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**Raychem**

Specification

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## **THERMOFIT® RNF-100 TUBING** **Polyolefin, Flexible, Heat-Shrinkable**

### **1. SCOPE**

This specification covers the requirements for two types of flexible electrical insulating, extruded tubing whose diameter will reduce to a predetermined size upon the application of heat in excess of 121°C (250°F).

#### **1.1 TYPE 1**

Type 1 tubing shall be flame-retardant and shall be black, white, red, yellow, or blue unless otherwise specified.

#### **1.2 TYPE 2**

Type 2 tubing shall not be flame-retardant and shall be clear.

### **2. 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

|              |                                                                 |
|--------------|-----------------------------------------------------------------|
| ASTM D 910   | Gasoline, Aviation, Grades 80/87, 100, and 115/145              |
| MIL-PRF-5606 | Hydraulic Fluid, Petroleum Base, Aircraft, Missile and Ordnance |
| MIL-T-83133  | Turbine Fuel, Aviation, Grade JP-8                              |
| MIL-STD-104  | Limits for Electrical Insulation Color                          |

#### **2.2 OTHER PUBLICATIONS**

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

|        |                                                                       |
|--------|-----------------------------------------------------------------------|
| D 910  | Standard Spec. for Aviation Gasolines                                 |
| D 2671 | Standard Methods of Testing Heat-Shrinkable Tubing for Electrical Use |

(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 via the ISO website at <http://www.iso.ch/iso/en/ISOOnline.frontpage>)

### 3. REQUIREMENTS

#### 3.1 MATERIALS

The tubing shall be fabricated from thermally stabilized, modified polyolefin and shall be crosslinked by irradiation. It shall be homogeneous and essentially free from flaws, defects, pinholes, bubbles, seams, cracks, and inclusions.

#### 3.2 PROPERTIES

The tubing shall meet the requirements of Table 3.

### 4. 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 be: dimensions, longitudinal change, tensile strength, ultimate elongation, secant modulus, flammability (Type 1 only), and heat shock. 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 black, white and clear tubing. Qualification of black and white shall qualify all colors. Clear shall be qualified separately. Qualification of any size within each size range specified below shall qualify all sizes within that size range.

##### **Range of Sizes**

3/64 through 1/4

3/8 through 1

1-1/4 through 5

##### 4.2.2 Acceptance Test Sample

Acceptance test samples shall consist of not less than 16 feet (5 m) of tubing selected at random from each compound batch or the first sleeving production lot of the batch compound. Physical property tests performed at this time qualify subsequent sleeving lots produced from the same compound batch.

#### 4.3 TEST PROCEDURES

Condition test specimens and measurement gauges at  $23 \pm 3^{\circ}\text{C}$  ( $73 \pm 5^{\circ}\text{F}$ ) and ambient relative humidity prior to all testing, whether before or after heat shrinking. Unless otherwise specified, perform tests on specimens which have been fully recovered by conditioning for 3 minutes in a  $200 \pm 5^{\circ}\text{C}$  ( $392 \pm 9^{\circ}\text{F}$ ) oven. Use mechanical convection type ovens in which air passes the specimens at a velocity of 100 to 200 feet (30 to 60 m) per minute.

#### 4.3.1 Dimensions and Longitudinal Change

Measure three 6-inch (150 mm) specimens of tubing, as supplied, for length  $\pm 1/32$  inch ( $\pm 1$  mm), and inside diameter in accordance with ASTM D 2671. Condition the specimens for 3 minutes in a  $200 \pm 5^\circ\text{C}$  ( $392 \pm 9^\circ\text{F}$ ) oven, cool to  $23 \pm 3^\circ\text{C}$  ( $73 \pm 5^\circ\text{F}$ ) and then remeasure. 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. Calculate the longitudinal change 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 and Ultimate Elongation

Determine the tensile strength and ultimate elongation of the tubing in accordance with ASTM D 2671 using 1-inch (25-mm) bench marks, a 1-inch (25-mm) initial jaw separation, and jaw separation speed of  $20 \pm 2$  inches (500  $\pm$  50 mm) per minute.

#### 4.4 REJECTION AND RETEST

Failure of any sample of tubing to conform to 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 defects and resubmitted for acceptance. Before resubmitting, full particulars concerning previous rejection and action taken to correct the defects shall be furnished to the inspector.

### 5. PREPARATION FOR DELIVERY

#### 5.1 FORM

The tubing shall be supplied on spools or in lengths of  $48 +1, -0$  inches ( $1220 +25.4, -0$  mm) unless otherwise specified.

#### 5.2 PACKAGING

Packaging shall be in accordance with good commercial practice.

#### 5.3 MARKING

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

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

| Size  | As Supplied     |        | As Recovered    |       |                |      |         |      |         |      |
|-------|-----------------|--------|-----------------|-------|----------------|------|---------|------|---------|------|
|       | Inside Diameter |        | Inside Diameter |       | Wall Thickness |      |         |      |         |      |
|       | Minimum         |        | Maximum         |       | Minimum        |      | Maximum |      | Nominal |      |
|       | in.             | mm.    | in.             | mm.   | in.            | mm.  | in.     | mm.  | in.     | mm.  |
| 3/64  | .046            | 1.17   | .023            | 0.58  | .013           | 0.33 | .019    | 0.48 | .016    | 0.40 |
| 1/16  | .063            | 1.60   | .031            | 0.79  | .014           | 0.35 | .020    | 0.50 | .017    | 0.43 |
| 3/32  | .093            | 2.36   | .046            | 1.17  | .017           | 0.43 | .023    | 0.58 | .020    | 0.50 |
| 1/8   | .125            | 3.17   | .062            | 1.57  | .017           | 0.43 | .023    | 0.58 | .020    | 0.50 |
| 3/16  | .187            | 4.74   | .093            | 2.36  | .017           | 0.43 | .023    | 0.58 | .020    | 0.50 |
| 1/4   | .250            | 6.35   | .125            | 3.17  | .022           | 0.56 | .028    | 0.71 | .025    | 0.64 |
| 3/8   | .375            | 9.50   | .187            | 4.74  | .022           | 0.56 | .028    | 0.71 | .025    | 0.64 |
| 1/2   | .500            | 12.70  | .250            | 6.35  | .022           | 0.56 | .028    | 0.71 | .025    | 0.64 |
| 3/4   | .750            | 19.05  | .375            | 9.50  | .027           | 0.69 | .033    | 0.84 | .030    | 0.76 |
| 1     | 1.000           | 25.40  | .500            | 12.70 | .030           | 0.76 | .040    | 1.01 | .035    | 0.88 |
| 1-1/4 | 1.250           | 31.75  | .625            | 14.30 | .034           | 0.86 | .046    | 1.17 | .040    | 1.01 |
| 1-1/2 | 1.500           | 38.10  | .750            | 19.05 | .034           | 0.86 | .046    | 1.17 | .040    | 1.01 |
| 2     | 2.000           | 50.80  | 1.000           | 25.40 | .038           | 0.96 | .052    | 1.32 | .045    | 1.14 |
| 3     | 3.000           | 76.20  | 1.500           | 38.10 | .042           | 1.06 | .058    | 1.47 | .050    | 1.27 |
| 4     | 4.000           | 101.60 | 2.000           | 50.80 | .046           | 1.16 | .064    | 1.63 | .055    | 1.39 |
| 5     | 5.000           | 127.00 | 2.500           | 63.50 | .051           | 1.30 | .069    | 1.75 | .060    | 1.52 |

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

| Tubing Size           | Mandrel Diameter |     |
|-----------------------|------------------|-----|
|                       | in.              | mm. |
| 3/64 to 1/4 inclusive | 5/16             | 7.9 |
| 3/8 to 5 inclusive    | 3/8              | 9.5 |

**TABLE 3**  
**Requirements**

| PROPERTY                                                                                              | UNIT                    | REQUIREMENT                                                                         |                                                                                     | TEST METHOD                           |
|-------------------------------------------------------------------------------------------------------|-------------------------|-------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|---------------------------------------|
|                                                                                                       |                         | TYPE 1                                                                              | TYPE 2                                                                              |                                       |
| <b>PHYSICAL</b><br>Dimensions                                                                         | Inches ( <i>mm</i> )    | In accordance with Table 1                                                          | In accordance with Table 1                                                          | Section 4.3.1<br>ASTM D 2671          |
| Longitudinal Change                                                                                   | Percent                 | +0, -5                                                                              | +0, -5                                                                              |                                       |
| Tensile Strength                                                                                      | psi ( <i>MPa</i> )      | 1500 minimum<br>(10.3)                                                              | 1500 minimum<br>(10.3)                                                              | Section 4.3.2<br>ASTM D 2671          |
| Ultimate Elongation                                                                                   | Percent                 | 200 minimum                                                                         | 200 minimum                                                                         |                                       |
| Secant Modulus (Expanded)                                                                             | psi ( <i>MPa</i> )      | 2.5 x 10 <sup>4</sup><br>maximum<br>(172)                                           | 2.5 x 10 <sup>4</sup><br>maximum<br>(172)                                           | ASTM D 2671                           |
| Specific Gravity                                                                                      | ---                     | 1.35 maximum                                                                        | 1.0 maximum                                                                         | ASTM D 2671                           |
| Low Temperature Flexibility<br>4 hours at -55 ± 1°C (-67 ± 2°F)                                       | ---                     | No cracking                                                                         | No cracking                                                                         | Table 2<br>ASTM D 2671<br>Procedure C |
| Heat Shock<br>4 hours at 250 ± 3°C (482 ± 5°F)                                                        | ---                     | No dripping,<br>flowing or<br>cracking                                              | No dripping,<br>flowing or<br>cracking                                              | Table 2<br>ASTM D 2671                |
| Heat Resistance<br>168 hours at 175 ± 2°C (347 ± 4°F)<br>Followed by test for:<br>Ultimate Elongation | ---                     | ---                                                                                 | ---                                                                                 | ASTM D 2671                           |
|                                                                                                       | Percent                 | 150 minimum                                                                         | 150 minimum                                                                         |                                       |
| Color                                                                                                 | ---                     | MIL-STD-104                                                                         | ---                                                                                 | MIL-STD-104                           |
| Color Stability<br>48 hours at 175 ± 2°C (347 ± 4°F)                                                  | ---                     | MIL-STD-104                                                                         | ---                                                                                 | ASTM D 2671                           |
| <b>ELECTRICAL</b><br>Dielectric Strength                                                              | Volts/mil<br>(volts/mm) | 500 minimum<br>(19,680)                                                             | 500 minimum<br>(19,680)                                                             | NOTE 1<br>ASTM D 2671                 |
| Volume Resistivity                                                                                    | ohm-cm                  | 10 <sup>14</sup> minimum                                                            | 10 <sup>16</sup> minimum                                                            | ASTM D 2671                           |
| <b>CHEMICAL</b><br>Copper Mirror Corrosion 16 hours at 175 ± 2°C (347 ± 4°F)                          | --                      | No removal of<br>copper                                                             | No removal of<br>copper                                                             | ASTM D 2671<br>Procedure A            |
| Copper Contact Corrosion<br>168 hours at 160 ± 2°C (320 ± 4°F)                                        | ---                     | No pitting or<br>blackening of<br>copper                                            | No pitting or<br>blackening of<br>copper                                            | ASTM D 2671<br>Procedure B            |
| Copper Stability<br>168 hours at 160 ± 2°C (320 ± 4°F)                                                | ---                     | No brittleness,<br>glazing,<br>cracking, or<br>severe<br>discoloration of<br>tubing | No brittleness,<br>glazing,<br>cracking, or<br>severe<br>discoloration of<br>tubing |                                       |
| Followed by test for:<br>Ultimate Elongation                                                          | Percent                 | 200 minimum                                                                         | 200 minimum                                                                         |                                       |

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

| PROPERTY                                                                                                                                                                                                                                                  | UNIT                                                        | TYPE 1                                                           | TYPE 2                                                           | TEST METHOD                                                            |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------|------------------------------------------------------------------|------------------------------------------------------------------|------------------------------------------------------------------------|
| <b>CHEMICAL</b> (continued)<br>Flammability                                                                                                                                                                                                               | ---                                                         | Self-extinguishing within 1 minute, 25% maximum flag burn        | ---                                                              | ASTM D 2671<br>Procedure B                                             |
| Water Absorption<br>24 hours at 23°C (73°F)                                                                                                                                                                                                               | Percent                                                     | 0.5 maximum                                                      | 0.2 maximum                                                      | ASTM D 2671                                                            |
| Fluid Resistance<br>24 hours at 23°C (73°F) in:<br>JP-8 Fuel (MIL-T-83133)<br>Skydrol* 500<br>Hydraulic Fluid (MIL-PRF-5606)<br>Aviation Gasoline (100)<br>(ASTM D 910)<br>Water<br>Followed by tests for:<br>Dielectric Strength<br><br>Tensile Strength | ---                                                         | ---                                                              | ---                                                              | ASTM D 2671                                                            |
|                                                                                                                                                                                                                                                           | Volts/mil<br>(volts/mm)                                     | 400 minimum<br>(15,760)                                          | 400 minimum<br>(15,760)                                          |                                                                        |
|                                                                                                                                                                                                                                                           | psi (MPa)                                                   | 1000 minimum<br>(6.9)                                            | 1000 minimum<br>(6.9)                                            |                                                                        |
| Fungus Resistance<br><br>Followed by tests for:<br>Tensile Strength<br><br>Ultimate Elongation<br>Dielectric Strength                                                                                                                                     | psi (Mpa)<br><br>percent<br>Volts per mil<br>(volts per mm) | 1500 minimum<br>(10.3)<br>200 minimum<br>500 minimum<br>(19,680) | 1500 minimum<br>(10.3)<br>200 minimum<br>500 minimum<br>(19,680) | ISO 846<br>Method B<br><br>Section 4.3.2<br>ASTM D 2671<br>ASTM D 2671 |

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NOTE 1: Recover the specimens on the metal mandrels for 10 minutes, minimum, at  $175 \pm 3^\circ\text{C}$  ( $347 \pm 5^\circ\text{F}$ ) or until the tubing is completely shrunk on the mandrels.

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