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400 COMMONWEALTH DRIVE WARRENDALE PA 15096

AEROSPACE MATERIAL SPECIFICATION

AMS 3632D
Superseding AMS 3632C

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PLASTIC TUBING, ELECTRICAL INSULATION
Irradiated Polyvinylidene Fluoride, Semi-Rigid, Heat-Shrinkable
2 to 1 Shrink Ratio

1. SCOPE:

1.1 Form: This specification covers an irradiated, thermally-stabilized, flame-resistant, modified-polyvinylidene-fluoride plastic in the form of semi-rigid, extra-thin-wall, heat-shrinkable 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 (350°F) or higher. This tubing is stable under the following conditions:

-55°C (-65°F) to +175°C (350°F)	Continuous
-55°C (-65°F) to +200°C (390°F)	15,000 hr
-55°C (-65°F) to +240°C (465°F)	1,000 hr
-55°C (-65°F) to +280°C (535°F)	110 hr
-55°C (-65°F) to +315°C (600°F)	24 hr
-55°C (-65°F) to +350°C (660°F)	5 hr

2. APPLICABLE DOCUMENTS: The following publications form a part of this specification to the extent specified herein. The latest issue of Aerospace Material Specifications (AMS) 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
AMS 3032 - Aviation Fuel, Grade 100/130

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-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 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, tests shall be performed in accordance with ASTM D2671 insofar as practicable.

3.3.1 Recovered Tubing: The following requirements apply to tubing after being shrunk by heating to 200°C ± 5 (390°F ± 9) in a convection-current air oven with an air velocity of 100 - 200 ft per min. (0.5 - 1.0 m/sec) past the tubing, holding at heat for not less than 3 min, removing from the oven, and conditioning for not less than 4 hr at 23°C ± 2 (73°F ± 4) and 45 - 55% relative humidity.

3.3.1.1	Tensile Strength, min Jaw separation rate 2.0 in. per min. (0.85 mm/s)	5000 psi (34.5 MPa)
3.3.1.2	Elongation, min	150%
3.3.1.3 Ø	Dielectric Strength (short time test), min	600 V/mil (23,600 V/mm)

3.3.1.4	Volume Resistivity, min	10^{13} ohm-cm	
3.3.1.5	Flammability, Procedure A	Burn time 15 sec, max	
3.3.1.6 Ø	Fungus Resistance	Rating of 1 or less	ASTM G21
3.3.1.7	Heat Aging, 168 hr ± 2 at 250°C ± 3 (480°F ± 5)		
3.3.1.7.1	Elongation, min	50%	
3.3.1.8	Solvent Resistance, at 23°C ± 3 (75°F ± 5)		4.5.1
3.3.1.8.1	Tensile Strength, min	5,000 psi (34.5 MPa)	
3.3.1.8.2 Ø	Dielectric Strength, min	500 V/mil (19,700 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, max	-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, min	100,000 psi (690 MPa)	
3.3.2.2	Heat Shock, 4 hr ± 0.25 at 300°C ± 5 (572°F ± 9)	No dripping, flowing, or cracking	4.5.2
3.3.2.3	Restricted Shrinkage, Procedure C, after 30 min. ± 1 at 200°C ± 5 (392°F ± 9)	No cracks; withstand 2000 V for 1 min.	
3.3.2.4	Specific Gravity, max	1.80	
3.3.2.5 Ø	Low-Temperature Flexibility 4 hr ± 0.25 at -55°C ± 2 (-69°F ± 4)	No cracks	4.5.3

3.3.2.6 Water Absorption, max 0.50%
24 hr ± 0.25 at 25°C ± 2
(77°F ± 4)

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 internal and external imperfections detrimental to usage of the tubing.

3.6 Standard Sizes and Tolerances: Tubing shall be supplied in lengths of 48 in. +1, -0 (1200 mm, +25, -0), and in the standard sizes and to the tolerances shown in Table I, unless otherwise specified. 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 min	Recovered Dimensions (After Heating) ID, Inch max	Nominal Wall Thickness Inch	Wall Thickness Tolerance, Inch 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) ID Millimetres min	Recovered Dimensions (After Heating) ID Millimetres max	Nominal Wall Thickness Millimetre	Wall Thickness Tolerance Millimetre plus and minus
3/64	1.17	0.58	0.25	0.05
1/16	1.60	0.79	0.25	0.05
3/32	2.36	1.17	0.25	0.05
1/8	3.18	1.57	0.25	0.05
3/16	4.75	2.36	0.25	0.05
1/4	6.35	3.18	0.30	0.08
3/8	9.52	4.75	0.30	0.08
1/2	12.70	6.35	0.30	0.08
3/4	19.05	9.52	0.43	0.08
1	25.40	12.70	0.48	0.08

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. 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), solvent 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 or 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, the contracting officer, or the 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 ft (5 m) of tubing taken at random Ø 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 Ø not exceed the quantities specified below and may be packaged in small quantities under the basic lot approval provided lot identification is maintained.

Tubing Size	Inspection Lot Size
3/64 - 1/4, incl	100,000 ft (30,500 m)
3/8 - 1/2, incl	30,000 ft (9,000 m)
3/4 - 1, incl	10,000 ft (3,000 m)

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 ft (15 m) of tubing of each size or size range. Certain representative sizes 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

4.3.3 For Preproduction Tests: As agreed upon by purchaser and vendor. Ø

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 material or 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 Solvent Resistance: Shall be determined in accordance with ASTM D2671 on specimens immersed for 24 hr ± 2 at 23°C ± 3 (73°F ± 5) in MIL-T-5624 JP-4 fuel, SAE phosphate ester test fluid No. 1A (See 8.2), MIL-H-5606 hydraulic oil, ASTM service fluid No. 101 (See ASTM D471), AMS 3032 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 deg 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	Millimetre
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 in. ± 0.010 (6.35 mm ± 0.25) wide and 12 in. (300 mm) long shall be cut from the expanded tubing. For tubing of expanded size less than 1/4 three tubular specimens 12 in. (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. Ø Mandrel diameter shall be 10 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, bend the tubing around the mandrel for not less than one complete wrap (360 deg) at a uniform speed of about 4 sec per wrap. 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 3632D, vendor's compound number, 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 3632D, contractor or other direct supplier of tubing, supplier's compound number, 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 of the results of the 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 and no additional testing shall be permitted. Results of all tests shall be reported.

5. PREPARATION FOR DELIVERY:

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

5.2 Packaging:

5.2.1 Packaging shall be accomplished in such a manner as will ensure that the tubing, during shipment and storage, will not be permanently distorted and will be protected against damage from exposure to weather or any other normal hazard. Standard packages shall each contain the following quantities:

Size	Quantity	
	Feet	Metres
3/64, 1/16, 3/32, 1/8, 3/16, 1/4, 3/8	1000	300
1/2	800	240
3/4	500	150
1	300	90