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Specification  
This Issue:  
Date:  
Replaces:

**RT-510**  
Issue 14  
16-Jun-15  
Issue 13

## **RAYCHEM NT TUBING**

### **Modified Chlorinated Polyolefin, Elastomeric, Flexible, Flame Retardant, 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 referenced 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**

|               |                                                                                        |
|---------------|----------------------------------------------------------------------------------------|
| SAE-AMS-1424  | Anti-Icing and Deicing - Defrosting Fluid                                              |
| MIL-DTL-83133 | Turbine Fuels, Aviation, Kerosene Types, NATO F-34 (JP-8),<br>NATO F-35 and JP-8 + 100 |
| MIL-PRF-5606  | Hydraulic Fluid, Petroleum Base, Aircraft, Missile and Ordnance                        |
| MIL-PRF-7808  | Lubricating Oil, Aircraft Turbine Engine, Synthetic Base,<br>NATO Code Number 0-148    |

##### **2.2 Other Publications**

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

|            |                                                                                                 |
|------------|-------------------------------------------------------------------------------------------------|
| ASTM D412  | Standard Test Methods for Rubber Properties in Tension                                          |
| ASTM D2240 | Standard Method of Test for Indentation Hardness of Rubber and Plastics by Means of a Durometer |
| ASTM D2671 | Standard Methods of Testing Heat-Shrinkable Tubing for Electrical Use                           |
| ASTM G21   | Standard Practice for Determining Resistance of Synthetic Polymeric Materials to Fungi          |

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 Varembe, 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.

##### **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. Tubing shall be allowed to cool to room temperature prior to testing. The Heat Shrinkable Sleeving and Measurement Gages shall be at room temperature with ambient relative humidity prior to testing before or after heat shrinking.

**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 D2671, 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 re-measured. 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**

Test three specimens of tubing for tensile strength and ultimate elongation in accordance with ASTM D2671 and for tensile stress in accordance with ASTM D412. The rate of jaw separation shall be  $20 \pm 2$  inches ( $500 \pm 50$  mm) per minute.

**4.3.3 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  $121 \pm 2^\circ\text{C}$  ( $250 \pm 4^\circ\text{F}$ ) 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, then 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 Ultimate Elongation in accordance with 4.3.2.

**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 be 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 |        | Inside Diameter |       | Wall Thickness |      |         |      |         |      |
|       | Minimum         |        | Maximum         |       | 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            | 6.35   | .143            | 3.63  | .025           | 0.63 | .045    | 1.14 | .035    | 0.89 |
| 3/8   | .375            | 9.52   | .214            | 5.45  | .030           | 0.76 | .050    | 1.27 | .040    | 1.01 |
| 1/2   | .500            | 12.70  | .286            | 7.25  | .033           | 0.83 | .063    | 1.60 | .048    | 1.21 |
| 5/8   | .625            | 15.87  | .357            | 9.06  | .037           | 0.93 | .067    | 1.70 | .052    | 1.32 |
| 3/4   | .750            | 19.05  | .428            | 10.88 | .042           | 1.06 | .072    | 1.82 | .057    | 1.44 |
| 7/8   | .875            | 22.22  | .500            | 12.70 | .050           | 1.27 | .080    | 2.03 | .065    | 1.65 |
| 1     | 1.000           | 25.40  | .570            | 14.48 | .050           | 1.27 | .090    | 2.28 | .070    | 1.77 |
| 1-1/4 | 1.250           | 31.75  | .714            | 18.13 | .067           | 1.70 | .107    | 2.71 | .087    | 2.20 |
| 1-1/2 | 1.500           | 38.10  | .857            | 21.76 | .075           | 1.90 | .115    | 2.92 | .095    | 2.41 |
| 1-3/4 | 1.750           | 44.45  | 1.000           | 25.40 | .087           | 2.20 | .127    | 3.22 | .107    | 2.71 |
| 2     | 2.000           | 50.80  | 1.140           | 28.96 | .090           | 2.28 | .130    | 3.30 | .110    | 2.79 |
| 3     | 3.000           | 76.20  | 1.710           | 43.43 | .105           | 2.65 | .145    | 3.67 | .125    | 3.17 |
| 4     | 4.000           | 101.60 | 2.280           | 58.90 | .120           | 3.04 | .160    | 4.05 | .140    | 3.55 |

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

| Tubing Size |         |       | Mandrel Diameter |      |
|-------------|---------|-------|------------------|------|
| in.         |         |       | 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**

| PROPERTY                                                                                                          | UNIT                                                        | REQUIREMENT                                                                | TEST METHOD                                 |
|-------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------|----------------------------------------------------------------------------|---------------------------------------------|
| <b>PHYSICAL</b>                                                                                                   |                                                             |                                                                            |                                             |
| Dimensions                                                                                                        | inches ( <i>mm</i> )                                        | In accordance with table 1                                                 | ASTM D 2671                                 |
| Longitudinal Change                                                                                               | percent                                                     | +1, -5                                                                     | Section 4.3.1                               |
| Tensile Strength                                                                                                  | psi ( <i>MPa</i> )                                          | 1500 (10.3) minimum                                                        | Section 4.3.2<br>ASTM D 2671                |
| Ultimate Elongation                                                                                               | percent                                                     | 225 minimum                                                                | ASTM D2671                                  |
| Tensile Stress at 100% elongation                                                                                 | psi ( <i>MPa</i> )                                          | 1500 (10.3) maximum                                                        | ASTM D 412                                  |
| Specific Gravity                                                                                                  | ---                                                         | 1.5 maximum                                                                | ASTM D 2671                                 |
| Low Temperature Flexibility<br>4 hours at -70°C ± 2°C (-94° ± 4° F)                                               | ---                                                         | No cracks                                                                  | ASTM D 2671<br>Procedure C<br>Table 2       |
| Heat Shock<br>4 hours at 200°C ± 3°C (392° ± 5° F)                                                                | ---                                                         | No cracks, flowing<br>or dripping                                          | ASTM D 2671<br>Table 2                      |
| Heat Resistance<br>168 hours at<br>121°C ± 2°C (250 ± 4°F)<br>Followed by tests for:                              | ---                                                         | ---                                                                        | ASTM D 2671                                 |
| Tensile strength                                                                                                  | psi ( <i>MPa</i> )                                          | 1200 (8.3)                                                                 | Section 4.3.2<br>ASTM D 2671                |
| Ultimate elongation                                                                                               | percent                                                     | 175 minimum                                                                | ASTM D 2671                                 |
| <b>ELECTRICAL</b>                                                                                                 |                                                             |                                                                            |                                             |
| Dielectric Strength                                                                                               | volts/mil ( <i>kV/mm</i> )                                  | 300 minimum (11.8 )                                                        | ASTM D 2671                                 |
| Volume Resistivity                                                                                                | ohm-cm                                                      | 10 <sup>11</sup> minimum                                                   | ASTM D 2671                                 |
| <b>CHEMICAL</b>                                                                                                   |                                                             |                                                                            |                                             |
| Copper Mirror Corrosion<br>16 hours at 150° ± 2°C (302° ± 4° F)                                                   | ---                                                         | Noncorrosive                                                               | ASTM D 2671<br>Procedure A                  |
| Copper Contact Corrosion<br>16 hours at 150 ± 2°C (302° ± 4° F)                                                   |                                                             | No pitting or blackening<br>of copper                                      | ASTM D 2671<br>Procedure B                  |
| Copper Stability<br>168 hours at 121° ± 2°C (250° ± 4° F)<br>Followed by test for:                                | ---                                                         | No brittleness, glazing,<br>cracking, or severe<br>discoloration of tubing | Section 4.3.3                               |
| Ultimate Elongation                                                                                               | percent                                                     | 175 minimum                                                                | ASTM D 2671                                 |
| Flammability                                                                                                      | Seconds                                                     | Self-extinguishing<br>within 15 seconds;                                   | 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> )<br>percent<br>volts/mil ( <i>kV/mm</i> ) | 1500 (10.3) minimum<br>225 minimum<br>300 (11.8) minimum<br><br>Or         | Section 4.3.2<br>ASTM D 2671<br>ASTM D 2671 |
| Fungus Resistance                                                                                                 | ---                                                         | Rating of 1 or less                                                        | ASTM G21                                    |
| Water Absorption<br>24 hours at 23° ± 2°C (73° ± 4°F)                                                             | Percent                                                     | 1.0 maximum                                                                | ASTM D 2671                                 |

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

| PROPERTY                          | UNIT                       | REQUIREMENTS       | TEST METHOD                  |
|-----------------------------------|----------------------------|--------------------|------------------------------|
| <b>CHEMICAL</b> (continued)       | ---                        | ---                |                              |
| Fluid Resistance                  |                            |                    | ASTM D 2671                  |
| 24 hours at 23°± 2°C (73° ± 4° F) |                            |                    |                              |
| JP-8 Fuel (MIL-DTL-83133)         |                            |                    |                              |
| Hydraulic Fluid (MIL-PRF-5606)    |                            |                    |                              |
| Lubricating Oil (MIL-PRF-7808)    |                            |                    |                              |
| De-Icing Fluid ( SAE-AMS-1424)    |                            |                    |                              |
| Water                             |                            |                    |                              |
| Followed by tests for:            |                            |                    |                              |
| Tensile Strength                  | psi ( <i>MPa</i> )         | 1000 (6.9) minimum | Section 4.3.2<br>ASTM D 2671 |
| Dielectric Strength               | volts/mil ( <i>kV/mm</i> ) | 250 (9.8) minimum  | ASTM D 2671                  |