials |
| UL 224 | Extruded Insulated Tubing |

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3 REQUIREMENTS

3.1 Material

The tubing shall be fabricated from thermally stabilized, flame-retardant, modified polyolefin and shall be cross-linked by irradiation. It shall be homogeneous and essentially free from flaws, defects, pin-holes, bubbles, cracks and inclusions.

3.2 Color

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

3.3 Form

The tubing shall conform to the dimensions given in Table 4 and 5 and shall be supplied as continuous lengths.

3.4 Properties

The tubing shall meet the requirements defined in Table 6.

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 submitted for acceptance under the contract.
Acceptance tests shall consist of the following:

Dimensions
Expanded Concentricity
Longitudinal Change
Tensile strength
Ultimate Elongation*
2% Secant Modulus*
Low Temperature Flexibility*
Heat Shock*
Print Adherence (Clause 4.3.11.1)
Flammability (ASTM D2671 only)

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.

* Physical property tests performed at this time qualify subsequent sleeving lots produced from the same compound batch

4.3 Test Procedures

Unless otherwise specified, tests shall be performed on specimens that have been fully recovered by placing them in a forced air oven for 3min at $200\pm 2^{\circ}\text{C}$. 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 $50 \pm 5\%$ 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 Expanded and Recovered Dimensions

Measure the expanded inside diameter, recovered inside diameter and recovered wall thickness in accordance with SAE AMS-DTL-23053 sections 4.6.3.1.1, 4.6.3.1.2 and 4.6.3.2 respectively

4.3.2 Expanded Concentricity

Measure the expanded concentricity in accordance with SAE AMS-DTL-23053 section 4.6.3.3.

4.3.3 Longitudinal Change

Measure and calculate the longitudinal change of the sample in accordance with SAE AMS-DTL-23053 section 4.6.4

4.3.4 Tensile Strength and Ultimate Elongation

The tensile strength and ultimate elongation of the tubing shall be determined in accordance with SAE DTL-23053 section 4.6.13. A 2inch (50.8mm) initial jaw separation and 1inch (25.4mm) bench marks shall be used. The speed of jaw separation shall be 20 ± 2 inches ($508 \pm 5\text{mm}$) per minute.

4.3.5 Secant Modulus – 2X products only

Measure the secant modulus of expanded tubing at 2% strain in accordance with SAE AMS-DTL-23053 section 4.6.12.1

4.3.6 Restricted shrinkage – 2X products only

Test the tubing for restricted shrinkage in accordance with SAE AMS-DTL-23053 section 4.6.6 using shrinkage procedure A. A shrinkage condition of 30 minutes at $175\pm 2^{\circ}\text{C}$ ($347\pm 4^{\circ}\text{F}$) shall be used.

4.3.6.1 Voltage Withstand

After completing the test in section 4.3.6 complete the Voltage withstand test in accordance with SAE AMS-DTL-23053 section 4.6.6.3.

4.3.7 Low Temperature Flexibility

Test low temperature flex of the tubing in accordance with SAE AMS DTL 23053/5 section 4.6.7.1. 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 tubular specimens 360 degrees, in 10 ± 2 seconds, over a similarly conditioned mandrel, selected in accordance with Table 1. Bend the strip specimens 360 degrees over an 11.1mm (7/16-inch) mandrel, similarly conditioned. Examine the specimens for cracks.

4.3.8 Heat Shock

Test for heat shock in accordance with SAE AMS DTL 23053 section 4.6.8. Samples should be printed with the recommended print system. Bend through 360 degrees, in 2 to 4 seconds, over a mandrel selected in accordance with Table 1 in accordance with SAE AMS DTL 23053 section 4.6.3.1.1. Disregard any side cracking caused by flattening of the specimens on the mandrel. Examine printed specimens for legibility at a distance of 14 inches.

TABLE 1
Mandrel Dimensions for Bend Testing

| Tubing Size (mm) | Diameter of Mandrel | |
|---------------------|---------------------|------|
| | inches | mm |
| 2.4 through 9.5 | 5/16 | 7.9 |
| 12.7 through 19.0 | 3/8 | 9.5 |
| 25.4 or above | 7/16 | 11.1 |

4.3.9 Heat Resistance

In accordance with SAE AMS DTL 23053 section 4.6.9, cut five 100mm (4 in.) lengths of tubing for sizes with recovered inside diameter less than 8.4mm (0.330 in.). For sizes with recovered inside diameter greater than 8.4mm (0.330 in.), prepare five samples by die cutting with Die C with the long dimension of the die parallel to the longitudinal axis of the 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 30 to 60 m (100 to 200 ft) per minute past the specimens. Remove the specimens from the oven, and allow them to cool to room temperature.

4.3.9.1 After conditioning samples in accordance with 4.3.9 above, test for ultimate elongation in accordance with section 4.3.4.

4.3.9.2 Mark three assembled markers in accordance with section 4.3.11 and condition the specimens in accordance with section 4.3.9 then test for print adherence in accordance with section 4.3.11.

4.3.10 Specific Gravity

Measure the specific gravity of freely recovered markers in accordance ASTM D 792.

4.3.11 Print Adherence

Print three specimens, a minimum of 2 inch (50mm) long, using a recommended TTMS Marker System thermal transfer printer and ribbon. See table 2 for recommended font type and size. The print shall be of random characters. The legend shall extend to within 1/4 inch (6mm) of the end of each 2 inch specimen.

The specimens shall be tested in expanded form in accordance with paragraph 4.6.2 of SAE-AS-81531. 50 rubs shall be applied using a load of 4kg and the specimens shall be examined for legibility at a distance of 14 inches.

TABLE 2: Recommended font and size for print performance testing

| Supplied I.D. mm (inch) | Font and size |
|--------------------------|---------------------------------|
| 2.4 (3/32) | Arial or Courier 8 Bold |
| 3.2 (1/8) | Arial or Courier 10 Bold |
| 4.8 (3/16) to 12.7 (1/2) | Arial or Courier 12 Bold |
| 19.0 (3/4) | Arial or Courier 14 Bold |
| 25.4 (1.0) and above | Arial or Courier 18 Bold |

4.3.12 Color – 2X product only

Test color in accordance with SAE AMS DTL 23053 section 3.4.2.1

4.3.13 Color Stability – 2X product only

Test for color stability in accordance with SAE AMS DTL 23053 section 4.6.15. Samples will be conditioned for 24 hours at 175 ± 2°C (347 ± 4°F).

4.3.14 Copper Mirror Corrosion

Test tubing for copper mirror corrosion in accordance with SAE AMS DTL 23053 section 4.6.10.2. Heat the samples for 16 hours at 175 ± 2°C (347 ± 4°F). After conditioning the mirror shall be visually examined for evidence of corrosion.

4.3.15 Copper Contact Corrosion

Test tubing for copper corrosion in accordance with SAE AMS DTL 23053 section 4.6.10.1. Heat the samples for 16 hours at 175 ± 2°C (347 ± 4°F). After conditioning the specimens shall be visually examined for evidence of corrosion.

4.3.16 Fungus Resistance

Tubing shall be tested in accordance with ASTM G 21.

4.3.16.1 After the exposure to fungus as given in 4.3.16, test for tensile strength and ultimate elongation in accordance with section 4.3.4.

4.3.17 Water Absorption

Test recovered tubing for water absorption in accordance with ASTM D 570. Immersion conditions are 24 hours at 23 ± 3°C (73 ± 5°F).

4.3.18 Flammability

Product shall be tested as detailed in table 3 below.

TABLE 3: Flammability Testing schedule

| Product Family | Test Method | Classification |
|----------------|---|----------------|
| TTMS (-MP) | SAE AMS DTL 23053/5: Clause 4.6.14; Proc. B ASTM D2671; UL224: All tube flame test | Class 1 |
| TTMS-2X | SAE AMS DTL 23053/5: Clause 4.6.14; Proc. B ASTM D2671; UL224: VW-1 | Class 3 |

4.3.19 Dielectric Strength

Test for dielectric strength in accordance with ASTM D 2671.

4.3.20 Volume Resistivity – 2X product only

Test for volume resistivity in accordance with ASTM D 876.

4.3.21 Solvent Resistance

Three specimens each a minimum of 2 inches (50mm) in length and printed in accordance with Section 4.3.11 are tested in the expanded form in accordance with MIL-STD-202G Method 215. 30 strokes shall be applied and the specimens shall then be examined for legibility at a distance of 14 inches.

4.3.22 Fluid Immersion

Completely immerse three unrecovered specimens, a minimum 2 inch (50mm) long, printed in accordance with Section 4.3.11 in each fluid at the specified temperature using fluids given in Table 6. After immersion lightly wipe the specimens with tissue and allow to air dry for 30-60 minutes at 23°C (73°F). The specimens are then 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.

TABLE 4 : TTMS & TTMS-MP Dimensions

| Product Size | Minimum Internal diameter as supplied mm (inch) | Maximum Internal diameter after Full Recovery mm (inch) | Wall Thickness Full Recovery mm \pm 0.08 (inch \pm0.003) |
|---------------------|--|--|---|
| 2.4 | 2.4 (3/32) | 0.79 (0.031) | 0.58 (0.023) |
| 3.2 | 3.2 (1/8) | 1.06 (0.042) | 0.58 (0.023) |
| 4.8 | 4.8 (3/16) | 1.57 (0.062) | 0.58 (0.023) |
| 6.4 | 6.4 (1/4) | 2.11 (0.083) | 0.58 (0.023) |
| 9.5 | 9.5 (3/8) | 3.17 (0.125) | 0.61 (0.023) |
| 12.7 | 12.7 (1/2) | 4.21 (0.166) | 0.61 (0.024) |
| 19.0 | 19.0 (3/4) | 6.35 (0.250) | 0.61 (0.024) |
| 25.4 | 25.4 (1.0) | 8.45 (0.333) | 0.64 (0.025) |
| 38.1 | 38.1 (1.5) | 19.0 (0.750) | 0.51 (0.020) |
| 50.8 | 50.8 (2.0) | 25.4 (1.00) | 0.64 (0.025) |

TABLE 5 : TTMS-2X Dimensions

| Product Size | Minimum Internal diameter as supplied mm (inch) | Maximum Internal diameter after Full Recovery mm (inch) | Wall Thickness Full Recovery mm \pm 0.08 (inch \pm 0.003) |
|---------------------|--|--|--|
| 2.4 | 2.4 (3/32) | 1.20 (0.047) | 0.51 (0.020) |
| 3.2 | 3.2 (1/8) | 1.60 (0.063) | 0.51 (0.020) |
| 4.8 | 4.8 (3/16) | 2.40 (0.095) | 0.51 (0.020) |
| 6.4 | 6.4 (1/4) | 3.20 (0.125) | 0.64 (0.025) |
| 9.5 | 9.5 (3/8) | 4.75 (0.187) | 0.64 (0.025) |
| 12.7 | 12.7 (1/2) | 6.35 (0.250) | 0.64 (0.025) |
| 19.0 | 19.0 (3/4) | 9.50 (0.374) | 0.76 (0.030) |

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TABLE 6: REQUIREMENTS

| Property | Unit | Requirement | Test Method |
|--|-------------|---|---|
| Physical | | | |
| As supplied & Recovered Dimensions | mm (in.) | In accordance with Table 4 or 5 | Section 4.3.1 SAE AMS-DTL-23053 |
| Expanded Concentricity | % | TTMS (-MP) 50% minimum TTMS-2X 70% minimum | Section 4.3.2 SAE AMS-DTL-23053 |
| Longitudinal Change | % | TTMS (-MP) 20 maximum TTMS-2X $\pm 5\%$ | Section 4.3.3 SAE AMS-DTL-23053 |
| Tensile Strength | MPa | 10.3 (1500) minimum | Section 4.3.4 SAE AMS-DTL-23053 |
| Ultimate Elongation | % | 200 minimum | Section 4.3.5 SAE AMS-DTL-23053 |
| Secant Modulus (Expanded) @ 2% Strain | MPa | 172.4 (25000) maximum | Section 4.3.6 SAE AMS-DTL-23053 |
| Restricted Shrinkage Followed by test for Voltage Withstand 2000V ac for 1min. | --- | No cracking Pass | Section 4.3.7 SAE AMS-DTL-23053 |
| Low Temperature Flexibility 4 Hrs at -55°C | --- | No cracking | Section 4.3.8 SAE AMS-DTL-23053 |
| Heat Shock 4 Hrs at 250°C Followed by print performance | ---- | No dripping, flowing or cracking Legible after 50 rubs | Section 4.3.9 SAE AMS-DTL-23053 Section 4.3.11 |
| Heat Resistance 168 Hrs at 175°C Followed by: Ultimate Elongation (-2X only) Print Adherence | % --- | No cracking 100% Minimum Legible after 50 rubs | Section 4.3.6.9 SAE AMS-DTL-23053 Section 4.3.4 Section 4.3.11 |
| Specific Gravity | --- | 1.35 maximum | Section 4.3.10 ASTM D792 |
| Print Adherence (Expanded) (SAE-AS-81531) | --- | Legible after 50 rubs | Section 4.3.11 |
| Color | --- | Pass | Section 4.3.12 SAE AMS-DTL-23053 |
| Color Stability | --- | Pass | Section 4.3.13 SAE AMS-DTL-23053 |
| Chemical | | | |
| Corrosive Effect: Copper Mirror 16 Hrs at 175°C | --- | Non Corrosive | Section 4.3.14 SAE AMS-DTL-23053 |
| Copper Contact 16 Hrs at 175°C | --- | No pitting or blackening of the copper | Section 4.3.15 SAE AMS-DTL-23053 |

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TABLE 6 continued: REQUIREMENTS

| Property | Unit | Requirement | Test Method |
|--|-----------------------|---|---|
| Fungus Resistance Followed by: Tensile Strength Ultimate Elongation | --- MPa (psi) % | 1 maximum 10.3 (1500) Minimum 200 minimum | Section 4.3.16 ASTM G 21 Section 4.3.4 SAE AMS-DTL-23053 |
| Water Absorption | % | 0.5 maximum | Section 4.3.17 ASTM D 570 |
| Flammability – TTMS(-MP) ASTM D 2671 Procedure B | --- | Burn time shall not exceed 1 min. Not more than 25% of indicator flag shall be burned or charred. No dripping or flowing | Section 4.3.18 SAE AMS-DTL-23053 |
| UL224 All tube flame test | --- | 1) No flaming or glowing longer than 1 minute from any flame application. 2) 25% maximum flag burn. 3) No burning of cotton. No dripping. | Section 4.3.18 UL 224 clause 5.10 |
| Flammability – TTMS-2X ASTM D 2671 Procedure B | --- | Burn time shall not exceed 1 min. Not more than 25% of indicator flag shall be burned or charred. No dripping or flowing | Section 4.3.18 SAE AMS-DTL-23053 |
| UL224 VW-1 | --- | 1) No flaming or glowing longer than 1 minute from any flame application. 2) 25% maximum flag burn. 3) No burning of cotton. No dripping. | Section 4.3.18 UL 224 clause 5.11 |
| Electrical | | | |
| Dielectric Strength | MV/m | 20 minimum | Section 4.3.19 ASTM D 2671 |
| Volume Resistivity | Ohm-cm | 10 ¹⁴ minimum | Section 4.3.20 ASTM D876 |

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TABLE 6 continued: REQUIREMENTS

| Property | Unit | Requirement | Test Method |
|---|--------------------------|-----------------------|------------------------------------|
| Print Performance | | | |
| Solvent Resistance (MIL-STD-202) | Strokes | Legible after 30 rubs | Section 4.3.21 |
| Fluid Resistance 24 Hrs at 23°C unless stated | --- | | Section 4.3.22 |
| JP 8 (F34) | --- | | |
| Skydrol 500 B4 | --- | | |
| Methyl Ethyl Ketone | --- | | |
| Hydraulic Fluid (MIL PRF 5606) | --- | | |
| Lubricating Oil (MIL PRF 23699) | --- | | |
| Diesel Fuel | --- | | |
| MIL-A-8243 anti-icing fluid | --- | | |
| Water – 1 Hr at 100°C | --- | | |
| Water – 168 hrs at 23°C | --- | | |
| Followed by: All product types Print Performance | --- | Legible after 20 rubs | Section 4.3.11 |
| TTMS-2X – Dielectric Strength | kV / mm (Volts / mil) | 6.9 (1000) minimum | Section 4.3.19 ASTM D 2671 |
| TTMS-2X – Tensile Strength | MPa (psi) | 20 minimum | Section 4.3.4 SAE AMS-DTL-23053 |

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