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400 COMMONWEALTH DRIVE, WARRENDALE, PA 15096

AEROSPACE MATERIAL SPECIFICATION

AMS 3683

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Submitted for recognition as an American National Standard

PLASTIC TUBING, ELECTRICAL INSULATION
Irradiated Modified Fluoropolymer, Flexible, Heat-Shrinkable
2 to 1 Shrink Ratio

1. SCOPE:

1.1 Form: This specification covers a thermally-stabilized, flame-resistant, modified fluoropolymer in the form of very-thin-wall tubing.

1.2 Applications: Primarily for use as a flexible, electrical insulation tubing whose diameter can be reduced to a predetermined size by heating to 150°C (302°F) or higher.

1.3 Safety - Hazardous Materials: While the materials, methods, applications, and processes described or referenced in this specification may involve the use of hazardous materials, this specification does not address the hazards which may be involved in such use. It is the sole responsibility of the user to ensure familiarity with the safe and proper use of any hazardous materials and to take necessary precautionary measures to ensure the health and safety of all personnel involved.

2. APPLICABLE DOCUMENTS: The following publications form a part of this specification to the extent specified herein. The latest issue of Aerospace Material Specifications shall apply. The applicable issue of other documents shall be as specified in AMS 2350.

2.1 SAE Publications: Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096.

2.1.1 Aerospace Material Specifications:

AMS 2350 - Standards and Test Methods

2.2 ASTM Publications: Available from American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103.

ASTM D471 - Rubber Property - Effect of Liquids
ASTM D2671 - Testing Heat-Shrinkable Tubing for Electrical Use
ASTM G21 - Determining Resistance of Synthetic Polymeric Materials to Fungi

2.3 U.S. Government Publications: Available from Commanding Officer, Naval Publications and Forms Center, 5801 Tabor Avenue, Philadelphia, PA 19120.

2.3.1 Military Specifications:

MIL-G-5572 - Gasoline, Aviation, Grades 80/87, 100/130, 115/145
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

2.3.2 Military Standards:

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

3. TECHNICAL REQUIREMENTS:

3.1 Material: Shall be an irradiated, thermally-stabilized, flame-resistant, modified fluoropolymer.

3.2 Color: Shall be black and white.

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 D2671.

3.3.1 Recovered Tubing: The following requirements apply to tubing after being shrunk by heating to 200°C + 5 (392°F + 9) in a convection-current air oven with an air velocity of 100 - 200 feet per minute (0.5 - 1.0 m/s) 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°C ± 2 (73°F ± 4) and 45 - 55% relative humidity.

3.3.1.1	Tensile Strength, minimum Jaw separation rate 2.0 inches per minute (0.85 mm/s)	3500 psi (24.8 MPa)
3.3.1.2	Elongation, minimum	300%
3.3.1.3	Dielectric Strength (short time test), minimum	500 V/mil (19,700 V/mm)
3.3.1.4	Volume Resistivity, minimum	10^{11} ohm-cm
3.3.1.5	Flammability, Procedure A Burn time, maximum (See 8.1)	15 seconds

3.3.1.6 Fungus Resistance	Rating of 1 or less	ASTM G21
3.3.1.7 Heat Aging, 336 hours ± 2 at 225°C ± 3 (437°F ± 5)		
3.3.1.7.1 Elongation, minimum	250%	
3.3.1.8 Fluid Resistance, at 23°C ± 3 (75°F ± 5)		4.5.1
3.3.1.8.1 Tensile Strength, minimum	3500 psi (24.2 MPa)	
3.3.1.8.2 Dielectric Strength, minimum	400 V/mil (15,760 V/mm)	
3.3.1.9 Dimensional Change on Heating		
3.3.1.9.1 Diametral	In accordance with Table I	
3.3.1.9.2 Longitudinal, maximum	-10%, +1%	

3.3.2 Expanded Tubing: 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% Strain, maximum	50,000 psi (345 MPa)	
3.3.2.2 Heat Shock, 4 hours ± 0.25 at 250°C ± 5 (482°F ± 9)	No dripping, flowing, or cracking	4.5.2
3.3.2.3 Restricted Shrinkage, Procedure C, after 30 minutes ± 1 at 200°C ± 5 (392°F ± 9)	No cracks; withstand 2000 V for 1 minute	
3.3.2.4 Specific Gravity, maximum	1.85	
3.3.2.5 Low-Temperature Flexibility 4 hours ± 0.25 at -55°C ± 2 (-69°F ± 4)	No cracks	4.5.3
3.3.2.6 Water Absorption, maximum 24 hours ± 0.25 at 25°C ± 2 (77°F ± 4)	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.

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 its use.

3.6 Standard Sizes and Tolerances: Tubing shall be supplied on spools or in lengths agreed upon by purchaser and vendor, and in the standard sizes to the tolerances shown in Table I. Tolerances apply at 23° - 30°C (73° - 86°F). Measurements shall be made in accordance with ASTM D2671.

TABLE I

Size	Expanded (As Supplied) ID, Inch minimum	Recovered Dimensions (After Heating) ID, Inch maximum	Nominal Wall Thickness Inch	Wall Thickness Tolerance, Inch plus and minus
3/64	0.046	0.023	0.009	0.003
1/16	0.063	0.031	0.009	0.003
3/32	0.093	0.046	0.009	0.003
1/8	0.125	0.062	0.009	0.003
3/16	0.187	0.093	0.009	0.003
1/4	0.250	0.125	0.011	0.004
3/8	0.375	0.187	0.011	0.004
1/2	0.500	0.250	0.011	0.004
3/4	0.750	0.375	0.016	0.004
1	1.000	0.500	0.018	0.004

TABLE I (SI)

Size	Expanded (As Supplied) ID, Millimetres minimum	Recovered Dimensions (After Heating) ID Millimetres maximum	Nominal Wall Thickness Millimetre	Wall Thickness Tolerance Millimetre plus and minus
3/64	1.17	0.58	0.23	0.08
1/16	1.60	0.79	0.23	0.08
3/32	2.36	1.17	0.23	0.08
1/8	3.18	1.57	0.23	0.08
3/16	4.75	2.36	0.23	0.08
1/4	6.35	3.18	0.28	0.10
3/8	9.52	4.75	0.28	0.10
1/2	12.70	6.35	0.28	0.10
3/4	19.05	9.52	0.41	0.10
1	25.40	12.70	0.46	0.10

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. Results of such tests shall be reported to the purchaser as required by 4.6. 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 to determine conformance to requirements for tensile strength (3.3.1.1), elongation (3.3.1.2), flammability (3.3.1.5), 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 classified as acceptance tests and shall be performed on each lot.

4.2.2 Periodic Tests: Tests to determine conformance to requirements for dielectric strength (3.3.1.3), 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 classified as 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 to determine conformance to all technical requirements of this specification are classified as preproduction tests and shall be performed prior to or on the initial shipment of tubing to a purchaser, when a change in material, processing, or both 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: Shall be in accordance with ASTM D2671 and as follows:

4.3.1 For Acceptance Tests: Not less than 16 feet (5 m) of tubing taken at random from each lot. 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.

4.3.1.1 A lot shall be all tubing of the same size from one production run presented for vendor's inspection at one time. An inspection lot shall not exceed the quantities specified below and may be packaged in smaller quantities and delivered under the basic lot approval provided lot identification is maintained.

Tubing Size	Inspection Lot Size	
	Feet	Metres
3/64 - 1/4, incl	1,000,000	305,000
3/8 - 1/2, incl	500,000	152,500
3/4 - 1, incl	50,000	15,250

4.3.1.2 When a statistical sampling plan and acceptance quality level (AQL) have 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 4.6.1 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 in the range may be used to demonstrate conformance of a range of sizes as follows:

Representative Size	Range of Sizes
3/16	3/64 - 3/16, incl
1	1/4 - 1, incl

For the fungus requirement, any size may be used to qualify the tubing.

4.3.3 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 producting 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 material, processing, or both, 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 Fluid Resistance: Shall be determined in accordance with ASTM D2671 on specimens immersed for 24 hours + 2 at 23°C + 3 (73°F + 5) in MIL-T-5624 JP-4 fuel, MIL-H-5606 hydraulic oil, ASTM #3 oil, MIL-G-5572 aviation gasoline Grade 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

MANDREL DIMENSIONS

Tubing Size	Diameter of Mandrel Inch	Diameter of Mandrel 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 + 0.010 (6.35 mm + 0.25) wide and 12 inches (300 mm) long shall be cut from the expanded tubing. For tubing of expanded size less than 1/4 three tubular specimens 12 inches (300 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 ten times specimen thickness, ±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, the tubing shall be wrapped around the mandrel for not less than one complete turn (360 degrees) at a uniform speed of about 4 seconds per turn. Any side cracking, caused by flattening of the specimens on the mandrel, shall be disregarded.

4.6 Reports:

4.6.1 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 of this specification. This report shall include the purchase order number, AMS 3683, lot number, size, and quantity.

4.6.2 The vendor of finished or semi-finished parts shall furnish with each shipment a report showing the purchase order number, AMS 3683, contractor or other direct supplier of tubing, part number, and quantity. When tubing for making parts is produced or purchased by the parts vendor, that vendor shall inspect each lot of tubing to determine conformance to the requirements of this specification and shall include in the report either a statement that the tubing conforms or copies of laboratory reports showing the results of tests to determine conformance.

4.7 Resampling and Retesting: If the average results of the specimens tests 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 and no additional testing shall be permitted. 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 3683, size, quantity, purchase order number, manufacturer's identification, and date of manufacture.