

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, thinwall, heat-shrinkable tubing with a low recovery temperature.

1.2 Application:

These products have been used typically as a flexible, electrical insulation tubing whose diameter can be reduced to a predetermined size by heating to 150 °C (302 °F) or higher, but usage is not limited to such applications. This tubing is stable for continuous exposure from -20 to +105 °C (- 4 to +221 °F).

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 applicable issue of referenced publication shall be the issue in effect on the date of the purchase order.

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2.1 ASTM Publications:

Available from, ASTM, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959 or www.astm.org.

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

2.2 U. S. Government Publications:

Available from DODSSP, Subscription Services Desk, Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.

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

2.3 ANSI Publications:

Available from American National Standards Institute, Inc., 25 West 43rd Street, New York, NY 10036-8002.

ANSI/UL 224-VW-1	UL Standard for Safety Extruded Insulative Tubing
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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 D 2671 insofar as practicable.

- 3.3.1 Recovered Tubing: The requirements shown in Table 1 apply to tubing after being shrunk by heating to $150\text{ }^{\circ}\text{C} \pm 5$ ($302\text{ }^{\circ}\text{F} \pm 10$) in a convection-current air oven with an air velocity of 100 to 200 feet per minute (0.5 to 1.0 m/sec) 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 $23\text{ }^{\circ}\text{C} \pm 2$ ($73\text{ }^{\circ}\text{F} \pm 4$) and 45 to 55% relative humidity:

TABLE 1 - Properties After Being Heat Shrunk

	Property	Requirement	Test Method
3.3.1.1	Tensile Strength, min Jaw separation rate 20 inches per minute (8.5 mm/s)	2000 psi (14 MPa)	ASTM D 2671
3.3.1.2	Elongation, min	200%	ASTM D 2671
3.3.1.3	Secant Modulus at 2% Strain, max	15,000 psi (103 MPa)	ASTM D 2671
3.3.1.4	Dielectric Strength, min	In accordance with Table 2	4.5.1
3.3.1.5	Volume Resistivity, min	1011 ohm-cm	ASTM D 2671
3.3.1.6	Flammability (Burning Time), max	15 seconds	4.5.2
3.3.1.6.1	Flammability, (UL Subject 224), min	Pass VW-1 rating	ANSI/UL 224-VW-1
3.3.1.7	Fungus Resistance	Rating of 1 or less	ASTM G 21
3.3.1.8	Low-Temperature Flexibility at -10 °C ± 1 (14 °F ± 2)	No Cracking	ASTM D 2671
3.3.1.9	Heat Aging, 400 hours ± 2 at 130 °C ± 2 (266 °F ± 4)		ASTM D 2671
3.3.1.9.1	Elongation, min	150%	ASTM D 2671
3.3.1.10	Corrosion, 168 hours ± 2 at 135 °C ± 2 (275 °F ± 4)	Pass	ASTM D 2671 Method B
3.3.1.11	Solvent Resistance		4.5.3
3.3.1.11.1	Tensile Strength, min	1800 psi (12.4 MPa)	
3.3.1.11.2	Dielectric Strength, min	70% of value determined in 3.3.1.4	
3.3.1.12	Dimensional Change on Heating		ASTM D 2671
3.3.1.12.1	Diametral	In accordance with Table 3	
3.3.1.12.2	Longitudinal, max	+1%, -25%	

TABLE 2A - Dielectric Strength, Inch/pound Units

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	Acceptable to purchaser

TABLE 2B - Dielectric Strength, SI Units

Nominal Wall Thickness Millimeters	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	Acceptable to purchaser

TABLE 3A - Dimensional Change on Heating, Inch/Pound Units

Tubing Size	Expanded (As Supplied) ID, Inches min	Recovered Dimensions (After Heating) ID, Inches max	Recovered Dimensions (After Heating) Nominal Wall Thickness Inch	Recovered Dimensions (After Heating) Wall Thickness Tolerance Inch Plus and Minus
1/16	0.063	0.037	0.014	0.003
3/32	0.094	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 3B - Dimensional Change on Heating, SI Units

Size	Expanded (As Supplied) ID, Millimeters min	Recovered Dimensions (After Heating) ID, Millimeters max	Recovered Dimensions (After Heating) Nominal Wall Thickness Millimeters	Recovered Dimensions (After Heating) Wall Thickness Tolerance Millimeters Plus and Minus
1/16	1.59	0.94	0.35	0.08
3/32	2.38	1.40	0.35	0.08
1/8	3.18	1.90	0.35	0.08
3/16	4.76	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: Requirements shown in Table 4 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 in accordance with 3.3.1.

TABLE 4 - Properties in the Expanded (As-Received) Condition

	Property	Requirement	Test Method
3.3.2.1	Heat Shock at 180 °C ± 5 (356 °F ± 10)	No dripping, flowing, or cracking	ASTM D 2671
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 135 °C ± 2 (275 °F ± 4)	No cracks; withstand 2000 V for 1 minute	ASTM D 2671 (Procedure C)
3.3.2.3	Specific Gravity, max	1.40	ASTM D 2671
3.3.2.4	Water Absorption, max 24 hours ± 0.25 at 25 °C ± 2 (77 °F ± 4)	1.00%	ASTM D 2671

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 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:

The manufacturer of tubing shall supply all samples and shall be responsible for 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.

4.2 Classification of Tests:

- 4.2.1 Acceptance Tests: 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: 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 periodic tests and shall be performed at a frequency selected by the manufacturer unless frequency of testing is specified by purchaser.
- 4.2.3 Preproduction Tests: All technical requirements of this specification are preproduction tests and shall be performed prior to or on the initial shipment of tubing by the manufacturer, 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 and Testing:

Shall be in accordance with ASTM D 2671.

- 4.3.1 A lot shall be all tubing of the same size from the same production run presented for manufacturer'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.
- 4.3.1.1 Acceptance Tests: Not less than 16 feet (15 m) of tubing from each lot.
- 4.3.1.2 Periodic Tests: Not less than 50 feet (115 m) of tubing of each size or size range. Certain representative sizes may be used to demonstrate conformance of a range of sizes in accordance with Table 5.

TABLE 5 - Representative Sizes

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

- 4.3.1.3 A statistical sampling plan, acceptable to purchaser, may be used in lieu of sampling as in 4.3.1.
- 4.3.1.4 Preproduction Tests: Acceptable to purchaser.