

PLASTIC TUBING, ELECTRICAL INSULATION
Non-Crosslinked Polyvinyl Chloride, Flexible, Heat Shrinkable
1.6 to 1 Shrink Ratio

1. SCOPE:

- 1.1 Form: This specification covers a non-crosslinked polyvinyl chloride plastic in the form of flexible, thin-wall, heat-shrinkable tubing with a low recovery temperature.
- 1.2 Application: Primarily for use as a flexible, electrical insulation tubing whose diameter can be reduced to a predetermined size by heating to 150°C (300°F) or higher. This tubing is stable for continuous exposure from -20°C to +105°C (-5° to +220°F).

2. APPLICABLE DOCUMENTS: The following publications form a part of this specification to the extent specified herein. The latest issue of Aerospace Material Specifications 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

- 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.

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2.3.1 Federal Specifications:

UU-T-450 - Tissue, Facial

2.3.2 Military Specifications:

MIL-H-5606 - Hydraulic Fluid, Petroleum Base, Aircraft, Missile and Ordnance

MIL-H-5624 - Turbine Fuel, Aviation, Grades JP-4 and JP-5

MIL-A-8243 - Anti-Icing and Deicing-Defrosting Fluid

2.3.3 Military Standards:

MIL-STD-794 - Parts and Equipment, Procedures for Packaging and Packing of

3. TECHNICAL REQUIREMENTS:

3.1 Material: Shall be a non-crosslinked, thermally-stabilized, flame-resistant, modified polyvinyl chloride.

3.2 Color: Shall be black.

3.3 Properties: Tubing shall conform to the following requirements; reported values shall be the average of all specimens tested for each requirement. 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 $150^{\circ}\text{C} + 5$ ($300^{\circ}\text{F} + 10$) 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 $23^{\circ}\text{C} \pm 2$ ($73^{\circ}\text{F} \pm 4$) and 45 - 55% relative humidity:

3.3.1.1 Tensile Strength, min	2000 psi
Jaw separation rate 20 in. per min. (8.5 mm/sec)	(14 MPa)

3.3.1.2 Elongation, min	200%
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3.3.1.3 Secant Modulus at 2% Strain, max	15,000 psi (105 MPa)
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3.3.1.4 Dielectric Strength, min	In accordance with Table I	4.5.1
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TABLE I

Nominal Wall Thickness Inch	Dielectric Strength V per mil
Up to 0.013, incl	1150
Over 0.013 to 0.016, incl	800
Over 0.016 to 0.024, incl	700
Over 0.024 to 0.029, incl	630
Over 0.029 to 0.034, incl	570
Over 0.034 to 0.039, incl	520
Over 0.039	As agreed upon

TABLE I (SI)

Nominal Wall Thickness Millimetres	Dielectric Strength V/mm
Up to 0.32, incl	45,280
Over 0.32 to 0.40, incl	31,500
Over 0.40 to 0.60, incl	27,560
Over 0.60 to 0.72, incl	24,800
Over 0.72 to 0.85, incl	22,440
Over 0.85 to 0.98, incl	20,470
Over 0.98	As agreed upon

3.3.1.5	Volume Resistivity, min	10^{11} ohm-cm	
3.3.1.6	Flammability (Burning Time), max	15 sec	4.5.2
3.3.1.7	Fungus Resistance	Rating of 1 or less	ASTM G21
3.3.1.8	Low-Temperature Flexibility at $-10^{\circ}\text{C} \pm 1$ ($15^{\circ}\text{F} \pm 2$)	No Cracking	
3.3.1.9	Heat Aging, 400 hr ± 2 at $130^{\circ}\text{C} \pm 2$ ($265^{\circ}\text{F} \pm 4$)		
3.3.1.9.1	Elongation, min	150%	
3.3.1.10	Corrosion, Method B, 168 hr ± 2 at $135^{\circ}\text{C} \pm 2$ ($275^{\circ}\text{F} \pm 4$)	Pass	
3.3.1.11	Solvent Resistance		4.5.3

3.3.1.11.1	Tensile Strength, min	1800 psi (12.5 MPa)
3.3.1.11.2	Dielectric Strength, min	70% of original value (Table I)
3.3.1.12	Dimensional Change on Heating	
3.3.1.12.1	Diametral	In accordance with Table II
3.3.1.12.2	Longitudinal, max	+1%, -25%

TABLE II

Size	Recovered Dimensions (After Heating)			
	Expanded (As Supplied) ID, Inches min	ID, Inches max	Nominal Wall Thickness Inch	Wall Thickness Tolerance Inch plus and minus
1/16	0.063	0.037	0.014	0.003
3/32	0.093	0.055	0.014	0.003
1/8	0.125	0.075	0.014	0.003
3/16	0.187	0.110	0.018	0.003
1/4	0.250	0.150	0.022	0.004
3/8	0.375	0.225	0.022	0.004
1/2	0.500	0.300	0.022	0.004
3/4	0.750	0.450	0.022	0.004
1	1.000	0.600	0.022	0.004
1-3/8	1.375	0.825	0.034	0.005
1-1/2	1.500	0.900	0.034	0.005
1-3/4	1.750	1.050	0.034	0.005
2	2.000	1.200	0.034	0.005
2-1/2	2.500	1.500	0.034	0.005
3	3.000	1.800	0.034	0.005
3-1/2	3.500	2.100	0.034	0.005
4	4.000	2.400	0.034	0.005
5	5.000	3.000	0.034	0.005
6	6.000	3.600	0.034	0.005

TABLE II (SI)

Size	Expanded (As Supplied) ID, Millimetres min	Recovered Dimensions (After Heating)		
		ID, Millimetres max	Nominal Wall Thickness Millimetres	Wall Thickness Tolerance Millimetre plus and minus
1/16	1.60	0.94	0.35	0.08
3/32	2.36	1.40	0.35	0.08
1/8	3.18	1.90	0.35	0.08
3/16	4.75	2.79	0.45	0.08
1/4	6.35	3.81	0.55	0.10
3/8	9.52	5.72	0.55	0.10
1/2	12.70	7.62	0.55	0.10
3/4	19.05	11.43	0.55	0.10
1	25.40	15.24	0.55	0.10
1-3/8	34.92	20.96	0.85	0.13
1-1/2	38.10	22.86	0.85	0.13
1-3/4	44.45	26.67	0.85	0.13
2	50.80	30.48	0.85	0.13
2-1/2	63.50	38.10	0.85	0.13
3	76.20	45.72	0.85	0.13
3-1/2	88.90	53.34	0.85	0.13
4	101.60	60.96	0.85	0.13
5	127.00	76.20	0.85	0.13
6	152.40	91.44	0.85	0.13

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

3.3.2.1 Heat Shock at $180^{\circ}\text{C} \pm 5$
($355^{\circ}\text{F} \pm 10$)

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, Procedure C
After 30 min. ± 1 at $135^{\circ}\text{C} \pm 2$
($275^{\circ}\text{F} \pm 4$)

No cracks;
withstand 2000 V
for 1 min.

3.3.2.3 Specific Gravity, max

1.40

3.3.2.4 Water Absorption, max
24 hr ± 0.25 at $25^{\circ}\text{C} \pm 2$ ($77^{\circ}\text{F} \pm 4$)

1.00%

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, clean, 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 shown in 5.2.1, and in the standard sizes and to the tolerances shown in Table II. Tolerances apply at 23° - 30°C (73° - 86°F). Measurements shall be made in accordance with ASTM D2671.

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), secant modulus (3.3.1.3), flammability (3.3.1.6), dimensional change on heating (3.3.1.12), heat shock (3.3.2.1), 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 (3.3.1.4), volume resistivity (3.3.1.5), fungus resistance (3.3.1.7), low-temperature flexibility (3.3.1.8), heat aging (3.3.1.9), corrosion (3.3.1.10), solvent 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 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, 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, contracting officer, or request for procurement.

4.3 Sampling: Shall be in accordance with ASTM D2671 and the following; a lot shall be all tubing of the same size from the same production run presented for vendor's inspection at one time. 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 Acceptance Tests: Not less than 16 ft (5 m) of tubing from each lot.

4.3.2 Periodic Tests: Not less than 50 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	Ranges of Sizes
1/4	3/64 - 1/4, incl
1	3/8 - 1, incl
4	1-1/2 - 4, incl

4.3.3 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.

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, 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 Dielectric Strength: Shall be determined by dividing the dielectric breakdown voltage, determined in accordance with ASTM D2671, by the wall thickness measured at the point of electrical rupture.

4.5.2 Flammability: Shall be determined in accordance with ASTM D2671, except that the bare steel wire used for support of the specimens during the test shall be 0.020 in. (0.50 mm) in diameter for size 1/16. An 8-in. (200-mm) square piece of tissue paper conforming to UU-T-450 shall be suspended taut and centered 9-1/2 in. (240 mm) below the test specimen, not less than 1/2 in. (12 mm) from the table top, in such a manner that any dripping particles will fall on the tissue paper. The specimen shall neither flow nor drop flaming or glowing particles which will ignite the tissue paper. Flaming of the tissue paper is not acceptable.

4.5.3 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, MIL-H-5606 hydraulic oil, ASTM Reference Fuel B (See ASTM D471), salt water (5% salt), and MIL-A-8243 anti-icing fluid.