Society of Automotive Engineers, Inc.
TWO PENNSYLVANIA PLAZA, NEW YORK, N.Y. 10001

AEROSPACE MATERIAL SPECIFICATION

AMS 3636D
Superseding AMS 3636C
Issued 2-15-65
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PLASTIC TUBING, ELECTRICAL INSULATION
Irradiated Polyolefin, Pigmented, Flexible, Heat Shrinkable
2 to 1 Shrink Ratio

1. SCOPE:

1.1 Form: This specification covers an irradiated, thermally-stabilized, flame-resistant, modified polyolefin plastic in the form of flexible, thin-wall, heat-shrinkable tubing.

1.2 Application: Primarily as a flexible, electrical insulation tubing whose diameter can be reduced to a predetermined size by heating to temperatures higher than 121 C (250 F). This material is stable under the following conditions:

-55 C (-67 F) to 135 C (275 F)	Continuous
-55 C (-67 F) to 150 C (302 F)	2000 hr
-55 C (-67 F) to 175 C (347 F)	336 hr
-55 C (-67 F) to 200 C (392 F)	48 hr
-55 C (-67 F) to 250 C (482 F)	8 hr
-55 C (-67 F) to 300 C (572 F)	2 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 Society of Automotive Engineers, Inc., Two Pennsylvania Plaza, New York, New York 10001.

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, Pennsylvania 19103.

ASTM D149 - Dielectric Breakdown Voltage and Dielectric Strength of Electrical Insulating Materials at Commercial Power Frequencies
ASTM D257 - D-C Resistance or Conductance of Insulating Materials
ASTM D471 - Change in Properties of Elastomeric Vulcanizates Resulting From Immersion in Liquids
ASTM D570 - Water Absorption of Plastics
ASTM D573 - Accelerated Aging of Vulcanized Rubber by the Oven Method
ASTM D638 - Tensile Properties of Plastics
ASTM D792 - Specific Gravity and Density of Plastics by Displacement
ASTM D876 - Testing Nonrigid Vinyl Chloride Polymer Tubing
ASTM D882 - Tensile Properties of Thin Plastic Sheeting
ASTM G21 - Resistance of Synthetic Polymeric Materials to Fungi

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

2.3.1 Federal Specifications:

UU-T-450 - Tissue, Facial

2.3.2 Military Specifications:

MIL-H-5606 - Hydraulic Fluid, Petroleum Base, Aircraft, Missiles and Ordnance
MIL-T-5624 - Turbine Fuel, Aviation, Grades JP-4 and JP-5

2.3.3 Military Standard:

MIL-STD-104 - Limit for Electrical Insulation Color

3. TECHNICAL REQUIREMENTS:

3.1 Composition: The material shall be an irradiated, thermally-stabilized, flame-resistant, modified polyolefin.

3.2 Color: The tubing shall be furnished in black, white, red, yellow, or blue, as ordered. Unless otherwise specified, the colors shall be in accordance with MIL-STD-104, Class 1.

3.3 Properties: The product shall conform to the requirements of 3.3.1 through 3.3.5 and shall be capable of meeting the requirements of 3.3.6 through 3.3.17. Tests shall be conducted in accordance with specified ASTM methods insofar as practicable. Unless otherwise specified, tubing shall be tested ø after being shrunk by heating for 3 min. in a mechanical convection oven which is at 200 C ± 5 (392 F ± 9), with an air velocity of 100 - 200 ft per min. (508 - 1016 mm/s) past the tubing, removed from the oven, and conditioned for 4 hr at 23 C ± 2 (73.4 F ± 3.6) and 45 - 55% relative humidity.

3.3.1 Tensile Strength: ø	1500 psi, min (10,340 kPa, min)	ASTM D638, Speed D (See 4.4.1)
3.3.2 Ultimate Elongation:	200%, min	ASTM D638, Speed D (See 4.4.1)
3.3.3 Secant Modulus at 2% Strain:	25,000 psi, max (172 MPa, max)	ASTM D882 (See 4.4.2)
3.3.4 Heat Shock:	No dripping, flowing, or cracking	4.4.3
3.3.5 Flammability:	Pass	4.4.4
3.3.6 Low Temperature Flexibility:	No cracks	4.4.5
3.3.7 Heat Aging:	Ultimate Elongation 150%, min	4.4.6
3.3.8 Copper Stability:	Pass	4.4.7
3.3.9 Corrosion:	Pass	4.4.8
3.3.10 Color Stability:	Meet limits of MIL-STD-104, Class 1	4.4.9
3.3.11 Solvent Resistance:		4.4.10
3.3.11.1 Tensile Strength:	1000 psi, min (6895 kPa, min)	
3.3.11.2 Dielectric Strength:	400 V/mil, min (15,750 V/mm, min)	
3.3.12 Fungus Resistance:	Not more than traces of growth	4.4.11

3.3.13	Restricted Shrinkage:	No cracks Withstand 2000 V for 1 min.	4.4.12
3.3.14	Specific Gravity:	1.35, max	ASTM D792, Method A
3.3.15	Water Absorption in 24 hr:	0.50%, max	ASTM D570
3.3.16	Dielectric Strength: (Short Time Test)	500 V/mil, min (19,680 V/mm, min)	ASTM D876
3.3.17	Volume Resistivity:	10^{14} ohm-cm, min	ASTM D257

3.4 Dimensions:

3.4.1	Diametral:	In accordance with Table I	ASTM D876
3.4.2	Longitudinal Change:	-5%, +1%, max	4.4.13

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

3.6 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.

3.7 Standard Sizes and Tolerances: Unless otherwise specified, tubing shall be supplied in lengths of 48 in., +1, -0 (1219 mm, +25, -0), and in the standard sizes and tolerances shown in Table I. Tolerances apply at 23 - 30 C (73.4 - 86 F).

TABLE I

Size	Expanded (As Supplied) ID, Inches min	Recovered Dimensions (After Heating) ID, Inches max	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	0.020	0.003
1/4	0.250	0.125	0.025	0.003
3/8	0.375	0.187	0.025	0.003
1/2	0.500	0.250	0.025	0.003
3/4	0.750	0.375	0.030	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

TABLE I (SI)

Size	Expanded (As Supplied) ID, Millimeters min	Recovered Dimensions (After Heating) ID, Millimeters max	Recovered Dimensions (After Heating) Wall Thickness Millimeters	Recovered Dimensions (After Heating) Wall Thickness Tolerance 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	1.58	0.51	0.08
3/16	4.75	2.36	0.51	0.08
1/4	6.35	3.18	0.64	0.08
3/8	9.53	4.75	0.64	0.08
1/2	12.70	6.35	0.64	0.08
3/4	19.05	9.53	0.76	0.08
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. QUALITY ASSURANCE PROVISIONS:

4.1 Responsibility for Inspection: The vendor of tubing shall supply all samples and shall be responsible for performing all required tests. Results of such tests shall be reported to the purchaser as required by 4.5. Purchaser reserves the right to perform such confirmatory testing as he deems necessary to assure 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 tensile strength (3.3.1), elongation (3.3.2), secant modulus (3.3.3), heat shock (3.3.4), flammability (3.3.5), diametral change (3.4.1), and longitudinal change (3.4.2) requirements are classified as acceptance or routine control tests.

4.2.2 Qualification Tests: Tests to determine conformance to low temperature flexibility (3.3.6), heat aging (3.3.7), copper stability (3.3.8), corrosion (3.3.9), color stability (3.3.10), solvent resistance (3.3.11), fungus resistance (3.3.12), restricted shrinkage (3.3.13), specific gravity (3.3.14), water absorption (3.3.15), dielectric strength (3.3.16) and volume resistivity (3.3.17) requirements are classified as qualification or periodic control tests.

4.3 Sampling:

4.3.1 Acceptance Tests: Samples shall consist of not less than 16 ft (4.88 m) of tubing selected at random from each lot. A lot shall consist of all tubing of the same size from the same production run and offered for inspection at the same time.

4.3.2 Qualification Tests: Samples shall consist of 50 ft (15.25 m) of tubing of each size and color. Certain sizes will qualify additional sizes of the same color, as shown below:

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

4.4 Test Methods:

4.4.1 Tensile Strength and Elongation: Five specimens, each 4 in. (102 mm) long, shall be tested, using 1 in. (25 mm) bench marks and 1 in. (25 mm) 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. (6.4 mm) wide cut longitudinally from sizes 3/8 and larger. Tubular specimens shall be measured in accordance with ASTM D876. Metal plugs are not necessary when testing full sections of tubing. A specimen break at a bench mark or outside the gage length shall be cause for retest.

4.4.2 Secant Modulus: Five specimens in the expanded form (as supplied), each 12 in. (305 mm) 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. (12.7 mm) wide cut longitudinally from sizes 3/8 and larger. Metal plugs are not necessary when testing full sections of tubing. Initial strain rate shall be 0.1 in. per in. per min. (0.1 mm/mm/min.)

4.4.3 Heat Shock: Three specimens in the expanded form (as supplied), each 6 in. (152 mm) long shall be conditioned for 4 hr in a mechanical convection oven which is at 250 C ± 5 (482 F ± 9), with an air velocity of 100 - 200 ft per min. (508 - 1016 mm/s) past the specimens. After conditioning, the specimens shall be removed from the oven, cooled to room temperature, and examined visually. Tubing shall then be bent through 180 deg (3.14 rad) over a mandrel of the diameter shown in Table II. 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 II

Size	Diameter of Mandrel	
	Inch	(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)

4.4.4 Flammability: Five specimens, each 5 in. (127 mm) long, shall be marked 1 in. (25 mm) from each end with contrasting color ink. Each specimen shall be reduced by heat near one end of an 8-in. (203-mm) long mandrel of the diameter and construction shown in Table III, with the mandrel extending through both ends of the tubing. The mandrel shall be mounted at an angle of approximately 45 deg (0.785 rad) in a draft-free chamber. An 8 x 8 in. (203 x 203 mm) piece of tissue paper conforming to UU-T-450 shall be centered approximately 9-1/2 in. (241 mm) below the test specimen and at least 1/2 in. (12.7 mm) from the table top, in such a manner that any dripping particle will fall on the tissue paper. A 5-in. (127-mm) high blue flame from a standard 3/8-in. (9.5-mm) diameter Bunsen burner shall then be applied to the lowest point of each specimen. When specimen has been burned to the lower ink mark or when the flame has been applied for 60 sec, whichever is sooner, the flame shall be removed and the specimen shall remain undisturbed until burning ceases. Failure of more than one specimen to extinguish within 3 in. (76 mm), failure of more than one specimen to extinguish within 10 sec, or flaming of the tissue paper shall be cause for rejection.

TABLE III

Size	Diameter of Mandrel Inches	(Millimeters)	Construction
3/64	0.023	0.58	
1/16	0.031	0.79	
3/32	0.046	1.17	
1/8	0.062	1.58	Solid Copper
3/16	0.093	2.36	or Aluminum
1/4	0.125	3.18	
3/8	0.187	4.75	
1/2	0.250	6.35	
3/4	0.375	9.53	Copper or Aluminum
1	0.500	12.70	tube 0.025 in.
1-1/2	0.750	19.05	(0.06 mm) wall
2	1.000	25.40	Copper or Aluminum
3	1.500	38.10	tube 0.050 in.
4	2.000	50.80	(0.13 mm) wall

4.4.4.1 The intention of this flammability requirement is to cause generous combustion of the lower inch of the tubing; therefore, on sizes over 1 in. (25 mm), it will be necessary to manipulate the burner so as to totally engulf the lower end of the tubing in flame.

4.4.5 Low Temperature Flexibility: Three specimens, each 12 in. (305 mm) long (1/4-in. (6.4-mm) wide strips cut from sizes 3/4 and larger), shall be conditioned at -55 C ± 2 (-67 F ± 3.6) for 4 hours. A fixed steel mandrel, selected in accordance with Table II, 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 (6.28 rad) about the mandrel in approximately 2 seconds. The specimens shall be visually examined for cracks.

4.4.6 Heat Aging: Specimens shall be prepared as in 4.4.1 and shall be conditioned for 336 hr in a mechanical convection oven which is at 175 C ± 3 (347 F ± 5.4), with an air velocity of 100 - 200 ft per min. (508 - 1016 mm/s) past the specimens. After conditioning, the specimens shall be removed from the oven, cooled to room temperature, and tested for ultimate elongation.

4.4.7 Copper Stability: A specimen of each color of tubing, 6 in. (152 mm) long, shall be slid over a straight, clean, unplated, uninsulated, solid copper conductor. For sizes 1/4 and smaller, a single copper conductor shall be used; for sizes 3/8 and larger, several copper conductors shall be used, each conductor AWG 18 (0.0403 in.) (1.024 mm) or smaller. 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 C ± 3 (77 F ± 5.4). The specimens on horizontally suspended conductors shall then be conditioned in accordance with ASTM D573 for 168 hr in an oven which is at 160 C ± 3 (320 F ± 5.4), cooled to room temperature, and examined. The tubing shall not be brittle, glazed, cracked, severely discolored, or otherwise deteriorated by direct contact with copper. The ultimate elongation of the tubing shall not be lower than 200%. The copper shall not be pitted or blackened. Darkening of the copper due to normal air oxidation shall be disregarded.

4.4.8 Corrosion: A specimen 1 in. (25 mm) long (a 1/4-in. (6.4-mm) wide strip cut from sizes 1/4 and larger), shall be placed in the bottom of each of two clean 1/2 x 12 in. (12.7 x 305 mm) test tubes. A third tube shall be used for control. A copper-glass mirror about 1/4 in. (6.4 mm) wide x 1 in. (25 mm) long shall be suspended 6 - 7 in. (152 - 178 mm) 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% ± 5 transmission of normal incident light of 5000 Angstroms (5×10^{-10} m). 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. (51 mm) of each tube shall be placed in an oven or oil bath

at 175 C ± 3 (347 F ± 5.4) for 16 hours. After cooling, the mirrors shall be examined in a good light against a white background. The copper shall not have been removed from a mirror leaving an area of transparency greater than 5% of the total area, disregarding the bottom 1/16 in. (1.6 mm) of the mirror. Discoloration of the copper film shall not be considered corrosion.

4.4.9 Color Stability: Three specimens, in the expanded form (as supplied), each 4 in. (102 mm) long, of each color shall be conditioned for 48 hr in a mechanical convection oven which is at 175 C ± 3 (347 F ± 5.4), with an air velocity of 100 - 200 ft per min. (508 - 1016 mm/s) past the specimens. After conditioning, the specimens shall be removed from the oven, cooled to room temperature, and compared to the limits of MIL-STD-104, Class 1.

4.4.10 Solvent Resistance: Tubing shall be immersed for 24 hr ± 2 at 23 C ± 3 (73.4 F ± 5.4) in JP-4 Fuel (MIL-T-5624), SAE Phosphate ester fluid No. 1, hydraulic oil (MIL-H-5606), ASTM Fuel B (ASTM D471), and water. Six specimens (a total of 30), each 6 in. (152 mm) long, shall be immersed in each of the fluids. The volume of fluid shall be not less than 20 times that of the specimens. After immersion, the specimens shall be lightly wiped and air dried for 30 - 60 min. at room temperature. After drying, three of each group of six specimens shall be tested for tensile strength; the other three shall have inner electrodes inserted as specified in ASTM D876 and shall be tested for dielectric strength.

4.4.11 Fungus Resistance: Fungus resistance shall be determined in accordance with ASTM G21 except that the incubation period shall be 28 days and the test organisms shall be Aspergillus niger, Aspergillus flavus, Penicilliumfuniculosum and Trichoderma sp. Three specimens, each 3 in. (76 mm) long, shall be used for each organism.

4.4.12 Restricted Shrinkage: 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 shall then be conditioned for 30 min. in an oven which is at 175 C ± 5 (347 F ± 9), in accordance with ASTM D573. When cooled to room temperature, the tubing shall be examined visually and shall then 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 shall then be applied in accordance with the short-time test of ASTM D149 using a 500 V per sec rate of rise. The specimen shall withstand 2000 v for 1 minute.

4.4.13 Dimensions and Longitudinal Change: Three specimens in the expanded form (as supplied), each 6 in. (152 mm) long, shall be measured for length and inside diameter. The specimens shall be conditioned for 3 min. in a mechanical convection oven which is at 200 C ± 5 (392 F ± 9), with an air velocity of 100 - 200 ft per min. (508 - 1016 mm/s) past the specimens. After conditioning, the specimens shall be removed from the oven, cooled to room temperature, and remeasured. Longer heating at such temperature shall cause no additional shrinkage. Measurements shall be made in accordance with ASTM D876.

Longitudinal change shall be computed as follows:

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

4.5 Reports:

4.5.1 The vendor of the product shall furnish with each shipment three copies of a report showing the results of tests made on the lot to determine conformance to the acceptance test requirements of this specification and a statement that the product conforms to all other technical requirements. This report shall include the purchase order number, material specification number and its revision letter, vendor's compound number, lot number, size, color, and quantity.

4.5.2 The vendor of finished or semi-finished parts shall furnish with each shipment three copies of a report showing the purchase order number, material specification number and its revision letter, contractor or other direct supplier of material, supplier's compound number, part number, and quantity. When material for making parts is produced or purchased by the parts vendor, that vendor shall inspect each lot of material to determine conformance to the requirements of this specification, and shall include in the report a statement that the material conforms, or shall include copies of laboratory reports showing the results of tests to determine conformance.

4.6 Resampling and Retesting: If any specimen used in the above tests fails to meet the specified requirements, disposition of the tubing may be based on the results of testing three additional specimens for each original nonconforming specimen. Failure of any retest specimen to meet the specified requirements 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 AMS 3636D, size, color, 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 product, during shipment and storage, will not be permanently distorted and will be protected against damage from exposure to weather and any normal hazard. Standard packages shall contain the following quantities:

Size	
3/64, 1/16, 3/32, 1/8, 3/16, 1/4, 3/8	1000 ft (305 m)
1/2	800 ft (244 m)
3/4	500 ft (152.5 m)
1	300 ft (91.5 m)
2, 3, 4	100 ft (30.5 m)

5.2.2 The product shall be prepared for shipment in accordance with commercial practice to assure carrier acceptance and safe transportation to the point of delivery. Packaging shall conform to carrier rules and regulations applicable to the mode of transportation.

6. ACKNOWLEDGMENT: A vendor shall mention this specification number and its revision letter in all quotations and when acknowledging purchase orders.

7. REJECTIONS: Material not conforming to this specification or to authorized modifications will be subject to rejection.

8. NOTES:

8.1 Definition of "Capability": The words "shall be capable of" are used to indicate characteristics or properties required in the product but for which testing of each lot is not required. However, if such testing is performed, material not conforming to the requirements may be rejected.

8.2 Marginal Indicia: The phi (Ø) symbol is used to denote technical changes from the previous issue of this specification.