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## RAYCHEM<sup>®</sup> NT-MIL TUBING

### Modified Chlorinated Polyolefin, Elastomeric, Flexible, Flame Retarded, Heat Shrinkable

#### 1.0 SCOPE

This specification covers the requirements for one type of highly flexible, electrically insulating, extruded tubing whose diameter will reduce to a predetermined size upon the application of heat in excess of 135°C (275°F).

#### 2.0 APPLICABLE DOCUMENTS

This specification takes precedence over documents references herein. Unless otherwise specified, the latest issue of referenced documents applies. The following documents form a part of this specification to the extent specified herein.

#### 2.1 GOVERNMENT-FURNISHED DOCUMENTS

##### Military

|              |  |
|--------------|--|
| MIL-H-5606   | Hydraulic Fluid, Petroleum Base, Aircraft, Missile, and Ordnance |
| MIL-L-7808   | Lubricating Oil, Aircraft Turbine Engine, Synthetic Base         |
| MIL-L-23699  | Lubricating Oil, Aircraft Turbine Engines, Synthetic Base        |
| MIL-T-5624   | Turbine Fuels Aviation Grades, JP-4, JP-5 and JP-5/JP-8 ST       |
| SAE-AMS-1424 | Anti-Icing and Deicing - Defrosting Fluid                        |
| A-A-694      | 5% NaCL, Technical   |

#### 2.2 Other Publications

##### American Society for Testing and Materials (ASTM)

|        |  |
|--------|--|
| D 412  | Standard Test Methods for Rubber Properties in Tension                   |
| D 570  | Plastic, Water Absorption of   |
| D 2671 | Standard Methods of Testing Heat-Shrinkable Tubing for Electrical Use    |
| D 876  | Tubing, Non-rigid Vinyl Chloride polymer, Used for Electrical Insulation |

Copies of ASTM publications may be obtained from the American Society for Testing and Materials, 1916 Race Street, Philadelphia, Pennsylvania 19103

##### International Organization for Standardization (ISO)

|         |   |
|---------|---|
| ISO 846 | Plastics – Evaluation of the Action of Microorganisms |
|---------|---|

Copies of ISO publications may be obtained from the International Organization for Standardization, 1, rue de Varembé, CH-1211 Geneva 20, Switzerland or at <http://www.iso.org/iso/home.html>

### 3.0 REQUIREMENTS

#### 3.1 MATERIAL

The tubing shall be fabricated from a stabilized, flame resistant, modified Chlorinated Polyolefin and shall be radiation crosslinked. It shall be homogeneous and essentially free from flaws, defects, pinholes, bubbles, seams, cracks, and inclusions.

#### 3.2 Color

The tubing shall be black, Per MIL-STD-104 Class 2

#### 3.3 PROPERTIES

The tubing shall meet the requirements of Table 3.

### 4.0 QUALITY ASSURANCE PROVISIONS

#### 4.1 CLASSIFICATION OF TESTS

##### 4.1.1 Qualification Tests

Qualification tests are those performed on tubing submitted for qualification as a satisfactory product and shall consist of all tests listed in this specification.

##### 4.1.2 Acceptance Tests

Acceptance tests are those performed on tubing submitted for acceptance under contract. Acceptance tests shall consist of the following:

Dimensions  
Longitudinal Change  
Tensile Strength  
Tensile Stress  
Ultimate Elongation  
Heat Shock  
Flammability  
Low Temperature Flexibility

Physical property tests performed at this time qualify subsequent sleeving lots produced from the same batch of compound. Statistical process control data may be used to demonstrate conformance for dimensions.

#### 4.2 SAMPLING INSTRUCTIONS

##### 4.2.1 Qualification Test Samples

Qualification test samples shall consist of 50 feet (15 m) of tubing of each size. Qualification of any size within each size range specified below will qualify all sizes in the same range.

**Size Range**  
1/8 through 7/8  
1 through 4

#### 4.2.2 Acceptance Test Samples

Acceptance test samples shall consist of not less than 16 feet (5 m) of tubing selected at random from each lot. A lot shall consist of all tubing of the same size, from the same production run, and offered for inspection at the same time.

#### 4.3 TEST PROCEDURES

Unless otherwise specified, tests shall be performed on specimens, which have been fully recovered by conditioning for 10 minutes in a  $175 \pm 5^{\circ}\text{C}$  ( $347 \pm 9^{\circ}\text{F}$ ) oven. All ovens shall be of the mechanical convection type in which air passes over the specimens at a velocity of 100 to 200 feet (30 to 61 m) per minute.

- The Heat Shrinkable Sleeving and Measurement Gages shall be at room temperature with ambient relative humidity prior to testing before or after heat shrink.

#### 4.3.1 Dimensions and Longitudinal Change

Three 6-inch (150 mm) specimens of tubing, as supplied, shall be measured for length  $\pm 1/32$  inch ( $\pm 1$  mm) and inside diameter in accordance with ASTM D 2671, conditioned for 10 minutes in a  $175 \pm 5^{\circ}\text{C}$  ( $347 \pm 9^{\circ}\text{F}$ ) oven, cooled to  $23 \pm 3^{\circ}\text{C}$  ( $73 \pm 5^{\circ}\text{F}$ ), and then remeasured. Prior to and after conditioning, the dimensions of the tubing shall be in accordance with Table 1 and the longitudinal change shall be in accordance with Table 3. Longitudinal change shall be calculated as follows:

$$C = \frac{L_1 - L_0}{L_0} \times 100$$

Where: C = Longitudinal Change [Percent]  
 L<sub>0</sub> = Length Before Conditioning [Inches (mm)]  
 L<sub>1</sub> = Length After Conditioning [Inches (mm)]

#### 4.3.2 Tensile Strength, Tensile Stress, and Ultimate Elongation

Three specimens of tubing shall be tested for tensile strength, tensile stress, and ultimate elongation in accordance with ASTM D 2671. For tubing sizes 3/8 and smaller, the specimens shall be full sections of tubing. For sizes 1/2 and larger, the specimens shall be 1/4-inch (6.3-mm) wide strips. The specimens shall have 1-inch (25-mm) bench marks, centrally located. The testing machine shall have an initial jaw separation of 1 inch (25 mm) for full sections of tubing, and 2 inches (51 mm) for strip specimens. The rate of jaw separation shall be  $20 \pm 2$  inches ( $500 \pm 50$  mm) per minute.

#### 4.3.3 Low Temperature Flexibility

Three specimens, each 12 inches (300 mm) in length, and a mandrel selected in accordance with Table 2, shall be conditioned at  $-70 \pm 3^{\circ}\text{C}$  ( $984 \pm 5^{\circ}\text{F}$ ) for 4 hours. For tubing sizes 5/8 or less, the specimens shall be whole sections of tubing recovered on a stranded wire (nearest AWG which is larger than the sleeving maximum inside diameter after unrestricted shrinkage). For tubing sizes larger than 5/8, the specimens shall be 1/4-inch (6.3-mm) wide strips cut from tubing which has been recovered in accordance with 4.3. After 4 hours conditioning, and while still at the conditioning temperature, the specimens shall be wrapped around the mandrel for not less than  $360^{\circ}$  ( $6.28$  rad) in  $10 \pm 2$  seconds. The specimens then shall be visually examined for evidence of cracking.

#### 4.3.4 Heat Shock

Three 6-inch (150-mm) specimens of tubing shall be conditioned for 4 hours in a  $200 \pm 3^{\circ}\text{C}$  ( $392 \pm 5^{\circ}\text{F}$ ) oven.

After 4 hours conditioning, and while still at the conditioning temperature, the specimens shall be wrapped around the mandrel for not less than  $360^{\circ}$  ( $6.28 \text{ rad}$ ) in 2 to 4 seconds. The specimens then shall be visually examined for evidence of cracking.

#### 4.3.5 Heat Resistance

Three specimens of tubing prepared and measured in accordance with 4.3.2, shall be conditioned for 168 hours in a  $121 \pm 3^{\circ}\text{C}$  ( $250 \pm 5^{\circ}\text{F}$ ) oven. After conditioning, the specimens shall be removed from the oven, cooled to  $23 \pm 3^{\circ}\text{C}$  ( $73 \pm 5^{\circ}\text{F}$ ), and tested for tensile strength and ultimate elongation in accordance with 4.3.2.

#### 4.3.6 Copper Stability

Three 6-inch (150-mm) specimens of tubing shall be slid over snug fitting, straight, clean, bare copper mandrels, either solid or tubular. The specimens on the mandrels shall be conditioned for 24 hours in a desiccator or similar humidity chamber at 90 to 95 percent relative humidity and  $25 \pm 3^{\circ}\text{C}$  ( $77 \pm 5^{\circ}\text{F}$ ). The specimens on the mandrels then shall be conditioned for 168 hours in a  $121 \pm 3^{\circ}\text{C}$  ( $250 \pm 5^{\circ}\text{F}$ ) oven. After conditioning, the specimens shall be removed from the oven, cooled to  $23 \pm 3^{\circ}\text{C}$  ( $73 \pm 5^{\circ}\text{F}$ ). The copper mandrels shall then be removed from the tubing and the tubing and copper mandrels shall be examined. Darkening of the copper due to normal air oxidation shall not be cause for rejection. The tubing shall be tested for elongation in accordance with 4.3.2.

#### 4.3.7 Dielectric Strength

The dielectric strength shall be determined in accordance with the ASTM D 2671 procedure for dielectric breakdown. When dielectric breakdown occurs, the thickness measurements for calculating dielectric strength shall be made adjacent to the point of breakdown and the dielectric strength shall be calculated in volts per mil.

#### 4.3.9 Fluid Resistance

Six specimens, three 6-inch (152.4mm) tubing specimens and three tensile specimens prepared and measured in accordance with 4.3.2, shall be immersed for 24 hours in each of the test fluids listed in Table 3 at the temperature specified. The volume of the fluid shall not be less than 20 times that of the specimens. After conditioning, all the specimens shall be lightly wiped and air dried for 30 to 60 minutes at  $23 \pm 3^{\circ}\text{C}$  ( $73 \pm 5^{\circ}$ ). The three specimens intended for the tensile strength and elongation tests shall then be tested in accordance with 4.3.2. The other three specimens shall be weighed before and after immersion and the weight change calculated as a percentage.

#### 4.4 REJECTION AND RETEST

Failure of any sample of tubing to comply with any one of the requirements of this specification shall be cause for rejection of the lot represented. Tubing which has been rejected may be replaced or reworked to correct the defect and then resubmitted for acceptance. Before resubmitting, full particulars concerning the rejection and the action taken to correct the defect shall be furnished to the inspector.

**5.0 PREPARATION FOR DELIVERY****5.1 PACKAGING**

Packaging shall be in accordance with good commercial practice. The shipping container shall be not less than 125 pound-test fiberboard.

**5.2 MARKING**

Each container of tubing shall be permanently and legibly marked with the size, quantity, manufacturer's identification, and lot number.

**TABLE 1**  
**Tubing Dimensions**

| Size  | AS SUPPLIED             |       | RECOVERED               |      |                |      |         |      |         |      |
|-------|-------------------------|-------|-------------------------|------|----------------|------|---------|------|---------|------|
|       | Inside Diameter Minimum |       | Inside Diameter Maximum |      | Wall Thickness |      |         |      |         |      |
|       |                         |       |                         |      | Minimum        |      | Maximum |      | Nominal |      |
|       | in.                     | mm.   | in.                     | mm.  | in.            | mm.  | in.     | mm.  | in.     | mm.  |
| 1/8   | .125                    | 3.18  | .061                    | 1.55 | .019           | 0.48 | .035    | 0.91 | .027    | 0.69 |
| 3/16  | .187                    | 4.75  | .100                    | 2.54 | .023           | 0.58 | .043    | 1.09 | .033    | 0.83 |
| 1/4   | .250                    | 6.4   | .143                    | 3.6  | .025           | 0.63 | .045    | 1.14 | .035    | 0.89 |
| 3/8   | .375                    | 9.5   | .211                    | 5.4  | .030           | 0.76 | .050    | 1.27 | .040    | 1.01 |
| 1/2   | .500                    | 12.7  | .286                    | 7.3  | .033           | 0.83 | .063    | 1.60 | .048    | 1.21 |
| 5/8   | .625                    | 15.9  | .357                    | 9.1  | .037           | 0.93 | .067    | 1.70 | .052    | 1.32 |
| 3/4   | .750                    | 19.1  | .428                    | 10.9 | .042           | 1.06 | .072    | 1.82 | .057    | 1.44 |
| 7/8   | .875                    | 22.2  | .500                    | 12.7 | .050           | 1.27 | .080    | 2.03 | .065    | 1.65 |
| 1     | 1.000                   | 25.4  | .570                    | 14.5 | .050           | 1.27 | .090    | 2.28 | .070    | 1.77 |
| 1-1/4 | 1.250                   | 31.8  | .714                    | 18.1 | .067           | 1.70 | .107    | 2.71 | .087    | 2.20 |
| 1-1/2 | 1.500                   | 38.1  | .857                    | 21.8 | .075           | 1.90 | .115    | 2.92 | .095    | 2.41 |
| 1-3/4 | 1.750                   | 44.5  | 1.000                   | 25.4 | .087           | 2.20 | .127    | 3.22 | .107    | 2.71 |
| 2     | 2.000                   | 50.8  | 1.140                   | 29.0 | .090           | 2.28 | .130    | 3.30 | .110    | 2.79 |
| 3     | 3.000                   | 76.2  | 1.710                   | 43.4 | .105           | 2.65 | .145    | 3.67 | .125    | 3.17 |
| 4     | 4.000                   | 101.6 | 2.280                   | 58.9 | .120           | 3.04 | .160    | 4.05 | .140    | 3.55 |

**TABLE 2**  
**Mandrel Dimensions for Bend Testing**

| Tubing Size<br>in. | Mandrel Diameter |      |
|--------------------|------------------|------|
|                    | in.              | mm.  |
| 1/8 through 3/16   | 5/16             | 7.9  |
| 1/4 through 3/8    | 3/8              | 9.5  |
| 1/2 through 1-3/4  | 7/16             | 11.1 |
| 2 through 3        | 7/8              | 22.2 |
| 4                  | 1.0              | 25.4 |

**TABLE 3**  
**Requirements**

| <b>PROPERTY</b>   | <b>UNIT</b>                | <b>REQUIREMENT</b>  | <b>TEST METHOD</b>            |
|---|----------------------------|---|-------------------------------|
| <b>PHYSICAL</b>   |                            |   |                               |
| Dimensions  | inches ( <i>mm</i> )       | In accordance with table 1  | ASTM D 2671                   |
| Longitudinal Change   | percent                    | +1, -5  | ASTM D 2671                   |
| Tensile strength  | psi ( <i>MPa</i> )         | 1500 ( <i>10.3</i> ) minimum  | ASTM D 412                    |
| Ultimate elongation   | percent                    | 225% minimum  | ASTM D 412                    |
| Tensile stress at 200% elongation   | psi ( <i>MPa</i> )         | 1500 ( <i>10.3</i> ) maximum  | AMS-DTL-23053                 |
| Restricted shrinkage<br>(30 minutes at 135°C/275 °F)<br>Followed by test for:<br>Voltage withstand  | ---                        | No cracks<br><br>Pass   | AMS-DTL-23053                 |
| Low temperature flexibility<br>(4 hours at -70°C/ -94°F)  | ---                        | No cracks   | AMS-DTL-23053                 |
| Heat shock<br>(4 hours at 200°C/ 392°F)   | ---                        | No cracks, flowing or dripping  | AMS-DTL-23053                 |
| Heat resistance<br>(168 hours at 121°C/250°F)<br>Followed by tests for:<br>Tensile strength<br>Ultimate elongation<br>Dielectric strength | ---                        | ---   | ASTM D 2671                   |
|   | psi ( <i>MPa</i> )         | 1200 ( <i>8.3</i> )   | ASTM D 412                    |
|   | percent                    | 175 minimum   | ASTM D 412                    |
|   | volts/mil ( <i>kV/mm</i> ) | 300 ( <i>11.8</i> ) minimum   | ASTM D 2671                   |
| <b>ELECTRICAL</b>   |                            |   |                               |
| Dielectric strength   | volts/mil ( <i>kV/mm</i> ) | 300 (11.8) minimum up to 0.070” wall.<br>200 (7.8) minimum 0.070” wall and above. | ASTM D 2671                   |
| Volume resistivity  | ohm-cm                     | 10E11 minimum   | ASTM D 876                    |
| <b>CHEMICAL</b>   |                            |   |                               |
| Copper mirror corrosion<br>(16 hours at 150°C/302°F)  | ---                        | No pitting or corrosion   | AMS-DTL-23053                 |
| Copper contact corrosion<br>(16 hours at 150°C/302°F)   |                            | No pitting or blackening of copper  | AMS-DTL-23053                 |
| Flammability  | Seconds                    | Self-extinguishing in 15 seconds; 3 inches maximum burn length                    | ASTM D 2671<br>Procedure A    |
| Fungus resistance<br><br>Followed by tests for:<br>Tensile strength<br>Ultimate elongation<br>Dielectric strength                         | ---                        | ---   | ISO 846<br>Method B           |
|   | psi ( <i>MPa</i> )         | 1500 ( <i>10.3</i> ) minimum  | ASTM D 412                    |
|   | percent                    | 250 minimum   |                               |
|   | volts/mil ( <i>kV/mm</i> ) | 300 (11.8) minimum up to 0.070” wall.<br>200 (7.8) minimum 0.070” wall and above. | ASTM D 412<br><br>ASTM D 2671 |
| Fungus resistance   |                            | Or<br>Rating of 1 or less   | ASTM G21                      |

**TABLE 3**  
**Requirements**  
(continued)

|  |                            |                    |               |
|--|----------------------------|--------------------|---------------|
| <b>CHEMICAL</b> (continued)<br>Water absorption<br>(24 hours at 23°C/73° F)  | percent                    | 1.0 maximum        | ASTM D 570    |
| Fluid Resistance<br>(24 hours at 23°C/73° F) in:<br>JP-8 fuel (MIL-T-5624)<br>Hydraulic fluid (MIL-H-5606)<br>Lubricating oil (MIL-L-7808)<br>Lubricating oil (MIL-L-23699)<br>5 Percent NaCL (A-A-694)<br>Anti-icing fluid (MIL-A-8243)<br>Followed by tests for: | ---                        | ---                | AMS-DTL-23053 |
| Tensile strength   | psi ( <i>MPa</i> )         | 1000 (6.9) minimum | ASTM D 412    |
| Ultimate elongation  | percent                    | 175 minimum        | ASTM D 412    |
| Dielectric strength  | volts/mil ( <i>kV/mm</i> ) | 250 (9.8) minimum  | ASTM D 2671   |