



# AEROSPACE MATERIAL SPECIFICATION

Society of Automotive Engineers, Inc.

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## AMS 3588

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Revised

### PLASTIC TUBING, ELECTRICAL INSULATION

Irradiated Polyolefin, Clear, Very Flexible

Heat Shrinkable (Low Recovery Temperature)

2 to 1 Shrink Ratio

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1. **ACKNOWLEDGMENT:** A vendor shall mention this specification number in all quotations and when acknowledging purchase orders.
2. **FORM:** Thin wall flexible tubing.
3. **APPLICATION:** Primarily for use as a very flexible, electrical insulation tubing whose diameter can be reduced to a predetermined size by heating to a temperature of approximately 98 C (208 F). This material is stable for continuous exposure from -55 C (-67 F) to +135 C (+275 F).
4. **COMPOSITION:** The material shall be an irradiated, thermally stabilized, non-flame-resistant, modified polyolefin.
5. **TECHNICAL REQUIREMENTS:**
  - 5.1 **Appearance:** Unless otherwise specified, a colorless transparent tubing shall be furnished. Tubing shall be sufficiently transparent to allow relatively undistorted visibility through two thicknesses produced by pressing the tubing flat upon itself. Typewritten letters shall be legible when viewed through these two thicknesses pressed onto the paper. Transparency shall apply to tubing in the expanded form (as supplied) and after tubing has been shrunk as specified in 5.2.
  - 5.2 **Properties:** The product shall conform to the requirements of 5.2.1 through 5.2.4 and shall be capable of meeting the requirements of 5.2.5 through 5.2.15. Tests shall be performed in accordance with the issue of specified ASTM methods listed in the latest issue of AMS 2350, insofar as practicable. Unless otherwise specified, tubing shall be tested after being shrunk by heating for 5 min. in a mechanical convection oven which is at 150 C  $\pm$  5 (302 F  $\pm$  9), with an air velocity of 100 - 200 ft per min. past the tubing, removed from the oven, and cooled to room temperature.
  - 5.2.1 Tensile Strength, psi, min 1500 ASTM D638, Speed D (See Note 1)
  - 5.2.2 Elongation, %, min 200 ASTM D638, Speed D (See Note 1)
  - 5.2.3 Secant Modulus at 2% Strain, psi, max  $1.2 \times 10^4$  ASTM D882 (See Note 2)
  - 5.2.4 Heat Shock Pass Note 3
  - 5.2.5 Low Temperature Flexibility Pass Note 4
  - 5.2.6 Heat Aging Pass Note 5
  - 5.2.7 Copper Stability Pass Note 6
  - 5.2.8 Corrosion Pass Note 7
  - 5.2.9 Solvent Resistance Pass Note 8
  - 5.2.10 Fungus Resistance Pass Note 9

|        |   |           |                     |
|--------|---|-----------|---------------------|
| 5.2.11 | Restricted Shrinkage                                    | Pass      | Note 10             |
| 5.2.12 | Specific Gravity, max                                   | 1.00      | ASTM D792, Method A |
| 5.2.13 | Water Absorption in 24 hr, %, max                       | 0.20      | ASTM D570           |
| 5.2.14 | Dielectric Strength, short time<br>test, v per mil, min | 500       | ASTM D876           |
| 5.2.15 | Volume Resistivity, ohm-cm, min                         | $10^{14}$ | ASTM D257           |

Note 1. Five specimens, each 4 in. long, shall be tested, using 1 in. bench marks and 1 in. initial jaw separation. The specimens shall be full sections of tubing for sizes 1/4 and smaller and strip specimens not less than 1/4 in. wide, cut longitudinally from sizes 3/8 and larger. No metal plugs are necessary when testing full sections of tubing. A specimen break at a bench mark or outside the gage length shall be cause for retest.

Note 2. Five specimens, each 12 in. long, shall be tested. The specimens shall be full sections of tubing for sizes 1/4 and smaller and strip specimens not less than 1/2 in. wide, cut longitudinally from sizes 3/8 and larger. No metal plugs are necessary when testing full sections of tubing. Initial strain rate shall be 0.1 in. per in. per minute.

Note 3. Three specimens in the expanded form (as supplied), each 6 in. long, shall be conditioned for 4 hr in a mechanical convection oven which is at  $250^{\circ}\text{C} \pm 5$  ( $482^{\circ}\text{F} \pm 9$ ), with an air velocity of 100 - 200 ft per min. past the specimens. After conditioning, the specimens shall be removed from the oven, cooled to room temperature, and visually examined. Tubing shall not drip, flow, or crack. Also, tubing shall be bent through 180 deg over a steel mandrel of the diameter shown in Table I. The tubing shall remain free from cracks except that any side cracking caused by flattening of the specimen on the mandrel shall be disregarded.

TABLE I

| Size              | Diameter of Mandrel, Inch |
|-------------------|---------------------------|
| 3/64 to 1/4, incl | 5/16                      |
| 3/8 to 1/2, incl  | 3/8                       |
| 3/4 to 2, incl    | 7/16                      |
| 3 to 4, incl      | 7/8                       |

Note 4. Three specimens, each 6 in. or more long ( $\times$  1/4 in. wide strips cut from sizes 3/4 and larger), shall be conditioned at  $-55^{\circ}\text{C} \pm 2$  ( $-67^{\circ}\text{F} \pm 3.6$ ) for 4 hours. A fixed steel mandrel, selected in accordance with Table I above, shall be conditioned at this temperature. Upon completion of this conditioning and at this same temperature, the specimens shall be wrapped not less than 360 deg about the mandrel in approximately 2 seconds. The specimens shall be free from cracks.

Note 5. Specimens shall be prepared as in Note 1 and shall be conditioned for 168 hr in a mechanical convection oven which is at  $175^{\circ}\text{C} \pm 3$  ( $347^{\circ}\text{F} \pm 5.4$ ), with an air velocity of 100 - 200 ft per min. past the specimens. After conditioning, the specimens shall be removed from the oven, cooled to room temperature, and tested for elongation. Specimens shall have elongation of not lower than 200%.

Note 6. A specimen 6 in. long shall be slid over a close-fitting, straight, clean, unplated, uninsulated, copper conductor. For sizes 1/4 and smaller, a solid copper conductor shall be used; for sizes 3/8 and larger, a solid or tubular conductor shall be used. The specimens on horizontally suspended conductors shall be conditioned for not less than 24 hr in a humidity chamber at 90 - 95% relative humidity and  $25^{\circ}\text{C} \pm 3$  ( $77^{\circ}\text{F} \pm 5.4$ ). The specimens on horizontally suspended conductors shall be conditioned for 168 hr in an oven which is at  $160^{\circ}\text{C} \pm 3$  ( $320^{\circ}\text{F} \pm 5.4$ ) with an air velocity of 100 - 200 ft per min. past the specimens. After conditioning, the specimens shall be removed from the oven, cooled to room temperature, and examined. The tubing shall not be brittle, cracked, severely discolored, or otherwise deteriorated by direct contact with copper. The elongation of the tubing shall be not lower than 200%. The copper shall not be pitted or blackened. Darkening of the copper due to normal air oxidation shall be disregarded.

Note 7. A specimen 1 in. long (a 1/8 in. wide strip cut from sizes 1/8 and larger), shall be placed in the bottom of each of two clean 1/2 in. x 12 in. test tubes. A third test tube shall be used for control. A copper-glass mirror about 1/4 in. wide x 1 in. long shall be suspended 6 - 7 in. above the bottom of each tube by fine copper wire attached to a silicone rubber stopper wrapped in aluminum foil. The mirrors shall be vacuum-deposited copper, on one side only, with a thickness equal to  $10\% \pm 5$  transmission of normal incident light of 5000 Angstroms. The coated mirrors shall be stored in vacuum and may be used for test only if no oxide film is present and the copper is not visibly damaged. The three test tubes shall be tightly sealed. The lower 2 in. of each tube shall be placed in an oven or oil bath at  $175^{\circ}\text{C} \pm 3$  ( $347^{\circ}\text{F} \pm 5.4$ ) for 16 hours. After cooling, the mirrors shall be examined in a good light against a white background. Any removal of copper from the mirror will be a sign of corrosion; disregard any removal of copper from the mirror on the bottom 1/16 in. of the mirror. Discoloration of the copper film shall not be considered corrosion.

Note 8. Tubing shall have tensile strength not lower than 750 psi and dielectric strength not lower than 400 v per mil after being immersed for 24 hr  $\pm 2$  at  $23^{\circ}\text{C} \pm 3$  ( $73.4^{\circ}\text{F} \pm 5.4$ ) in JP-4 Fuel, SAE phosphate ester test fluid No. 1, hydraulic oil, aviation gasoline 100/130, and water. Six specimens (a total of 30), each 6 in. long, shall be immersed in each of the fluids. The volume of the fluid shall be not less than 20 times that of the specimens. After immersion, the specimens shall be lightly wiped, air dried for 30 - 60 min. at room temperature, and subjected to the tensile strength and dielectric strength tests; three of each group of six specimens shall be tested for tensile strength and the other three for dielectric strength.

Note 9. Fungus resistance shall be determined in accordance with ASTM D1924 except that the incubation period shall be 28 days and the test organisms shall be *Aspergillus niger*, *Aspergillus flavus*, *Penicillium luteum*, and *Trichoderma T-1*. At the end of the incubation period, not more than traces of growth on the specimens are permissible. Three specimens, each 3 in. long, shall be used for each organism.

Note 10. A specimen in the expanded form (as supplied) shall be shrunk onto a clean metallic mandrel of the configuration and size shown in Fig. 1. The tubing on the mandrel then shall be conditioned for 30 min. in an oven which is at  $150^{\circ}\text{C} \pm 5$  ( $302^{\circ}\text{F} \pm 9$ ), with an air velocity of 100 - 200 ft per min. past the specimen. After conditioning, the tubing shall be visually examined and then shall be subjected to the following voltage withstand test. The tubing shall snugly fit the mandrel and shall not be cracked. The test potential shall be applied between the mandrel and a metal foil electrode wrapped around the largest diameter of the tubing in accordance with ASTM D876. The test potential then shall be applied in accordance with the short-time test of ASTM D149 using 500 v per sec rate of rise. The specimen shall withstand 2000 v for 1 minute.

5.3 Dimensions After Shrinkage:

5.3.1 Diametral: Three specimens in the expanded form (as supplied), each 6 in. long, shall be measured for length and inside diameter. The specimens shall be conditioned for 1 min. in boiling water. After conditioning, the specimens shall be wiped dry, cooled to room temperature, and then remeasured. Prior to and after conditioning, the dimensions of the tubing shall be in accordance with Table II. Measurements shall be made in accordance with ASTM D876.

5.3.2 Longitudinal: In reaching its recovered dimensions, the tubing shall not exhibit a longitudinal change greater than +3%, -5%, computed as follows:

$$\% \text{ change} = \frac{\text{Length after heating} - \text{Length before heating}}{\text{Length before heating}} \times 100$$

5.4 Marking: Prior to or after shrinkage, tubing shall be capable of having numbers or characters printed on it with conventional tubing marking techniques.

6. QUALITY: The product shall be uniform in quality and condition, clean, smooth, and free from foreign materials and from imperfections detrimental to fabrication, appearance, or performance of parts.

7. STANDARD SIZES AND TOLERANCES: Unless otherwise specified, tubing shall be supplied in lengths of 48 in., +1, -0, and in the standard sizes and tolerances shown in Table II. Tolerances apply at 23 - 30 C (73.4 - 86 F).

TABLE II

| Expanded (As Supplied) |            | Recovered Dimensions (After Heating) |                              |   |
|------------------------|------------|--------------------------------------|------------------------------|---|
| Size                   | ID, Inches | ID, Inches                           | Nominal Wall Thickness, Inch | Wall Thickness Tolerance, Inch plus and minus |
| 3/64                   | 0.046      | 0.023                                | 0.016                        | 0.003   |
| 1/16                   | 0.063      | 0.031                                | 0.017                        | 0.003   |
| 3/32                   | 0.093      | 0.046                                | 0.020                        | 0.003   |
| 1/8                    | 0.125      | 0.062                                | 0.020                        | 0.003   |
| 3/16                   | 0.187      | 0.093                                | 0.023                        | 0.003   |
| 1/4                    | 0.250      | 0.125                                | 0.028                        | 0.003   |
| 3/8                    | 0.375      | 0.187                                | 0.028                        | 0.003   |
| 1/2                    | 0.500      | 0.250                                | 0.028                        | 0.003   |
| 3/4                    | 0.750      | 0.375                                | 0.033                        | 0.003   |
| 1                      | 1.000      | 0.500                                | 0.035                        | 0.005   |
| 1-1/2                  | 1.500      | 0.750                                | 0.040                        | 0.006   |
| 2                      | 2.000      | 1.000                                | 0.045                        | 0.007   |
| 3                      | 3.000      | 1.500                                | 0.050                        | 0.008   |
| 4                      | 4.000      | 2.000                                | 0.055                        | 0.009   |

8. REPORTS:

8.1 Unless otherwise specified, the vendor of the product shall furnish with each shipment three copies of a report showing the results of tests made on the product to determine conformance to the requirements of 5.2.1 through 5.2.4 and a statement that the product conforms to all other requirements of this specification. This report shall include the purchase order number, material specification number, vendor's compound number, size, and quantity.