AEROSPACE
MATERIAL SPECIFICATIONS

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

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

2. FORM: Thin wall flexible tubing.

3. 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

4. COMPOSITION: The material shall be an irradiated, thermally stabilized, non-flame-resistant, modified polyolefin.

5. TECHNICAL REQUIREMENTS:

5.1 Appearance: Unless otherwise specified, a colorless transparent tubing shall be furnished. Tubing shall be sufficiently transparent to allow relatively undistorted visibility through two thicknesses produced by pressing the tubing flat upon itself. Typewritten letters shall be legible when viewed through these two thicknesses pressed onto the paper. Transparency shall apply to tubing in the expanded form (as supplied) and after tubing has been shrunk as specified in 5.2.

5.2 Properties: The product shall conform to the requirements of 5.2.1 through 5.2.4 and shall be capable of meeting the requirements of 5.2.5 through 5.2.13. Tests shall be performed in accordance with the issue of specified ASTM methods listed in the latest issue of AMS 2350, insofar as practicable. Unless otherwise specified, tubing shall be tested 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 past the tubing, removed from the oven, and cooled to room temperature.

5.2.1	Tensile Strength, psi, min	1500	ASTM D638, Speed D (See Note 1)
5.2.2	Elongation, %, min	200	ASTM D638, Speed D (See Note 1)
5.2.3	Secant Modulus at 2% Strain, psi, max	2.5×10^4	ASTM D882 (See Note 2)
5.2.4	Heat Shock	Pass	Note 3
5.2.5	Low Temperature Flexibility	Pass	Note 4
5.2.6	Heat Aging	Pass	Note 5
5.2.7	Corrosion	Pass	Notes 6 and 7

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5.2.8	Solvent Resistance	Pass	Note 8
5.2.9	Fungus Resistance	Pass	Note 9
5.2.10	Specific Gravity, max	1.00	ASTM D792, Method A
5.2.11	Water Absorption in 24 hr, %, max	0.20	ASTM D570
5.2.12	Dielectric Strength, short time test, v per mil, min	500	ASTM D876
5.2.13	Volume Resistivity, ohm-cm, min	10^{16}	ASTM D257

Note 1. Five specimens, each 4 in. long, shall be tested, using 1 in. bench marks and 1 in. 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. wide, cut longitudinally from sizes 3/8 and larger. No metal plugs are necessary when testing full sections of tubing. A specimen break at a bench mark or outside the gage length shall be cause for retest.

Note 2. Five specimens in the expanded form (as supplied), each 12 in. 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. wide, cut longitudinally from sizes 3/8 and larger. No metal plugs are necessary when testing full sections of tubing. Initial strain rate shall be 0.1 in. per in. per minute.

Note 3. Three specimens in the expanded form (as supplied), each 6 in. in length, 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. past the specimens. After conditioning, the specimens shall be removed from the oven, cooled to room temperature, and visually examined. Tubing shall not drip, flow, or crack. Also, tubing shall be bent through 180 deg over a steel mandrel of the diameter shown in Table I. 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 I

Size	Diameter of Mandrel, Inch
3/64 to 1/4, incl	5/16
3/8 to 1/2, incl	3/8
3/4 to 2, incl	7/16
3 to 4, incl	7/8

Note 4. Three specimens, each 6 in. in length (x 1/4 in. 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 I above, 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 about the mandrel in approximately 2 seconds. The specimens shall be free from cracks.

Note 5. Specimens shall be prepared as in Note 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. past the specimens. After conditioning, the specimens shall be removed from the oven, cooled to room temperature, and tested for elongation. Specimens shall have elongation of not less than 150%.

Note 6. A specimen 1 in. in length (a 1/4 in. wide strip cut from sizes 1 and larger), shall be placed in the bottom of each of two clean 1/2 in. x 12 in. test tubes. A third test tube shall be used for control. A copper-glass mirror about 1/4 in. wide x 1 in. long shall be suspended 6 - 7 in. 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. 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 be removed from a mirror leaving an area of transparency greater than 5% of the total area. Discoloration of the copper film shall not be considered corrosion.

Note 7. Three specimens of tubing, each 6 in. in length, shall be slid over straight, clean, bare, solid copper conductors. 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 or smaller. The specimens on the conductors shall be conditioned for 16 hr in a 175 C ± 3 (347 F ± 5.4) oven in accordance with ASTM D573. When cooled to room temperature, the tubing shall be removed and the copper shall be examined. The copper shall not be pitted or blackened. Darkening of the copper due to normal air oxidation shall be disregarded.

Note 8. Tubing shall have tensile strength not lower than 1000 psi and dielectric strength not lower than 400 v per mil after being immersed for 24 hr ± 2 at 23 C ± 3 (73.4 F ± 5.4) in JP-4 Fuel, SAE phosphate ester test fluid No. 1, hydraulic oil, aviation gasoline 100/130, and water. Six specimens (a total of 30), each 6 in. in length, shall be immersed in each of the fluids. The volume of the fluid shall be not less than 20 times that of the specimens. After immersion, the specimens shall be lightly wiped, air dried for 30 - 60 min. at room temperature, and subjected to the tensile strength and dielectric strength tests; three of the six specimens shall be tested for tensile strength and the other three for dielectric strength.

Note 9. Fungus resistance shall be determined in accordance with ASTM D1924, except that the incubation period shall be 28 days and the test organisms shall be Aspergillus niger, Aspergillus flavus, Penicillium luteum, and Trichoderma T-1. At the end of the incubation period, not more than traces of growth on the specimens are permissible. Three specimens, each 3 in. long, shall be used for each organism.

5.3 Dimensions After Shrinkage:

5.3.1 Diametral: Three specimens in the expanded form (as supplied), each 6 in. in length, 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. past the specimens. After conditioning, the specimens shall be removed from the oven, cooled to room temperature, and then 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 II. Measurements shall be made in accordance with ASTM D876.

5.3.2 Longitudinal: In reaching its recovered dimensions, the tubing shall not exhibit a longitudinal change greater than +1%, -5%, computed as follows:

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

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

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.

7. STANDARD SIZES AND TOLERANCES: Unless otherwise specified, tubing shall be supplied in lengths of 48 in., + 1, - 0. The sizes shown in Table II are standard and the tolerances apply between 23 - 30 C (73.4 - 86 F).

TABLE II

Expanded (As Supplied)		Recovered Dimensions (After Heating)		
Size	ID, Inches min	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

8. REPORTS:

8.1 Unless otherwise specified, the vendor of the product shall furnish with each shipment three copies of a report stating that the product conforms to the requirements of this specification. This report shall include the purchase order number, material specification number, vendor's compound number, size, and quantity.

8.2 Unless otherwise specified, 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, 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.

9. PACKAGING:

9.1 Packaging shall be accomplished in such a manner as to ensure that the product, during shipment and storage, will not be permanently distorted and will be protected against damage from exposure to weather or any normal hazard. Unless otherwise specified, standard packages shall contain the following quantities:

Size	Quantity, ft
3/64, 1/16, 3/32, 1/8, 3/16	200
1/4, 3/8, 1/2, 3/4	100
1, 1-1/2	48
2, 3, 4	24