

**TUBING, IRRADIATED POLYCHLOROPRENE ELASTOMER, ELECTRICAL INSULATION**  
**Flexible, Heat-Shrinkable, 1.750 to 1 Shrink Ratio**

**1. SCOPE:**

**1.1 Form:**

This specification covers an irradiated, thermally-stabilized, flame-resistant modified-polychloroprene rubber in the form of thin-wall tubing.

**1.2 Application**

This tubing has been used typically as a flexible, electrical insulation tubing whose diameter can be reduced to a predetermined size by heating to 135 °C (275 °F) or higher, but usage is not limited to such applications. This tubing is stable, after being heat shrunk, under the following conditions:

**-70 to +105 °C (-94 to +221 °F) Continuous**

**-70 to +200 °C (-94 to +392 °F) 4 hours**

**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.

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## 2.1 ASTM Publications:

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

ASTM D 910 Aviation Gasolines

ASTM D 2240 Rubber Property-Durometer Hardness

ASTM D 2671 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 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-T-5624 Turbine Fuel, Aviation, Grades Jp-4, Jp-5, and Jp-5/Jp-8 St

MIL-L-7808 Lubricating Oil, Aircraft Turbine Engine, Synthetic Base

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

MIL-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 polychloroprene rubber.

### 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. Except as otherwise specified herein, tests shall be performed in accordance with ASTM D 2671, insofar as practicable.

- 3.3.1 Recovered Tubing:** Requirements shown in Table 1 apply to tubing after being shrunk by heating to  $175\text{ }^{\circ}\text{C} \pm 5$  ( $347\text{ }^{\circ}\text{F} \pm 9$ ) in a convection-current air oven with an air velocity of 100 to 200 feet per minute (0.5 to 1.0 m/s) past the tubing, holding at heat for not less than 10 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<br>Jaw separation rate 20 inches<br>per minute (8.5 mm/s)        | 1500 psi<br>(10.3 MPa)           |             |
| 3.3.1.2    | Elongation, minimum                                                                        | 225%                             |             |
| 3.3.1.3    | Tensile Stress, maximum                                                                    | 2000 psi (13.8 MPa)              |             |
| 3.3.1.4    | Hardness, Durometer A,<br>or Equivalent                                                    | 80 $\pm$ 5                       | ASTM D 2240 |
| 3.3.1.5    | Dielectric Strength, minimum                                                               | 200 volts per mil<br>(7874 V/mm) |             |
| 3.3.1.6    | Volume Resistivity, minimum                                                                | 10 <sup>11</sup> ohm-cm          |             |
| 3.3.1.7    | Flammability (Burning Time),<br>maximum, Procedure A                                       | 15 seconds                       |             |
| 3.3.1.8    | Copper Stability                                                                           | Pass                             | 4.5.1       |
| 3.3.1.8.1  | Elongation, minimum                                                                        | 150%                             |             |
| 3.3.1.9    | Fungus Resistance                                                                          | Rating of 1<br>or less           | ASTM G 21   |
| 3.3.1.10   | Low-Temperature Flexibility<br>at -70 °C $\pm$ 2 (-94 °F $\pm$ 4)                          | No cracks                        | 4.5.2       |
| 3.3.1.11   | Heat Aging, After 168 hours $\pm$ 2 at<br>120 °C $\pm$ 3 (248 °F $\pm$ 5)                  |                                  |             |
| 3.3.1.11.1 | Tensile Strength, minimum                                                                  | 1200 psi<br>(8.27 MPa)           |             |
| 3.3.1.11.2 | Elongation, minimum                                                                        | 175%                             |             |
| 3.3.1.12   | Corrosion, Procedure A, After<br>16 hours $\pm$ 0.25 at 150 °C $\pm$ 3<br>(302 °F $\pm$ 5) | Pass                             |             |
| 3.3.1.13   | Solvent Resistance                                                                         |                                  | 4.5.3       |
| 3.3.1.13.1 | Tensile Strength, minimum                                                                  | 1200 psi<br>(8.27 MPa)           |             |

TABLE 1 - Recovered Tubing Properties (Continued)

| Paragraph  | Property                      | Requirement                      | Test Method |
|------------|-------------------------------|----------------------------------|-------------|
| 3.3.1.13.2 | Elongation, minimum           | 150%                             |             |
| 3.3.1.13.3 | Dielectric Strength, minimum  | 200 volts per mil<br>(7874 V/mm) |             |
| 3.3.1.14   | Dimensional Change on Heating |                                  |             |
| 3.3.1.14.1 | Diametral                     | In accordance<br>with Table 2    |             |
| 3.3.1.14.2 | Longitudinal, maximum         | -10%, +1%                        |             |
| 3.3.1.15   | Shelf Life                    | Pass                             | 4.5.4       |

TABLE 2A - Standard Sizes and Tolerances, Inch/Pound Units

| Tubing<br>Size | Expanded<br>(As Supplied)<br>ID, Inches<br>minimum | Recovered Dimensions<br>(After Heating)<br>ID, Inches<br>maximum | Recovered Dimensions<br>(After Heating)<br>Nominal Wall<br>Thickness, Inch | Recovered Dimensions<br>(After Heating)<br>Wall Thickness<br>Tolerance, Inch<br>plus and minus |
|----------------|----------------------------------------------------|------------------------------------------------------------------|----------------------------------------------------------------------------|------------------------------------------------------------------------------------------------|
| 1/4            | 0.250                                              | 0.143                                                            | 0.035                                                                      | 0.010                                                                                          |
| 3/8            | 0.375                                              | 0.214                                                            | 0.040                                                                      | 0.010                                                                                          |
| 1/2            | 0.500                                              | 0.286                                                            | 0.048                                                                      | 0.015                                                                                          |
| 5/8            | 0.625                                              | 0.357                                                            | 0.052                                                                      | 0.015                                                                                          |
| 3/4            | 0.750                                              | 0.429                                                            | 0.057                                                                      | 0.015                                                                                          |
| 7/8            | 0.875                                              | 0.500                                                            | 0.065                                                                      | 0.015                                                                                          |
| 1              | 1.000                                              | 0.571                                                            | 0.070                                                                      | 0.020                                                                                          |
| 1-1/4          | 1.250                                              | 0.714                                                            | 0.087                                                                      | 0.020                                                                                          |
| 1-1/2          | 1.500                                              | 0.857                                                            | 0.095                                                                      | 0.020                                                                                          |
| 1-3/4          | 1.750                                              | 1.000                                                            | 0.107                                                                      | 0.020                                                                                          |
| 2              | 2.000                                              | 1.143                                                            | 0.110                                                                      | 0.020                                                                                          |
| 3              | 3.000                                              | 1.713                                                            | 0.125                                                                      | 0.020                                                                                          |
| 4              | 4.000                                              | 2.284                                                            | 0.140                                                                      | 0.020                                                                                          |

TABLE 28 - Standard Sizes and Tolerances, SI Units

| Tubing Size | Expanded (As Supplied) ID, Millimeters minimum | Recovered Dimensions (After Heating) ID, Millimeters maximum | Recovered Dimensions (After Heating) Wall Thickness Millimeters | Recovered Dimensions (After Heating) Wall Thickness Tolerance, Millimeter plus and minus |
|-------------|------------------------------------------------|--------------------------------------------------------------|-----------------------------------------------------------------|------------------------------------------------------------------------------------------|
| 1/4         | 6.35                                           | 3.63                                                         | 0.89                                                            | 0.25                                                                                     |
| 3/8         | 9.52                                           | 5.44                                                         | 1.02                                                            | 0.25                                                                                     |
| 1/2         | 12.70                                          | 7.26                                                         | 1.22                                                            | 0.38                                                                                     |
| 5/8         | 15.88                                          | 9.07                                                         | 1.32                                                            | 0.38                                                                                     |
| 3/4         | 19.05                                          | 10.90                                                        | 1.45                                                            | 0.38                                                                                     |
| 7/8         | 22.22                                          | 12.70                                                        | 1.65                                                            | 0.38                                                                                     |
| 1           | 25.40                                          | 14.50                                                        | 1.78                                                            | 0.51                                                                                     |
| 1-1/4       | 31.75                                          | 18.14                                                        | 2.21                                                            | 0.51                                                                                     |
| 1-1/2       | 38.10                                          | 21.77                                                        | 2.41                                                            | 0.51                                                                                     |
| 1-3/4       | 44.45                                          | 25.40                                                        | 2.72                                                            | 0.51                                                                                     |
| 2           | 50.80                                          | 29.03                                                        | 2.79                                                            | 0.51                                                                                     |
| 3           | 76.20                                          | 43.51                                                        | 3.18                                                            | 0.51                                                                                     |
| 4           | 101.60                                         | 58.01                                                        | 3.56                                                            | 0.51                                                                                     |

**3.3.2 Expanded Tubing:** Requirements shown in Table 3 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.

TABLE 3 - Expanding Tubing Properties

| Paragraph | Property                                                                                                                                   | Requirement                                  | Test Method |
|-----------|--------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------|-------------|
| 3.3.2.1   | Heat Shock, After 4 hours $\pm 0.25$ at $200\text{ }^{\circ}\text{C} \pm 5$ ( $392\text{ }^{\circ}\text{F} \pm 9$ )                        | 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, Procedure C, After 30 minutes $\pm 1$ at $175\text{ }^{\circ}\text{C} \pm 5$ ( $347\text{ }^{\circ}\text{F} \pm 9$ ) | No cracks; withstand 2000 volts for 1 minute |             |
| 3.3.2.3   | Specific Gravity, maximum                                                                                                                  | 1.50                                         |             |
| 3.3.2.4   | Water Absorption, maximum, After 24 hours $\pm 0.25$ at $25\text{ }^{\circ}\text{C} \pm 2$ ( $77\text{ }^{\circ}\text{F} \pm 4$ )          | 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, 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 the standard sizes and to the tolerances shown in Table 2. 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:  
(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), elongation (3.3.1.2), tensile stress (3.3.1.3), hardness (3.3.1.4), flammability (3.3.1.7), dimensional change on heating (3.3.1.14), 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 (3.3.1.5), volume resistivity (3.3.1.6), copper stability (3.3.1.8), fungus resistance (3.3.1.9), low-temperature flexibility (3.3.1.10), heat aging (3.3.1.11), corrosion (3.3.1.12), solvent resistance (3.3.1.13), shelf life (3.3.1.15), 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 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:

**4.3.1 For Acceptance Tests:** Not less than 16 feet (4.9 m) of tubing taken at random from each lot. 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** A lot shall be all tubing of the same size from the same production run presented for vendor's inspection at one time.

**4.3.1.2** When a statistical sampling plan has been agreed upon by purchaser and 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 (15.2 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 - Sizes

| Representative Size | Range of Sizes                                        |
|---------------------|-------------------------------------------------------|
| $\frac{7}{8}$<br>4  | $\frac{1}{4}$ to $\frac{7}{8}$ , incl<br>1 to 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.

**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. 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 Copper Stability:** Specimens of tubing, approximately 6 inches (152 mm) long, shall be slid over straight, clean, unplated, uninsulated, 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 being AWG 18 [0.0403 inch (1.024 mm)] or smaller. The specimens, on horizontally suspended conductors, shall be conditioned for not less than 24 hours in a humidity chamber at 90 to 95% relative humidity and  $25\text{ }^{\circ}\text{C} \pm 3$  ( $77\text{ }^{\circ}\text{F} \pm 5$ ). The specimens, on horizontally suspended conductors, shall then be conditioned for 168 hours  $\pm 2$  in an oven which is at  $120\text{ }^{\circ}\text{C} \pm 3$  ( $248\text{ }^{\circ}\text{F} \pm 5$ ), cooled to room temperature, visually examined, and tested for elongation in accordance with 3.3.1.2. 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.
- 4.5.2 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<br>Diameter<br>Inch | Mandrel<br>Diameter<br>Millimeters |
|------------------|-----------------------------|------------------------------------|
| 1/4 to 1/2, incl | 3/8                         | 9.5                                |
| 5/8 to 1, incl   | 5/8                         | 15.9                               |
| 1-1/4 to 2, incl | 7/8                         | 22.2                               |
| 2-1/4 to 4, incl | 1-1/8                       | 28.6                               |

- 4.5.3 Solvent Resistance:** Shall be determined in accordance with ASTM D 2671 on specimens immersed for 24 hours  $\pm 2$  at  $23\text{ }^{\circ}\text{C} \pm 3$  ( $73\text{ }^{\circ}\text{F} \pm 5$ ) in MIL-T-5624 (JP-4) Fuel, SAE phosphate ester test fluid No. 1A, MIL-H-5606 hydraulic oil, MIL-L-7808 lubricating oil, ASTM D 910 aviation gasoline Grade 100/130, MIL-A-8243 deicing fluid, and water.
- 4.5.4 Shelf Life:** Three specimens, each approximately 6 inches (152 mm) long, shall be tested in accordance with ASTM D 2671. Tubing shall meet expanded (as supplied) dimensions shown in Table 2 after conditioning for not less than two weeks at  $60\text{ }^{\circ}\text{C} \pm 1$  ( $140\text{ }^{\circ}\text{F} \pm 2$ ) and shall meet recovered dimensions shown in Table 2 after heat shrinkage as described in 3.3.1.