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**PLASTIC TUBING, ELECTRICAL INSULATION  
Irradiated Polyolefin, Pigmented, Very Flexible, Heat-Shrinkable  
Low Recovery Temperature  
2 to 1 Shrink Ratio**

**1. SCOPE:**

**1.1 Form**

This specification covers an irradiated, thermally-stabilized, modified polyolefin plastic in the form of a thin-wall, heat-shrinkable tubing with a low recovery temperature.

**1.2 Application:**

This tubing has been used typically as a very flexible, electrical insulation tubing whose diameter can be reduced to a predetermined size by heating to 100 °C (212°F) or higher, but usage is not limited to such applications. This tubing is stable for continuous exposure from -55 to +135 °C (-67 to +275 °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 publications shall be the issue in effect on the date of the purchase order.

SAE Technical Standards Board Rules provide that: "This report is published by SAE to advance the state of technical and engineering sciences. The use of this report is entirely voluntary, and its applicability and suitability for any particular use, including any patent infringement arising therefrom, is the sole responsibility of the user."

SAE reviews each technical report at least every five years at which time it may be reaffirmed.

## 2.1 ASTM Publications:

Available from ASTM 1916 Race Street, Philadelphia, PA 19103-1187.

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

## 2.2 U.S. Government Publications:

Available from Standardization Documents Order Desk, Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.

UU-T-450 Tissue, Facial  
 ML-H-5606 Hydraulic Fluid, Petroleum Base, Aircraft, Missile, and Ordnance  
 ML-T-5624 Turbine Fuel, Aviation, Grades JP-4 and JP-5  
 ML-STD-104 Limit for Electrical Insulation Color  
 ML-STD-2073-1 DOD Materiel, Procedures for Development and Application of Packaging Requirements

## 3. TECHNICAL REQUIREMENTS:

### 3.1 Material:

Shall be an irradiated, thermally-stabilized, flame-resistant, modified polyolefin plastic.

### 3.2 Color:

Shall be black, white, red, yellow, or blue, as ordered. Colors shall be in accordance with ML-STD-104.

### 3.3 Properties:

Tubing shall conform to the following requirements; reported values shall be the average of all specimens tested for each requirement. Except as otherwise specified herein, tests shall be performed in accordance with ASTM D 2671.

- 3.3.1 Recovered Tubing: The requirements shown in Table 1 apply to tubing after being shrunk by heating to  $125\text{ }^{\circ}\text{C} \pm 3$  ( $257\text{ }^{\circ}\text{F} \pm 5$ ) in a convection-current air oven with an air velocity of 100 to 200 feet/minute (0.5 to 1.0 m/second) 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 - Recovered Tubing Properties

Paragraph	Property	Requirement	Test Method
3.3.1.1	Tensile Strength, minimum Jaw Separation rate 20 inches/ minute (8.5 mm/s)	1500 psi (10.3 MPa)	
3.3.1.2	Ultimate Elongation, minimum	200%	
3.3.1.3	Secant Modulus at 2% Strain, maximum	12.0 ksi (82.7 MPa)	
3.3.1.4	Dielectric Strength, minimum	500 Volts/mil (19.7 kV/mm)	4.5.1
3.3.1.5	Volume Resistivity, minimum	$10^{12}$ ohm-cm	
3.3.1.6	Flammability (Burning Time), maximum	15 seconds	4.5.2
3.3.1.7	Copper Stability 168 hours $\pm$ 2 at 160 °C $\pm$ 3 (320 °F $\pm$ 5)	No pitting or blackening of copper	
3.3.1.7.1	Ultimate Elongation, minimum	200%	
3.3.1.8	Fungus Resistance	Rating of one or less	ASTM G 21
3.3.1.9	Low-Temperature Flexibility at -55 °C $\pm$ 2 (-67 °F $\pm$ 4)	No cracks	4.5.3
3.3.1.10	Heat Aging, 168 hours $\pm$ 2 at 175 °C $\pm$ 3 (347 °F $\pm$ 5)		
3.3.1.10.1	Ultimate Elongation, minimum	200%	
3.3.1.11	Corrosion, After 16 hours $\pm$ 0.25 at 175 °C $\pm$ 3 (347 °F $\pm$ 5)	Non-Corrosive	Procedure A
3.3.1.12	Fluid Resistance		4.5.4
3.3.1.12.1	Tensile Strength, minimum	750 psi (5.17 MPa)	
3.3.1.12.2	Dielectric Strength, minimum	400 Volts/mil (15.75 kV/mm)	
3.3.1.13	Dimensional Change on Heating		
3.3.1.13.1	Diametral	In accordance with Table 3	
3.3.1.13.2	Longitudinal, maximum	-5%, +3%	

3.3.2 Expanded Tubing: The requirements shown in Table 2 apply to tubing in the expanded (as-received) condition. Heating for the tests of 3.3.2.1, 3.3.2.2, and 3.3.2.5 shall be performed in an oven as specified in 3.3.1.

TABLE 2 - Expanded Tubing Properties

Paragraph	Property	Requirement	Test Method
3.3.2.1	Heat Shock at 250 °C ± 5 (482 °F ± 9)	No dripping, flowing, or cracking	
3.3.2.1.1	Bending after Heat Shock	No cracks	4.5.5
3.3.2.2	Restricted Shrinkage, 30 minutes ± 1 at 150 °C ± 5 (302 °F ± 9)	No cracks; withstand 2000 Volts for one minute	Procedure C
3.3.2.3	Specific Gravity, maximum	1.35	
3.3.2.4	Water Absorption, maximum 24 hours ± 0.25 at 25 °C ± 2 (77 °F ± 4)	0.50%	
3.3.2.5	Color Stability after heating 48 hours ± 0.5 at 175 °C ± 5 (347 °F ± 9)	Pass	ML-STD-104

#### 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, 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 of 48 inches, +1, -0 (1219 mm, +25, -0) 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.

TABLE 3A - Standard Sizes, and Recovered Dimensions (After Heating)  
Inch/Pound Units

Size	Expanded (As Supplied) ID, Inches minimum	ID After Heating Inch maximum	Nominal Wall Thickness After Heating Inch	Wall Thickness Tolerance After Heating plus Inch 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	0.023	0.004
1/4	0.250	0.125	0.028	0.004
3/8	0.375	0.187	0.028	0.004
1/2	0.500	0.250	0.028	0.004
3/4	0.750	0.375	0.033	0.004
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 3B - Standard Sizes, and Recovered Dimensions (After Heating)  
SI Units

Size	Expanded (As Supplied) ID, Millimeters minimum	ID After Heating Millimeters maximum	Nominal Wall Thickness After Heating Millimeters	Wall Thickness Tolerance After Heating plus and minus Millimeter
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	0.58	0.10
1/4	6.35	3.18	0.71	0.10
3/8	9.52	4.75	0.71	0.10
1/2	12.70	6.35	0.71	0.10
3/4	19.05	9.52	0.84	0.10
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:

(R)

The vendor of tubing shall supply all samples for vendor's tests and shall be responsible for performing 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: Tests for tensile strength (3.3.1.1), ultimate elongation (3.3.1.2), secant modulus (3.3.1.3), flammability (3.3.1.6), dimensional change on heating (3.3.1.13), heat shock (3.3.2.1), and sizes and tolerances (3.6) are acceptance tests and shall be performed on each lot.

4.2.2 Periodic Tests: Tests for dielectric strength (3.3.1.4), volume resistivity (3.3.1.5), copper stability (3.3.1.7), fungus resistance (3.3.1.8), low temperature flexibility (3.3.1.9), heat aging (3.3.1.10), corrosion (3.3.1.11), fluid resistance (3.3.1.12), restricted shrinkage (3.3.2.2), specific gravity (3.3.2.3), water absorption (3.3.2.4), color stability (3.3.2.5), and marking (3.4) are 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 for all technical requirements are preproduction tests and shall be performed prior to or on the initial shipment of tubing to a purchaser, when a change in ingredients and/or processing 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:

(R)

Shall be in accordance with ASTM D 2671 and the following: 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 For Acceptance Tests: Not less than 16 feet (4.9 m) of tubing from each lot.

4.3.1.1 A lot shall be all tubing of the same size from the same production run presented for vendor's inspection at one time. A lot shall be not more than 250,000 feet (76,200 m).

4.3.1.2 When a statistical sampling plan has been agreed upon by purchaser and (R) vendor, sampling shall be in accordance with such plan in lieu of sampling as in 4.3.1 and the report of 4.6 shall state that such plan was used.

- 4.3.2 For Periodic Tests: Not less than 50 feet (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 shown in Table 4.

TABLE 4 - Representative Sizes

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

- 4.3.3 For 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 tubing.

- 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 ingredients and/or processing 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 in accordance with ASTM D 2671 on specimens recovered on metal mandrels for not less than 10 minutes at  $175\text{ }^{\circ}\text{C} \pm 3$  ( $347\text{ }^{\circ}\text{F} \pm 5$ ) or until the tubing is completely shrunk on the mandrels.

- 4.5.2 Flammability: Shall be determined in accordance with ASTM D 2671, Procedure A, except that the bare steel wire used for support of the specimens during the test shall be 0.020 inch (0.51 mm) in diameter for sizes 1/16 and smaller. An 8-inch (203-mm) square piece of UU-T-450 tissue paper shall be suspended taut and centered 9-1/2 inches (241 mm) below the test specimen, not less than 1/2 inch (12.7 mm) from the table top, in 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 **Low-Temperature Flexibility:** Shall be determined in accordance with ASTM D 2671, Procedure C, bending the specimen around the applicable mandrel of Table 5. Any side-cracking, caused by flattening of the specimen on the mandrel, shall be disregarded.

TABLE 5 - Mandrel Diameters

Size	Mandrel Diameter	Mandrel Diameter 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

- 4.5.4 **Fluid Resistance:** Shall be determined in accordance with ASTM D 2671 on specimens immersed for 24 hours  $\pm$  2 at 23 °C  $\pm$  3 (73 °F  $\pm$  5) in ML-T-5624 (JP-4) Fuel, SAE phosphate ester test fluid No. 1A ML-H-5606 hydraulic oil, ASTM Fuel B (See ASTM D 471), and water.
- 4.5.5 **Bending After Heat Shock:** Specimens from the heat shock test of 3.3.2.1 shall be bent 180 degrees around the applicable mandrel of Table 5. Any side-cracking, caused by flattening of the specimen on the mandrel, shall be disregarded.

#### 4.6 Reports:

The vendor of tubing shall furnish with each shipment a report showing the results of tests to determine conformance to the acceptance test requirements and, when performed, to the periodic test requirements and stating that the tubing conforms to the other technical requirements. This report shall include the purchase order number, lot number, AMS 3587D, vendor's compound number, size, and quantity.

#### 4.7 Resampling and Retesting:

(R)

If the average results of the specimens tested for any requirement fail to meet the specified value, disposition of the tubing may be based on the results of testing three additional specimens for each original specimen failing to meet the specified average requirement. Failure of the average of the original specimens plus the retest specimens to meet any specified requirement shall be cause for rejection of the tubing represented. Results of all tests shall be reported.