

**AEROSPACE  
MATERIAL  
SPECIFICATION**

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Superseding AMS3632E

Tubing, Plastic, Electrical Insulation  
Irradiated Polyvinylidene Fluoride, Semi-Rigid, Heat-Shrinkable  
2 to 1 Shrink Ratio

**RATIONALE**

This document has been determined to contain basic and stable technology which is not dynamic in nature.

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1. SCOPE:

1.1 FORM: This specification covers an irradiated, thermally-stabilized, flame-resistant, modified-polyvinylidene-fluoride plastic in the form of extra-thin-wall tubing.

1.2 Applications: Primarily for use as a semi-rigid, electrical insulation tubing whose diameter can be reduced to a predetermined size by heating to 175°C (347°F) or higher. This tubing is stable under the following conditions:

|                                 |              |
|---------------------------------|--------------|
| -55" to +175°C (-67° to +347°F) | Continuous   |
| -55" to +200°C (-67° to +392°F) | 15,000 hours |
| -55" to +240°C (-67° to +464°F) | 1,000 hours  |
| -55" to +280°C (-67° to +536°F) | 110 hours    |
| -55" to +315°C (-67° to +599°F) | 24 hours     |
| -55" to +350°C (-67° to +662°F) | 5 hours      |

2. APPLICABLE DOCUMENTS: The following publications form a part of this specification to the extent specified herein. The applicable issue of other publications shall be the issue in effect on the date of the purchase order.

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2.1 ASTM Publications: Available from ASTM, 1916 Race Street, Philadelphia, PA 19103-1187.

ASTM D 471 - Rubber Property - Effect of Liquids  
ASTM D 910 - Aviation Gasolines  
ASTM D 2671 - Testing Heat-Shrinkable Tubing for Electrical Use  
ASTM G 21 - Determining Resistance of Synthetic Polymeric Materials to Fungi

2.2 U.S. Government Publications: Available from Standardization Documents Order Desk, Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.

2.2.1 Military Specifications:

MIL-H-5606 - Hydraulic Fluid, Petroleum Base, Aircraft, Missile, and Ordnance  
MIL-T-5624 - Turbine Fuel, Aviation, Grades JP-4 and JP-5  
MIL-A-8243 - Anti-icing and Deicing-Defrosting Fluid

2.2.2 Military Standards:

MIL-STD-794 - Parts and Equipment, Procedures for Packaging and Packing of

3. TECHNICAL REQUIREMENTS:

3.1 Materials: Shall be an irradiated, thermally-stabilized, flame-resistant, modified-polyvinylidene fluoride plastic.

3.2 Color: Shall be in a standard unpigmented state, transparent to translucent, light tan in color.

3.3 Properties: Tubing shall conform to the following requirements; reported values shall be the average of all specimens tested for each requirement. Except as otherwise specified, herein, tests shall be performed in accordance with ASTM D 2671 insofar as practicable.

3.3.1 Recovered Tubing: The following requirements apply to tubing after being shrunk by heating to  $200^{\circ}\text{C} \pm 5$  ( $392^{\circ}\text{F} \pm 9$ ) in a convection-current air oven with an air velocity of 100 - 200 feet per minute (0.5 - 1.0 m/second) past the tubing, holding at heat for not less than 3 minutes, removing from the oven, and conditioning for not less than 4 hours at  $23^{\circ}\text{C} \pm 2$  ( $73^{\circ}\text{F} \pm 4$ ) and 45 - 55% relative humidity.

3.3.1.1 Tensile Strength, minimum  
Jaw separation rate 2.0 inches per minute (0.85 mm/second)      5000 psi (34.5 MPa)

3.3.1.2 Elongation, minimum      150%

3.3.1.3 Dielectric Strength (short time test), minimum      600 volts/mil (23,622 V/mm)

|           |   |  |           |
|-----------|---|--|-----------|
| 3.3.1.4   | Volume Resistivity, minimum   | $10^{13}$ ohm-cm                                   |           |
| 3.3.1.5   | Flammability, Procedure A<br>Burning Time, maximum (See 8.3)  | 15 seconds   |           |
| 3.3.1.6   | Fungus Resistance   | Rating of 1 or less                                | ASTM G 21 |
| 3.3.1.7   | Heat Aging, 168 hours $\pm$ 2 at<br>$250^{\circ}\text{C} \pm 3$ ( $482^{\circ}\text{F} \pm 5$ )   |  |           |
| 3.3.1.7.1 | Elongation, minimum   | 50%  |           |
| 3.3.1.8   | Fluid Resistance,<br>at $23^{\circ}\text{C} \pm 3$ ( $75^{\circ}\text{F} \pm 5$ )   |  | 4.5.1     |
| 3.3.1.8.1 | Tensile Strength, minimum   | 5000 psi<br>(34.5 MPa)                             |           |
| 3.3.1.8.2 | Dielectric Strength, minimum  | 500 volts/mil<br>(19,685 V/mm)                     |           |
| 3.3.1.9   | Dimensional Change on Heating   |  |           |
| 3.3.1.9.1 | Diametral   | In accordance with<br>Table I                      |           |
| 3.3.1.9.2 | Longitudinal, maximum   | -10%, +1%  |           |
| 3.3.2     | <u>Expanded Tubing:</u> The following requirements apply to tubing in the expanded (as-received) condition. Heating for the tests of 3.3.2.2 and 3.3.2.3 shall be performed in an oven as specified in 3.3.1. |  |           |
| 3.3.2.1   | Secant Modulus at 2%<br>Strain, minimum   | 100,000 psi<br>(689 MPa)                           |           |
| 3.3.2.2   | Heat Shock, 4 hours $\pm$ 0.25 at<br>$300^{\circ}\text{C} \pm 5$ ( $572^{\circ}\text{F} \pm 9$ )  | No dripping,<br>flowing, or cracking               | 4.5.2     |
| 3.3.2.3   | Restricted Shrinkage,<br>Procedure C, after<br>30 minutes $\pm$ 1 at $200^{\circ}\text{C} \pm 5$<br>( $392^{\circ}\text{F} \pm 9$ )   | No cracks;<br>withstand 2000 volts<br>for 1 minute |           |
| 3.3.2.4   | Specific Gravity, maximum   | 1.80   |           |
| 3.3.2.5   | Low-Temperature Flexibility<br>4 hours $\pm$ 0.25 at $-55^{\circ}\text{C} \pm 2$<br>( $-67^{\circ}\text{F} \pm 4$ )   | No cracks  | 4.5.3     |

## 3.3.2.6 Water Absorption, maximum

24 hours  $\pm$  0.25 at 25°C  $\pm$  2  
(77°F  $\pm$  4)  $\pm$  0.50%

3.4 Marking: Tubing, prior to and after shrinkage, shall be suitable for having numbers or characters printed on it with conventional tubing marking techniques. Marking applied prior to shrinkage shall not be distorted by non-concentric shrinkage.

3.5 Quality: Tubing, as received by purchaser, shall be uniform in quality and condition, smooth, and free from foreign materials and from imperfections detrimental to usage of the tubing.

3.6 Standard Sizes and Tolerances: Tubing shall be supplied in lengths of 48 inches  $\pm$  1, -0 (1219 mm,  $\pm$  25, -0), and in the standard sizes and to the tolerances shown in Table I. Tolerances apply at 23°- 30°C (73°- 86°F). Measurements shall be made in accordance with ASTM D 2671.

TABLE I

| Size | Expanded (AS Supplied)<br>ID, Inch<br>min | Recovered Dimensions (After Heating) |                                   |   |
|------|---|--------------------------------------|-----------------------------------|---|
|      |   | ID, Inch<br>max                      | Nominal<br>Wall Thickness<br>Inch | Wall Thickness<br>Tolerance, Inch<br>plus and minus |
| 3/64 | 0.046                                     | 0.023                                | 0.010                             | 0.002   |
| 1/16 | 0.063                                     | 0.031                                | 0.010                             | 0.002   |
| 3/32 | 0.093                                     | 0.046                                | 0.010                             | 0.002   |
| 1/8  | 0.125                                     | 0.062                                | 0.010                             | 0.002   |
| 3/16 | 0.187                                     | 0.093                                | 0.010                             | 0.002   |
| 1/4  | 0.250                                     | 0.125                                | 0.012                             | 0.003   |
| 3/8  | 0.375                                     | 0.187                                | 0.012                             | 0.003   |
| 1/2  | 0.500                                     | 0.250                                | 0.012                             | 0.003   |
| 3/4  | 0.750                                     | 0.375                                | 0.017                             | 0.003   |
| 1    | 1.000                                     | 0.500                                | 0.019                             | 0.003   |

TABLE I (SI)

| Size | Expanded (As Supplied) |                          | Recovered Dimensions (After Heating) |                |                              |
|------|------------------------|--------------------------|--------------------------------------|----------------|------------------------------|
|      | ID                     | ID<br>Millimetres<br>min | ID                                   | Nominal        | Wall Thickness               |
|      | Millimetres            |                          | Millimetres                          | Wall Thickness | Tolerance                    |
|      |                        |                          | max                                  | Millimetre     | Millimetre<br>plus and minus |
| 3/64 | 1.17                   |                          | Ø.58                                 | Ø.25           | Ø.05                         |
| 1/16 | 1.60                   |                          | Ø.79                                 | Ø.25           | Ø.05                         |
| 3/32 | 2.36                   |                          | 1.17                                 | Ø.25           | Ø.05                         |
| 1/8  | 3.18                   |                          | 1.57                                 | Ø.25           | Ø.05                         |
| 3/16 | 4.75                   |                          | 2.36                                 | Ø.25           | Ø.05                         |
| 1/4  | 6.35                   |                          | 3.18                                 | Ø.30           | Ø.08                         |
| 3/8  | 9.52                   |                          | 4.75                                 | Ø.30           | Ø.08                         |
| 1/2  | 12.70                  |                          | 6.35                                 | Ø.30           | Ø.08                         |
| 3/4  | 19.05                  |                          | 9.52                                 | Ø.43           | Ø.08                         |
| 1    | 25.40                  |                          | 12.70                                | Ø.48           | Ø.08                         |

#### 4. QUALITY ASSURANCE PROVISIONS:

- 4.1 Responsibility for Inspection: The vendor of tubing shall supply all samples for vendor's tests and shall be responsible for performing all required tests. Purchaser reserves the right to sample and to perform any confirmatory testing deemed necessary to ensure that the tubing conforms to the requirements of this specification.
- 4.2 Classification of Tests:
- 4.2.1 Acceptance Tests: Tests for tensile strength (3.3.1.1), elongation (3.3.1.2), dimensional change on heating (3.3.1.9), secant modulus (3.3.2.1), heat shock (3.3.2.2), and sizes and tolerances (3.6) are acceptance tests and shall be performed on each lot.
- 4.2.2 Periodic Tests: Tests for dielectric strength (3.3.1.1), volume resistivity (3.3.1.4), fungus resistance (3.3.1.6), heat aging (3.3.1.7), fluid resistance (3.3.1.8), restricted shrinkage (3.3.2.3), specific gravity (3.3.2.4), low-temperature flexibility (3.3.2.5), water absorption (3.3.2.6), and marking (3.4) are periodic tests and shall be performed at a frequency selected by the vendor unless frequency of testing is specified by purchaser.
- 4.2.3 Preproduction Tests: Tests for all technical requirements are preproduction tests and shall be performed prior to or on the initial shipment of tubing to a purchaser, when a change in ingredients and/or processing requires reapproval as in 4.4.2, and when purchaser deems confirmatory testing to be required.
- 4.2.3.1 For direct U.S. Military procurement, substantiating test data and, when requested, preproduction test material shall be submitted to the cognizant agency as directed by the procuring activity, contracting officer, or request for procurement.

- 4.3 Sampling and Testing: shall be in accordance with ASTM D 2671 and the following; the number of determinations for each requirement shall be as specified in the applicable test procedure or, if not specified therein, not less than three. A lot shall be all tubing of the same size from the same production run presented for vendor's inspection at one time. A lot may be packaged in small quantities and delivered under the basic lot approval provided lot identification is maintained.
- 4.3.1 For Acceptance Tests: Not less than 16 feet (4.9 m) of tubing from each lot.
- 4.3.1.1 When a statistical sampling plan has been agreed upon by purchaser and vendor, sampling shall be in accordance with such plan in lieu of sampling as in 4.3.1 and the report of 4.6 shall state that such plan was used.
- 4.3.2 For Periodic Tests: Not less than 48 feet (15 m) of tubing of each size or size range. Any size within a size range may be chosen to demonstrate conformance to that size range.
- | Range of Sizes    |
|-------------------|
| 3/64 - 3/16, incl |
| 1/4 - 1, incl     |
- 4.3.2. For Preproduction Tests: As agreed upon by purchaser and vendor.
- 4.4 Approval:
- 4.4.1 Sample tubing shall be approved by purchaser before tubing for production use is supplied, unless such approval be waived by purchaser. Results of tests on production tubing shall be essentially equivalent to those on the approved sample tubing.
- 4.4.2 Vendor shall use ingredients, manufacturing procedures, processes, and methods of inspection on production tubing which are essentially the same as those used on the approved sample tubing. If necessary to make any change in ingredients, in type of equipment for processing, or in manufacturing procedures vendor shall submit for reapproval a statement of the proposed changes in ingredients and/or processing and, when requested, sample tubing. Tubing made by the revised procedure shall not be shipped prior to receipt of reapproval.
- 4.5 Test Methods:
- 4.5.1 Solvent Resistance: Shall be determined in accordance with ASTM D 2671 on specimens immersed for 24 hours  $\pm$  2 at 23°C  $\pm$  3 (73°F  $\pm$  5 in MIL-T-5624 JP-4 fuel, SAE phosphate ester test fluid No. 1A, MIL-H-5606 hydraulic oil, ASTM service fluid No. 101 (See ASTM D 471), ASTM D 910 aviation gasoline 100/130, MIL-A-8243 anti-icing fluid, and salt water (5% salt), using separate specimens for each fluid.

- 4.5.2 Bending After Heat Shock: Specimens from the heat shock test of 3.3.2.2 shall be bent 180 degrees around the applicable mandrel of Table II. Any side-cracking, caused by flattening of the specimens on the mandrel shall be disregarded.

TABLE II

| Tubing Size        | Diameter of Mandrel |             |
|--------------------|---------------------|-------------|
|                    | Inch                | Millimetres |
| 3/64 to 3/16, incl | 5/16                | 7.9         |
| 1/4 to 1, incl     | 3/4                 | 19.0        |

- 4.5.3 Low-Temperature Flexibility: For tubing of expanded size 1/4 or greater, three strip specimens, 0.250 inch  $\pm$  0.010 (6.35 mm  $\pm$  0.25) wide and 12 inches (305 mm) long shall be cut from the expanded tubing. For tubing of expanded size less than 1/4 three tubular specimens, 12 inches (305 mm) long, shall be cut from the expanded tubing. The specimens shall be recovered in accordance with 3.3.1 and conditioned in accordance with 3.3.2.5. Mandrel diameter shall be 10 times specimen thickness  $\pm$ 10%. For tubular specimens, the specimen thickness shall be taken as the outside diameter. After the conditioning period, and while at the specified low temperature, and without removing the specimens from the chamber, bend the specimens around the mandrel for not less than one complete wrap (360 degrees) at a uniform speed of about 4 seconds per wrap. Any side cracking, caused by flattening of the specimens on the mandrel, shall be disregarded.
- 4.6 Reports: The vendor of tubing shall furnish with each shipment a report showing the results of tests to determine conformance to the acceptance test requirements and, when performed, to the periodic test requirements and stating that the tubing conforms to the other technical requirements. This report shall include the purchase order number, lot number, AMS-3632F, manufacturer's identification, size, and quantity.
- 4.7 Resampling and Retesting: If the average results of specimens tested for any requirement fails to meet the specified value, disposition of the tubing may be based on the results of testing three additional specimens for each original specimen failing to meet the specified average requirement. Failure of the average of the original specimens plus the retest specimens to meet any specified requirement shall be cause for rejection of the tubing represented. Results of all tests shall be reported.

## 5. PREPARATION FOR DELIVERY:

- 5.1 Identification: Each package of tubing shall be permanently and legibly marked with not less than AMS-3632F size, quantity, purchase order number, manufacturer's identification, and date of manufacture.