Society of Automotive Engineers, Inc.
400 COMMONWEALTH DRIVE, WARRENDALE, PA. 15096

AEROSPACE MATERIAL SPECIFICATION

AMS 3637C
Superseding AMS 3637B
Issued 2-15-65
Revised 6-15-75

PLASTIC TUBING, ELECTRICAL INSULATION
Irradiated Polyolefin, Clear, 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 flexible, thin-wall, heat-shrinkable tubing.

1.2 Application: Primarily for use 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

1.2.1 For flame-retardant, opaque material, refer to AMS 3636.

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., 400 Commonwealth Drive, Warrendale, Pennsylvania 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, 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.

Printed in U.S.A.

2.3.1 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

3. TECHNICAL REQUIREMENTS:

3.1 Composition: The material shall be an irriadiated, thermally-stabilized, modified-polyolefin plastic.

3.2 Appearance: A colorless transparent tubing shall be supplied, unless otherwise specified. Tubing shall be sufficiently transparent to allow relatively undistorted visibility through one wall thickness. Typewritten ø 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.

3.3 Properties: The product shall conform to the following requirements; tests shall be conducted in accordance with the specified methods insofar as practicable. Unless otherwise specified, tubing shall be tested ø after being shrunk by heating for not less than 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 not less than 4 hr at 23°C ± 2 (73.4°F ± 3.6) and 45 - 55% relative humidity.

3.3.1 Tensile Strength, min	1500 psi (10.3 MPa)	ASTM D638, Speed D (See 4.5.1)
3.3.2 Elongation, min	200%	ASTM D638, Speed D (See 4.5.1)
3.3.3 Secant Modulus at 2% Strain, max	25,000 psi (172 MPa)	ASTM D882 (See 4.5.2)
3.3.4 Heat Shock	No dripping, flowing, or cracking	4.5.3
3.3.5 Low-Temperature Flexibility	No cracks	4.5.4
3.3.6 Heat Aging		4.5.5
3.3.6.1 Elongation, min	150%	
3.3.7 Copper Stability	Pass	4.5.6
3.3.7.1 Elongation, min	200%	
3.3.8 Corrosion	Pass	4.5.7
3.3.9 Solvent Resistance		4.5.8
3.3.9.1 Tensile Strength, min	1000 psi (6.90 MPa)	
3.3.9.2 Dielectric Strength, min	400 V/mil (15,750 V/mm)	

Ø 3.3.10 Fungus Resistance	Rating of 1 or less	4.5.9
3.3.11 Restricted Shrinkage, Withstand 2000 V for 1 min.	No cracks	4.5.10
3.3.12 Specific Gravity, max	1.00	ASTM D792, Method A
3.3.13 Water Absorption in 24 hr, max	0.20%	ASTM D570
3.3.14 Dielectric Strength, min (Short Time Test)	500 V/mil (19,680 V/mm)	ASTM D876
3.3.15 Volume Resistivity, min	10^{16} ohm-cm	ASTM D257
3.3.16 Dimensional Change on Heating		ASTM D876 (See 4.5.11)
3.3.16.1 Diametral	In accordance with Table I	
3.3.16.2 Longitudinal, max	-5%, +1%	

3.4 Marking: Prior to and after shrinkage, tubing shall be suitable for having numbers or characters printed on it with conventional tubing marking techniques.

3.5 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.

3.6 Standard Sizes and Tolerances: Unless otherwise specified, tubing shall be supplied in lengths of 48 in., Ø +1, -0 (1219 mm, +25, -0), and in the standard sizes and to the tolerances shown in Table 1. Tolerances apply at 23° - 30° C (73.4° - 86° F). Measurements shall be made in accordance with ASTM D876.

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, Millimetres min	Recovered Dimensions (After Heating) ID, Millimetres max	Recovered Dimensions (After Heating) Wall Thickness Millimetres	Recovered Dimensions (After Heating) Wall Thickness Tolerance Millimetre 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	0.51	0.08
1/4	6.35	3.18	0.64	0.08
3/8	9.52	4.75	0.64	0.08
1/2	12.70	6.35	0.64	0.08
3/4	19.05	9.52	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 reponsible 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 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), dimensional change on heating (3.3.16), and size and tolerance (3.6) requirements are classified as acceptance or routine control tests.

4.2.2 Qualification Tests: Tests to determine conformance to low temperature flexibility (3.3.5), heat aging (3.3.6), copper stability (3.3.7), corrosion (3.3.8), solvent resistance (3.3.9), fungus resistance (3.3.10), restricted shrinkage (3.3.11), specific gravity (3.3.12), water absorption (3.3.13), dielectric strength (3.3.14), and volume resistivity (3.3.15) requirements are classified as qualification or periodic control tests.

4.3 Sampling: Shall be in accordance with the following; a lot shall be all tubing of the same size from the same production run offered for inspection at the same time.

4.3.1 Acceptance Tests: Not less than 16 ft (4.88 m) of tubing from each lot.

4.3.2 Qualification Tests: Not less than 50 ft (15.25 m) of tubing of each size or size range. Certain sizes will qualify additional sizes, 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 Approval:

4.4.1 Sample tubing shall be approved by purchaser before tubing for production use is supplied, unless such approval be waived. Results of tests on production tubing shall be essentially equivalent to those on the approved sample.

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 any change is necessary 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 and processing and, when requested, sample revised tubing. No tubing made by the revised procedure shall be shipped prior to receipt of reapproval.

4.5 Test Methods:

4.5.1 Tensile Strength and Elongation: Five specimens, each approximately 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 but such breaks shall not be considered failure to meet requirements in determining the need for retesting as in 4.7.

4.5.2 Secant Modulus: Five specimens in the expanded form (as supplied) each approximately 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.).

4.5.3 Heat Shock: Three specimens in the expanded form (as supplied), each approximately 6 in. (152 mm) long, shall be conditioned for 4 hr ± 0.2 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	(Millimetres)
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)

4.5.4 Low-Temperature Flexibility: Three specimens, each approximately 12 in. (305 mm) long shall be conditioned at -55°C ± 2 (-67°F ± 3.6) for 4 hr ± 0.2. The specimens shall be full sections of tubing for sizes smaller than 3/4. For sizes 3/4 and larger, strips approximately 1/4 in. (6.4 mm) in width shall be cut from the tubing. A fixed steel mandrel, selected in accordance with Table II, shall be conditioned at -55°C ± 2 (-67F ± 3.6). 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 free from cracks except that any side cracking caused by flattening of the specimen on the mandrel shall be disregarded.

4.5.5 Heat Aging: Three specimens shall be prepared as in 4.5.1 and shall be conditioned for 336 hr ± 2 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 elongation in accordance with ASTM D638.

4.5.6 Copper Stability: A specimen of tubing, approximately 6 in. (152 mm) long, shall be slid over a straight, clean, unplated, uninsulated, solid, copper conductor. For size 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 being 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 ± 2 in an oven which is at 160°C ± 3 (320°F ± 5.4), cooled to room temperature, visually examined, and tested for elongation in accordance with ASTM D638. The tubing shall not be brittle, glazed, cracked, severely discolored, or otherwise deteriorated by direct contact with copper. The copper shall not be pitted or blackened. Darkening of the copper due to normal air oxidation shall be disregarded.

4.5.7 Corrosion: A specimen, approximately 1 in. (25 mm) long, shall be placed in the bottom of each of two clean 1/2 x 12 in. (12.7 x 305 mm) test tubes. The specimens shall be full sections of tubing for sizes smaller than 1/4. For sizes 1/4 and larger, strips approximately 1/4 in. (6.4 mm) in width shall be cut from the tubing. 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. 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 hr ± 0.5. 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.

4.5.8 Solvent Resistance: Tubing shall be immersed for 24 hr ± 2 at 23°C ± 3 (73.4°F ± 5.4) in MIL-T-5624, JP-4 fuel SAE phosphate ester test fluid No. 1A (See 8.2), MIL-H-5606, hydraulic oil ASTM Fuel B as in ASTM D471, and water. Six specimens (a total of 30), each approximately 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 in accordance with ASTM D638 for tensile strength; the other three shall have inner electrodes inserted as specified in ASTM D876 and shall be tested in accordance with ASTM D149 for dielectric strength.

4.5.9 Fungus Resistance: Shall be determined in accordance with ASTM G21 except that the incubation period shall be 28 days ± 0.5 and the test organisms shall be Aspergillus niger, Aspergillus flavus, Penicillium funicolosum, and Trichoderma sp. Three specimens, each approximately 3 in. (76 mm) long, shall be used for each organism.

4.5.10 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 not less than 30 min. in an oven which is at 175°C ± 5 (347°F ± 9), in accordance with ASTM D573, and cooled to room temperature. The tubing shall be examined visually and then 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.

4.5.11 Dimensional Change: Three specimens in the expanded form (as supplied), each approximately 6 in. (152 mm) long, shall be measured for length and inside diameter. The specimens shall be conditioned for 3 min. ± 0.2 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. Prior to and after conditioning, the dimensions of the tubing shall be in accordance with Table I. Measurements shall be made in accordance with ASTM D876. Longitudinal change shall be computed as follows:

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

4.6 Reports:

4.6.1 The vendor of tubing 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 Ø and a statement that the tubing conforms to the 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, and quantity.

4.6.2 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 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 a statement that the tubing conforms, or shall include copies of laboratory reports showing the results of tests to determine conformance.

4.7 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 Ø 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 3637C, 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 Ø storage, will not be permanently distorted and will be protected against damage from exposure to weather or any normal hazard. Standard packages shall each contain the following quantities:

Size	Quantity
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)