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AEROSPACE MATERIAL SPECIFICATION

SAE AMS 3588D

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Superseding AMS 3588C

Submitted for recognition as an American National Standard

PLASTIC TUBING, ELECTRICAL INSULATION
Irradiated Polyolefin, Clear, Very Flexible, Heat-Shrinkable
2 to 1 Shrink Ratio

1. SCOPE:

1.1 Form:

This specification covers an irradiated, thermally-stabilized, modified polyolefin plastic in the form of thin-wall, heat-shrinkable tubing with a low recovery temperature.

1.2 Application:

This tubing has been used typically as a very flexible, electrical insulation tubing whose diameter can be reduced to a predetermined size by heating to 100 °C (212 °F) or higher, but usage is not limited to such applications. This tubing is stable for continuous exposure from -55 to +135 °C (-67 to +275 °F).

1.2.1 For flame-retardant, opaque tubing, refer to AMS 3587.

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 SAE publications shall apply. The applicable issue of other publications shall be the issue in effect on the date of the purchase order.

2.1 SAE Publications:

Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

AMS 3587 Plastic Tubing, Electrical Insulation, Irradiated Polyolefin, Pigmented, Very Flexible, Heat Shrinkable, Low Recovery Temperature, 2 to 1 Shrink Ratio

2.2 ASTM Publications:

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

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

2.3 U.S. Government Publications:

Available from Standardization Documents Order Desk, Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.

MIL-H-5606 Hydraulic Fluid, Petroleum Base, Aircraft, Missile, and Ordnance
MIL-T-5624 Turbine Fuel, Aviation, Grades JP-4 and JP-5
MIL-STD-2073-1 DOD Materiel, Procedures for Development and Application of Packaging Requirements

3. TECHNICAL REQUIREMENTS:

3.1 Material:

Shall be an irradiated, thermally-stabilized, modified polyolefin plastic.

3.2 Color and Transparency:

Shall be colorless and sufficiently transparent to allow relatively undistorted visibility through one wall thickness. Typewritten letters shall be legible when viewed through one wall thickness pressed onto the typewritten paper. Transparency shall apply to tubing in the expanded form (as supplied) and after tubing has been shrunk as specified in 3.3.1.

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.

3.3.1 Recovered Tubing: The requirements shown in Table 1 apply to tubing after being shrunk by heating to 125 °C ± 3 (257 °F ± 5) in a convection-current air oven with an air velocity of 100 to 200 feet/minute (0.5 to 1.0 m/second) past the tubing, holding at heat for not less than three minutes, removing from the oven, and conditioning for not less than four hours at 23 °C ± 2 (73 °F ± 4) and 45 to 55% relative humidity:

TABLE 1 - Recovered Tubing Properties

Paragraph	Property	Requirement	Test Method
3.3.1.1	Tensile Strength, minimum Jaw separation rate 20 inches/minute (8.5 mm/s)	1500 psi (10.3 MPa)	
3.3.1.2	Ultimate Elongation, minimum	200%	
3.3.1.3	Secant Modulus at 2% Strain, maximum	12.0 ksi (82.7 MPa)	
3.3.1.4	Dielectric Strength, minimum	500 Volts/mil (19.7 kV/mm)	4.5.1
3.3.1.5	Volume Resistivity, minimum	10^{14} ohm-cm	
3.3.1.6	Copper Stability 168 hours ± 2 at 160 °C ± 3 (320 °F ± 5)	No pitting or blackening of copper	
3.3.1.6.1	Ultimate Elongation, minimum	200%	
3.3.1.7	Fungus Resistance	Rating of one or less	ASTM G 21
3.3.1.8	Low-Temperature Flexibility At -55 °C ± 2 (-67 °F ± 4)	No cracks	4.5.2
3.3.1.9	Heat Aging, 168 hours ± 2 at 175 °C ± 3 (347 °F ± 5)		
3.3.1.9.1	Elongation, minimum	200%	
3.3.1.10	Corrosion, after 16 hours ± 0.25 at 175 °C ± 3 (347 °F ± 5)	Non-Corrosive	Procedure A
3.3.1.11	Fluid Resistance		4.5.3
3.3.1.11.1	Tensile Strength, minimum	750 psi (5.17 MPa)	
3.3.1.11.2	Dielectric Strength, minimum	400 Volts/mil (15.75 kV/mm)	
3.3.1.12	Dimensional Change on Heating		
3.3.1.12.1	Diametral	In accordance with Table 3	
3.3.1.12.2	Longitudinal, maximum	-5%, +3%	

3.3.2 Expanded Tubing: The requirements shown in Table 2 apply to tubing in the expanded (as-received) condition. Heating for the tests of 3.3.2.1 and 3.3.2.2 shall be performed in an oven as specified in 3.3.1.

TABLE 2 - Expanded Tubing Properties

Paragraph	Property	Requirement	Test Method
3.3.2.1	Heat Shock at 250 °C ± 5 (482 °F ± 9)	No dripping, flowing, or cracking	
3.3.2.1.1	Bending after Heat Shock	No cracks	4.5.4
3.3.2.2	Restricted Shrinkage, after 30 minutes ± 1 at 150 °C ± 5 (302 °F ± 9)	No cracks; withstand 2000 Volts for one minute	Procedure C
3.3.2.3	Specific Gravity, maximum	1.00	
3.3.2.4	Water Absorption, maximum 24 hours ± 0.25 at 25 °C ± 2 (77 °F ± 4)	0.20%	

3.4 Marking:

Tubing, prior to and after shrinkage, shall be suitable for having numbers or characters printed on it with conventional tube 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 usage of the tubing.

3.6 Standard Sizes and Tolerances:

Tubing shall be supplied in lengths of 48 inches, +1, -0 (1219 mm, +25, -0) and in the standard sizes and to the tolerances shown in Table 3. Tolerances apply at 23 to 30 °C (73 to 86 °F). Measurements shall be made in accordance with ASTM D 2671.

4. QUALITY ASSURANCE PROVISIONS:

4.1 Responsibility for Inspection:

(R)

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.

TABLE 3A - Standard Sizes, and Recovered Dimensions (After Heating)
Inch/Pound Units

Standard Sizes	Expanded (As Supplied) ID, Inches Minimum	ID After Heating Inches maximum	Nominal Wall Thickness After Heating Inch	Wall Thickness Tolerance After Heating 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	0.004
1/4	0.250	0.125	0.028	0.004
3/8	0.375	0.187	0.028	0.004
1/2	0.500	0.250	0.028	0.004
3/4	0.750	0.375	0.033	0.004
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

TABLE 3B - Standard Sizes, and Recovered Dimensions (After Heating) SI Units

Standard Sizes	Expanded (As Supplied) ID, Millimeters minimum	ID After Heating Millimeters maximum	Nominal Wall Thickness After Heating Millimeters	Wall Thickness Tolerance After Heating Millimeter plus and minus
3/64	1.17	0.58	0.41	0.08
1/16	1.60	0.79	0.43	0.08
3/32	2.36	1.17	0.51	0.08
1/8	3.18	1.57	0.51	0.08
3/16	4.75	2.36	0.58	0.10
1/4	6.35	3.18	0.71	0.10
3/8	9.52	4.75	0.71	0.10
1/2	12.70	6.35	0.71	0.10
3/4	19.05	9.52	0.84	0.10
1	25.40	12.70	0.89	0.13
1-1/2	38.10	19.05	1.02	0.15
2	50.80	25.40	1.14	0.18
3	76.20	38.10	1.27	0.20
4	101.60	50.80	1.40	0.23

4.2 Classification of Tests:

4.2.1 Acceptance Tests: Tests for tensile strength (3.3.1.1), ultimate elongation (3.3.1.2), secant modulus (3.3.1.3), dimensional change on heating (3.3.1.12), heat shock (3.3.2.1), 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 (3.3.1.4), volume resistivity (3.3.1.5), copper stability (3.3.1.6), fungus resistance (3.3.1.7), low-temperature flexibility (3.3.1.8), heat aging (3.3.1.9), corrosion (3.3.1.10), fluid resistance (3.3.1.11), restricted shrinkage (3.3.2.2), specific gravity (3.3.2.3), water absorption (3.3.2.4), 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:

(R) 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.

4.3.1 For Acceptance Tests: Not less than 16 feet (4.9 m) of tubing from each lot.

4.3.1.1 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 shall be not more than 250,000 feet (76,200 m).

4.3.1.2 When a statistical sampling plan has been agreed upon by purchaser and
(R) 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 50 feet (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 shown in Table 4.

TABLE 4 - Representative Sizes

Representative Size	Range of Sizes
1/4	3/64 - 1/4, incl
1	3/8 - 1, incl
4	1-1/2 - 4, incl

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 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 Dielectric Strength: Shall be determined in accordance with ASTM D 2671 on specimens recovered on metal mandrels for not less than 10 minutes at 175 °C ± 3 (347 °F ± 5) or until tubing is completely shrunk on the mandrels.

4.5.2 Low-Temperature Flexibility: Shall be determined in accordance with ASTM D 2671, Procedure C, bending the specimen around the applicable mandrel of Table 5. Any side-cracking, caused by flattening of the specimen on the mandrel, shall be disregarded.

TABLE 5 - Mandrel Diameters

Size	Mandrel Diameter Inch	Mandrel Diameter Millimeters
3/64 to 1/4, incl	5/16	7.9
3/8 to 1/2, incl	3/8	9.5
3/4 to 2, incl	7/16	11.1
3 to 4, incl	7/8	22.2

4.5.3 Fluid Resistance: Shall be determined in accordance with ASTM D 2671 on specimens immersed for 24 hours ± 2 at 23 °C ± 3 (73 °F ± 5) in MIL-T-5624 (JP-4) Fuel, SAE phosphate ester test fluid No. 1A, MIL-H-5606 hydraulic oil, ASTM Fuel B (See ASTM D 471), and water.

4.5.4 Bending after Heat Shock: Specimens from the heat shock test of 3.3.2.1 shall be bent 180 degrees around the applicable mandrel of Table 5. Any side-cracking, caused by flattening of the specimen 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 3588D, vendor's compound number, size, and quantity.

4.7 Resampling and Retesting:
(R)

If the average results of the specimens tested for any requirement fail 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 3588D, size, quantity, purchase order number, manufacturer's identification, and date of manufacture.