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Raychem

Specification	**RT-770_Type-I**
This Issue:	Issue 3
Date:	November 10, 2009
Replaces:	Issue 2

Raychem RT-770 Type I Tubing
Nuclear, Biological, Chemical Contamination Survivable
Modified Fluoropolymer, Radiation Crosslinked, Heat Shrinkable

1. SCOPE

This specification covers the requirements for one type of flexible, electrical insulating, extruded component whose diameter will reduce to a predetermined size upon the application of heat in excess of 150ºC *(302°F)*. The tubing is suitable for use in wire harness systems requiring resistance to the effects of nuclear, biological and chemical exposure and decontamination using DS-2 and 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-AMS1424	Deicing fluid (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	Arctic Lube
MIL-PRF-46170	Hydraulic Fluid, Rust Inhibited, Fire-resistance, Synthetic Hydrocarbon Base
MIL-DTL-83133	Turbine Fuel, Aviation, 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

* Raychem RT-770 Type I is a trade mark of Tyco Electronics/Raychem

2.2 OTHER PUBLICATIONS

American Society for Testing and Materials (ASTM)

ASTM G 21	Standard Recommended Practice for Determining Resistance of Synthetic Polymeric Materials to Fungi
ASTM D 149	Test Methods for Dielectric Breakdown Voltage and Dielectric Strength of Solid Electrical Insulating Materials at Commercial Power Frequencies.
ASTM D 412	Standard Methods of Test for Rubber Properties in Tension
ASTM D 570	Standard Methods of Test for Water Absorptions of Plastics
ASTM D 632	Standard Specification for Sodium Chloride
ASTM D 792	Specific Gravity & Density of Plastics by Displacement, Tests for
ASTM D 910	Standard Specification for Gasoline
ASTM D 1876	Test Method for Peel Resistance of Adhesives (T-Peel Test)
ASTM 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.)

Tyco Electronics Corporation

RT-700	System 700 Series Harness Component Performance Specification
RT-1012	Epoxy, Flexible, Two-part, Raychem Type S1264

3. REQUIREMENTS

3.1 MATERIAL

The product shall consist of a heat shrinkable, cross-linked, modified fluoropolymer material. The product shall be essentially free from flaws, defects, pinholes, bubbles, cracks and inclusions.

3.2 COLOR

The product shall be black.

3.3 FORM

The form shall be a single layer, flexible, NBC agent resistant tubing with a shrink ratio of approximately 2:1.

3.4 PROPERTIES

The product shall meet the requirements of Table 3.

3.5 SYSTEM PERFORMANCE

The performance of harness systems fabricated with this material shall satisfy the requirements of Raychem 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

3/4 inch and smaller
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 that 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 ± 3°C *(73 ± 5°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, Longitudinal Change and Concentricity

4.3.1.1 Three 6 inch *(152 mm)* specimens of tubing, as supplied, shall be measured for length, ± 1/32 inch *(± 1 mm)* and inside diameter in accordance with ASTM D 2671. These specimens shall be conditioned for 3 minutes in a 200 ± 5°C *(392 ± 9°F)* oven, removed from the oven and cooled to 23 ± 3°C *(73 ± 5°F)* and then re-measured. Longitudinal change shall be calculated as follows:

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

Where: LC = Longitudinal Change [percent]
L_0 = Length Before Conditioning [inches *(mm)*]
L_1 = Length After Conditioning [inches *(mm)*]

4.3.1.2 The wall thickness of three expanded 6 inch *(152 mm)* long specimens shall be measured in accordance with ASTM D 2671. The concentricity shall be calculated as follows:

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

Where: C = Concentricity [percent]
M_1 = Minimum Thickness [inches *(mm)*]
M_2 = 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 D2671 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 shall be used.

4.3.3 Low Temperature Flexibility

Three specimens, each 12 inches *(305 mm)* in length, and a mandrel selected in accordance with Table 2, shall be conditioned at -55 ± 3°C *(-67 ± 5°F)* for 4 hours. For tubing sizes 3/4 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 3/4, the specimens shall be 1/4 inch *(6.4 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, the specimens consisting of whole sections of tubing shall be wrapped around the mandrel (from Table 2) for not less than 180 degrees in 10 ± 2 seconds. Strip specimens shall be wrapped around the mandrel for not less than 360 degrees in 10 ± 2 seconds. The specimens then shall be visually examined for evidence of cracking.

4.3.4 Heat Shock

Three 6 inch *(152 mm)* specimens of tubing shall be conditioned for 4 hours in a 225 ± 5°C *(437 ± 9°F)* oven. After conditioning, the specimens shall be removed from the oven, cooled to 23 ± 3°C *(73 ± 5°F)* and visually examined for evidence of dripping, flowing or cracking.

4.3.5 Heat Resistance

Three 6 inch *(152 mm)* specimens prepared in accordance with 4.3.1 shall be conditioned for 336 hours in a 175 ± 3°C *(347 ± 5°F)* oven. After conditioning, the specimens shall be removed from the oven, cooled to 23 ± 3°C *(73 ± 5°F)* and tested for tensile strength and ultimate elongation in accordance with 4.3.2.

4.3.6 Dielectric Strength

The dielectric strength of the tubing shall be measured under oil in accordance with ASTM D 149. Five 6 inch *(152 mm)* specimens of tubing shall be recovered over a metal mandrel by conditioning for 3 minutes in a 200 ± 5°C *(392 ± 9°F)* oven. The mandrel diameter shall be slightly larger than the fully recovered inside diameter of the tubing being tested. The metal mandrel shall serve as one electrode and a 1 inch *(25 mm)* wide strip of metal foil wrapped around the outside of the tubing as the other electrode. The test voltage shall be applied at a rate of rise of 500 volts per second. Thickness measurements for calculating dielectric strength shall be made adjacent to the point of breakdown.

4.3.7 Corrosive Effect – Copper Mirror

Test the tubing for copper mirror corrosion in accordance with ASTM D 2671, Procedure A, for 16 hours at 175 ± 2ºC *(347 ± 4ºF)*. Use specimens of 1/4 x 1 inch *(6 x 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.

4.3.8 Fungus Resistance

Three 3 inch *(76 mm)* long specimens shall be tested in accordance with ASTM G 21.

4.3.9 Water Absorption

Three 1/4 inch *(6.3 mm)* wide strips, 3 inches *(76 mm)* long shall be tested in accordance with ASTM D 2671.

4.3.10 Flammability

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

4.3.11 Fluid Resistance

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:

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

4.3.12 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 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. 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 size, quantity, manufacturer's identification, lot number and date of manufacture.

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	0.125	*3.17*	0.062	*1.57*	0.011	*0.28*	0.017	*0.43*	0.014	*0.35*
3/16	0.187	*4.74*	0.093	*2.36*	0.013	*0.33*	0.019	*0.48*	0.016	*0.41*
1/4	0.250	*6.35*	0.125	*3.17*	0.015	*0.38*	0.022	*0.56*	0.018	*0.46*
3/8	0.375	*9.50*	0.187	*4.74*	0.018	*0.46*	0.24	*0.61*	0.020	*0.51*
1/2	0.500	*12.70*	0.250	*6.35*	0.020	*0.51*	0.026	*0.66*	0.022	*0.56*
5/8	0.625	*15.90*	0.312	*7.93*	0.023	*0.58*	0.030	*0.76*	0.026	*0.66*
3/4	0.750	*19.05*	0.375	*9.50*	0.029	*0.74*	0.036	*0.91*	0.032	*0.81*
1	1.000	*25.40*	0.500	*12.70*	0.034	*0.86*	0.041	*1.04*	0.037	*0.99*
1-1/4	1.250	*31.75*	0.625	*15.87*	0.037	*0.94*	0.044	*1.12*	0.040	*1.01*
1-1/2	1.500	*38.10*	0.750	*19.05*	0.041	*1.04*	0.048	*1.22*	0.045	*1.14*
2	2.000	*50.80*	1.000	*25.40*	0.044	*1.12*	0.052	*1.32*	0.048	*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 *(mm)*	In accordance with Table 1	Section 4.3.1 ASTM D 2671
Concentricity	percent	60 minimum	Section 4.3.1
Longitudinal Change	percent	+1, -8	Section 4.3.1 ASTM D 2671
Tensile Strength	psi *(MPa)*	2500 *(17.3)* minimum	Section 4.3.2 ASTM D 2671
Ultimate Elongation	percent	300 minimum	Section 4.3.2 ASTM D 2671
Secant Modulus (expanded), 2%	psi *(MPa)*	100,000 (*689*) maximum	Section 4.3.2 ASTM 2671
Specific Gravity		1.85 maximum	ASTM D 792
Low Temperature Flexibility 4 hours at -55 ± 3°C *(-65 ± 5°F)*		No cracking	Section 4.3.3
Heat Shock 4 hours at 225 ± 5°C *(437 ± 9°F)*		No dripping, flowing or cracking	Section 4.3.4
Heat Resistance 336 hours at 175 ± 3°C *(347 ± 5°F)* Followed by tests for: Tensile Strength Ultimate Elongation	 psi *(MPa)* percent	 2000 *(13.8)* minimum 250 minimum	Section 4.3.5
ELECTRICAL Dielectric Strength	volts/mil *(kV/mm)*	400 *(15.7)* minimum	Section 4.3.6 ASTM D 149
Volume Resistivity	ohm-cm	1×10^{11} minimum	ASTM D 2671

TABLE 3
Requirements
(continued)

PROPERTY	UNIT	REQUIREMENT	TEST METHOD
CHEMICAL Copper Mirror Corrosion 16 hours at 175 ± 3ºC *(347 ± 5ºF)*	---	Non corrosive	Section 4.3.7 ASTM D 2671 Procedure A
Fungus Resistance	Growth	Rating of 1 or less	Section 4.3.8 ASTM G 21
Water Absorption 24 hours at 23 ± 3°C *(73 ± 5°F)*	percent	0.5 maximum	Section 4.3.9 ASTM D 2671
Flammability, Average Burn Time	seconds	15 maximum	Section 4.3.10 ASTM D 2671, Procedure A
Fluid Resistance 24 hours at 23 ± 3°C *(73 ± 5°F)* a) JP-8 Jet Fuel (MIL-DTL-83133) b) Diesel Fuel DF-2 (A-A-52557A) Followed by tests for: Tensile Strength Ultimate Elongation Weight Increase 24 hours at 50 ± 3°C *(122 ± 5°F)* a) Bore Cleaner (MIL-PRF-372) b) Anti-Icing Fluid (SAE-AMS-1424) c) Salt-5% solution (ASTM D 632) d) Lubricating Oil (MIL-PRF-2104) e) Lubricating Oil (MIL-PRF-23699) f) Arctic Lube (MIL-PRF-46167) g) Cleaning Compound (A-A-59133) h) Electrolyte (p/n 10873919) Followed by tests for: Tensile Strength Ultimate Elongation Weight Increase 24 hours at 71 ± 3°C *(160 ± 5°F)* Hydraulic, synthetic, (MIL-PRF-46170) Followed by tests for: Tensile Strength Ultimate Elongation Weight Increase	 psi *(Mpa)* Percent Percent psi (*Mpa*) Percent Percent psi (*Mpa*) Percent Percent	 2000 *(13.8)* minimum 250 minimum 3 maximum 2000 *(13.8)* minimum 250 minimum 3 maximum 2000 (*13.8*) minimum 250 minimum 3 maximum	Section 4.3.11
NUCLEAR Radiation Resistance-10 Mrads gamma Followed by tests for: Tensile Strength Ultimate Elongation	 psi (MPa) percent	 2000 (13.8) minimum 150 minimum	Section 4.3.12