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Contact us

Tel: +86-755-8981 8866 Fax: +86-755-8427 6832

Email & Skype: info@chipsmall.com Web: www.chipsmall.com

Address: A1208, Overseas Decoration Building, #122 Zhenhua RD., Futian, Shenzhen, China



Tyco Electronics Corporation
300 Constitution Drive
Menlo Park, CA 94025 USA

Raychem

Specification

This Issue:

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RT-780_Type-I

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Issue 4

**Raychem RT-780 Type I Tubing
Nuclear, Biological, Chemical Contamination Survivable
Modified Fluoropolymer, Radiation Crosslinked, Flexible, Heat Shrinkable**

1. SCOPE

This specification covers the requirements for one type of flexible, electrical insulating extruded tubing whose diameter will reduce to a predetermined size upon the application of heat in excess of 180°C (356°F). The tubing is suitable for use in wire harness systems requiring resistance to the effects of nuclear, biological and chemical contamination and decontamination using solution of STB as defined herein and in RT-700.

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

| | |
|---------------|--|
| MIL-PRF-372 | Bore Cleaner |
| SAE-AMS-1424 | Deicing/Anti-Icing Fluid, Aircraft, SAE Type I (formerly MIL-A-8243) |
| MIL-PRF-2104 | Lubricating Oil, Internal Combustion Engine, Heavy Duty |
| MIL-PRF-23699 | Lubricating Oil, Aircraft Turbine Engine, Synthetic Base |
| MIL-PRF-46167 | Lubricating Oil, Internal Combustion Engine, Arctic |
| MIL-PRF-46170 | Hydraulic Fluid, Rust Inhibited, Fire-resistance, Synthetic Hydrocarbon Base |
| MIL-DTL-83133 | Turbine Fuel, Aviation, Kerosene Type, Grade JP-8 |

Federal

| | |
|------------|---|
| A-A-52557A | Fuel Oil, Diesel DF-2 |
| A-A-59133 | Cleaning Compound, High Pressure (Steam) Cleaner (formerly P-C-437) |

Ordnance Drawings

| | |
|----------|-------------|
| 10873919 | Electrolyte |
|----------|-------------|

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2.2 OTHER PUBLICATIONS

American Society for Testing and Materials (ASTM)

| | |
|------------|---|
| ASTM G21 | Standard Recommended Practice for Determining Resistance of Synthetic Polymeric Materials to Fungi |
| ASTM D149 | Test Methods for Dielectric Breakdown Voltage and Dielectric Strength of Solid Electrical Insulating Materials at Commercial Power Frequencies. |
| ASTM D412 | Standard Methods of Test for Rubber Properties in Tension |
| ASTM D570 | Standard Methods of Test for Water Absorption of Plastics |
| ASTM D632 | Standard Specification for Sodium Chloride |
| ASTM D792 | Specific Gravity & Density of Plastics by Displacement, Tests for |
| ASTM D910 | Standard Specification for Gasoline |
| ASTM D1876 | Test Method for Peel Resistance of Adhesives (T-Peel Test) |
| ASTM D2671 | 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.)

Tyco Electronics Corporation

| | |
|---------|--|
| RT-700 | 700 Series Harness Component Performance Specification |
| RT-1014 | S1255-04 One-part Tape Epoxy, Flexible |

3. REQUIREMENTS

3.1 MATERIAL

The product shall consist of a heat shrinkable, crosslinked, thermally stabilized, flame-retardant, modified fluoropolymer material. The product shall be homogeneous and essentially free from flaws, defects, pinholes, bubbles, cracks and inclusions.

3.2 COLOR

The tubing shall be available in black and orange.

3.3 PROPERTIES

The tubing shall meet the requirements of Table 3.

3.4 SYSTEMS PERFORMANCE

The performance of harness systems fabricated with this material shall satisfy the requirements of Raychem Specification RT-700.

4. QUALITY ASSURANCE PROVISIONS

4.1 CLASSIFICATION OF TESTS

4.1.1 Qualification Tests

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

Dimensions
Longitudinal Change
Tensile Strength
Ultimate Elongation
Heat Shock

4.2 SAMPLING INSTRUCTIONS

4.2.1 Qualification Test Samples

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

Size Ranges

1/4 through 3/4 inch
Above 3/4 inch

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 in accordance with 4.3.1. Prior to all testing, the test specimens (and measurement gauges, when applicable) shall be conditioned for 3 hours at $23 \pm 3^{\circ}\text{C}$ ($73 \pm 5^{\circ}\text{F}$) and 50 ± 5 percent relative humidity. All ovens shall be of the mechanical convection type in which air passes the specimens at a velocity of 100 to 200 feet (30 to 60 m) per minute.

4.3.1 Dimensions, Dimensional Recovery, Longitudinal Change and Concentricity

Measure three 6 inch (152 mm) specimens of tubing, as supplied, for length $\pm 1/32$ inch (± 1 mm) and inside diameter in accordance with ASTM D 2671. Recover these specimens fully by conditioning for 3 minutes in a $225 \pm 5^{\circ}\text{C}$ ($437 \pm 9^{\circ}\text{F}$) oven. Remove the specimens from the oven, allow to cool to $23 \pm 3^{\circ}\text{C}$ ($73 \pm 5^{\circ}\text{F}$) and re-measure. Calculate longitudinal change as follows:

$$\text{LC} = \frac{L_1 - L_0}{L_0} \times 100$$

Where: LC = Longitudinal Change [Percent]
L₀ = Length Before Conditioning [inches (mm)]
L₁ = Length After Conditioning [inches (mm)]

Measure the wall thickness of three 6 inch (152 mm) long specimens, as supplied, in accordance with ASTM D 2671. Calculate concentricity as follows:

$$\text{C} = \frac{M_1}{M_2} \times 100$$

Where: C = Concentricity [Percent]
M₁ = Minimum Thickness [inches (mm)]
M₂ = Maximum Thickness [inches (mm)]

4.3.2 Tensile Strength, Ultimate Elongation and Secant Modulus

Test three specimens of tubing for tensile strength and ultimate elongation in accordance with ASTM D 2671 and for tensile stress in accordance with ASTM D412 and a jaw separation speed of 2.0 ± 0.2 inches (51 ± 5 mm) per minute.

4.3.3 Low Temperature Flexibility

Condition three specimens, each 12 inches (300 mm) in length, and a mandrel selected in accordance with Table 2, at $-55 \pm 3^\circ\text{C}$ ($-67 \pm 5^\circ\text{F}$) for 4 hours. For tubing sizes $3/4$ or less, use 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 $3/4$, use $1/4$ inch (6.3 mm) wide strips cut from tubing which has been recovered in accordance with 4.3.1. After 4 hours conditioning and while still at the conditioning temperature, wrap the specimens consisting of whole sections of tubing around the mandrel for not less than 180 degrees in 10 ± 2 seconds. Wrap strip specimens around the mandrel for not less than 360 degrees in 10 ± 2 seconds. Examine the specimens visually for evidence of cracking.

4.3.4 Heat Shock

Condition three 6 inch (152 mm) specimens of tubing for 4 hours in a $275 \pm 5^\circ\text{C}$ ($527 \pm 9^\circ\text{F}$) oven. Remove the specimens from the oven, cool to $23 \pm 3^\circ\text{C}$ ($73 \pm 5^\circ\text{F}$), wrap 360 degrees around a mandrel selected in accordance with Table 2 and then visually examine for evidence of dripping, flowing or cracking. Any side cracking caused by flattening of the specimen on the mandrel shall not constitute failure.

4.3.5 Heat Resistance

Condition three 6 inch (152 mm) specimens prepared in accordance with 4.3.1 for 336 hours in a $200 \pm 3^\circ\text{C}$ ($392 \pm 5^\circ\text{F}$) 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 Corrosive Effect - Copper Mirror

Test the tubing for copper mirror corrosion in accordance with ASTM D 2671, Procedure A, for 16 hours at $175 \pm 3^\circ\text{C}$ ($347 \pm 5^\circ\text{F}$). Use specimens of $1/4 \times 1$ inch (6×25 mm) strips cut longitudinally from the tubing. Evidence of corrosion shall be the removal of copper from the mirror, leaving an area of transparency greater than 5 percent of its total area.

4.3.7 Fluid Resistance

4.3.7.1 Six 6 inch (152 mm) long specimens shall be prepared from fully recovered samples for each fluid listed in Table 3. The specimens shall be cooled to room temperature and three designated for weight increase (W_1) shall be weighed. All specimens shall be immersed in the test fluid for the time and temperature listed in Table 3. The specimens shall be removed from the fluid, lightly wiped and air dried for at least thirty minutes. The specimens shall be prepared and the tests for tensile strength and elongation performed on three of the specimens in accordance with 4.3.2 within thirty to sixty minutes after removal from the fluid. The weight increase specimens (W_2) shall be reweighed after thirty to sixty minutes drying time and the weight increase calculated as follows:

$$\% \text{ Weight Increase} = \frac{W_2 - W_1}{W_1} \times 100$$

4.3.8 Flammability

Flammability tests shall be performed in accordance with ASTM D 2671 Procedure C on a 22 inch (559 mm) length of the tubing.

4.3.9 Radiation Resistance

Three specimens prepared in accordance with Section 4.3.1 shall be subjected to gamma radiation for a total dosage of 10 Mrad at a rate of less than 0.5 Mrad per hour. The specimens shall be measured for tensile strength and ultimate elongation in accordance with Section 4.3.2.

4.4 REJECTION AND RETEST

Failure of any sample to conform to any one of the requirements of the specification shall be cause for rejection of the lot represented. Product that 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. PREPARATION FOR DELIVERY

5.1 PACKAGING

Packaging shall be in accordance with good commercial practice.

5.2 MARKING

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

TABLE 1
Inside Diameters and Wall Thickness of Tubing

| Size No. | As Supplied | | Recovered Dimensions | | | | | | | |
|----------|-------------------------|-------|-------------------------|-------|----------------|------|---------|------|---------|------|
| | Inside Diameter Minimum | | Inside Diameter Maximum | | Wall Thickness | | | | | |
| | | | | | Minimum | | Maximum | | Nominal | |
| | in | mm | in | mm | in | mm | in | mm | in | mm |
| 1/8 | .125 | 3.17 | .062 | 1.57 | .011 | 0.28 | .017 | 0.43 | .014 | 0.35 |
| 3/16 | .187 | 4.74 | .093 | 2.36 | .013 | 0.33 | .019 | 0.48 | .016 | 0.41 |
| 1/4 | .250 | 6.35 | .125 | 3.18 | .015 | 0.38 | .022 | 0.56 | .018 | 0.46 |
| 3/8 | .375 | 9.53 | .187 | 4.75 | .018 | 0.46 | .024 | 0.61 | .020 | 0.51 |
| 1/2 | .500 | 12.70 | .250 | 6.35 | .020 | 0.51 | .026 | 0.66 | .022 | 0.56 |
| 5/8 | .625 | 15.88 | .313 | 7.95 | .023 | 0.58 | .030 | 0.76 | .026 | 0.66 |
| 3/4 | .750 | 19.05 | .375 | 9.53 | .029 | 0.74 | .035 | 0.91 | .032 | 0.81 |
| 1 | 1.000 | 25.40 | .500 | 12.70 | .034 | 0.86 | .041 | 1.04 | .037 | 0.99 |
| 1-1/4 | 1.250 | 31.75 | .625 | 15.88 | .037 | 0.94 | .044 | 1.12 | .040 | 1.01 |
| 1-1/2 | 1.500 | 38.10 | .750 | 19.05 | .041 | 1.04 | .048 | 1.22 | .045 | 1.14 |
| 2 | 2.000 | 50.80 | 1.000 | 25.40 | .044 | 1.12 | .052 | 1.32 | .048 | 1.22 |

TABLE 2

Mandrel Dimensions for Low Temperature Flexibility Testing

| Tubing Size | | | Mandrel Diameter | |
|-------------|---------|-----|------------------|------|
| | | | in | mm |
| 1/8 | through | 3/8 | 5/16 | 7.9 |
| 1/2 | through | 2 | 7/16 | 11.1 |

TABLE 3
Requirements

| PROPERTY | UNIT | REQUIREMENT | TEST METHOD |
|---|----------------------------|---|--|
| PHYSICAL | | | |
| Dimensions | inches (<i>mm</i>) | In accordance with Table 1 | Section 4.3.1 |
| Longitudinal Change | Percent | +0, -10 | ASTM D2671 |
| Concentricity as Supplied | Percent | 60 minimum | |
| Tensile Strength | psi (<i>MPa</i>) | 3000 (<i>20.7</i>) minimum | Section 4.3.2 |
| Ultimate Elongation | Percent | 300 minimum | ASTM D2671 |
| Secant Modulus, 2% (Expanded) | psi (<i>MPa</i>) | 50,000 (<i>345</i>) maximum | ASTM D2671 |
| Specific Gravity | --- | 2.0 maximum | ASTM D792 |
| Low Temperature Flexibility 4 hours at $-55 \pm 3^{\circ}\text{C}$ ($-67 \pm 5^{\circ}\text{F}$) | --- | No cracking | Section 4.3.3 |
| Heat Shock 4 hours at $275 \pm 5^{\circ}\text{C}$ ($527 \pm 9^{\circ}\text{F}$) | --- | No dripping, flowing or cracking | Section 4.3.4 |
| Heat Resistance 336 hours at $200 \pm 3^{\circ}\text{C}$ ($392 \pm 5^{\circ}\text{F}$) Followed by test for | --- | --- | Section 4.3.5 |
| Tensile | psi | 2000 (<i>13.8</i>) minimum | Section 4.3.2 |
| Ultimate Elongation | Percent | 150 minimum | ASTM D2671 |
| ELECTRICAL | | | |
| Dielectric Strength | Volts/mil (<i>kV/mm</i>) | 200 (<i>7.9</i>) minimum | ASTM D2671 |
| Volume Resistivity | ohm-cm | 10^{11} minimum | ASTM D2671 |
| CHEMICAL | | | |
| Corrosion - Copper Mirror 16 hours at $175 \pm 3^{\circ}\text{C}$ ($347 \pm 5^{\circ}\text{F}$) | --- | Noncorrosive | Section 4.3.6 ASTM D2671 Procedure A |
| Flammability | --- | 1) 25% maximum flag burn 2) No burning of cotton 3) No flaming or glowing longer than 60 seconds | Section 4.3.8 ASTM D2671 Procedure C |
| Fungus Resistance | --- | Rating of 1 or less | ASTM G21 |
| Water Absorption 24 hours at $23 \pm 3^{\circ}\text{C}$ ($73 \pm 5^{\circ}\text{F}$) | Percent | 0.5 maximum | ASTM D2671 |

TABLE 3
Requirements (continued)

| PROPERTY | UNIT | REQUIREMENT | TEST METHOD |
|---|---------------------------------|---|--------------------------------------|
| CHEMICAL (continued) Fluid Resistance <u>24 hours at 23 ± 3°C (73 ± 5°F)</u> JP-8 (MIL-DTL-83133) Followed by tests for: Tensile Strength Ultimate Elongation Weight Increase | psi (MPa) Percent Percent | 2000 (13.8) minimum 250 minimum 3 maximum | Section 4.3.7.1 |
| Fluid Resistance <u>24 hours at 50 ± 3°C (122 ± 5°F)</u> a) Bore Cleaner (MIL-PRF-372) b) Diesel Fuel, DF-2, A-A-52557A c) Anti-Icing Fluid (SAE-AMS-1424) d) Salt-5% solution (ASTM D632) e) Lubricating Oil (MIL-PRF-2104) f) Lubricating Oil (MIL-PRF-23699) g) Arctic Lube (MIL-PRF-46167) h) Cleaning Compound (A-A-59133) i) Electrolyte (p/n 10873919) Followed by tests for: Tensile Strength Ultimate Elongation Weight Increase | psi (MPa) Percent Percent | 2000 (13.8) minimum 250 minimum 3 maximum | Section 4.3.7.1 Section 4.3.2 |
| <u>24 hours at 71 ± 3°C (160 ± 5°F)</u> Hydraulic Fluid (MIL-PRF-46170) Followed by tests for: Tensile Strength Ultimate Elongation Weight Increase | psi (MPa) Percent Percent | 2000 (13.8) minimum 250 minimum 3 maximum | Section 4.3.7.1 |
| NUCLEAR Radiation Resistance Followed by tests for: Tensile Strength Ultimate Elongation | psi (MPa) Percent | 2000 (13.8) minimum 150 minimum | Section 4.3.9 |