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Raychem

Specification	**RT-790_Type-I**
This Issue:	Issue 4
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Raychem RT-790 Type I, Tubing
Nuclear, Biological, Chemical Contamination Survivable
Modified Fluoropolymer, Radiation Crosslinked, Heat Shrinkable
High Temperature, Abrasion Resistant, Flame Retardant

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 220ºC *(428ºF)*. The tubing is suitable for use in wire harness systems requiring resistance to the effects of nuclear, biological and chemical contamination 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
SC-X15111D	Material Specification for Insulation Sleeving, Boots and Transitions, Electrical, Heat Shrinkable (High temp)

Federal

A-A-59133	Cleaning Compound, High Pressure (Steam) Cleaner (Formerly P-C-437)
A-A-52557A	Fuel Oil, Diesel

Drawings, Ordnance

10873919	Electrolyte

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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 Absorption 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.)

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RT-700	700 Series Harness Component Performance Specification
RT-1014	Epoxy, Flexible, Tape Epoxy, Raychem Type S1255-04

3. REQUIREMENTS

3.1 MATERIAL

The product shall consist of a heat shrinkable, crosslinked, thermally stabilized, flame-retarded 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 black.

3.3 PROPERTIES

The tubing shall meet the requirements of Table 3.

3.4 SYSTEM PERFORMANCE

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

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4.1.2 Acceptance Tests

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

Visual
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
1/8 through 3/4
Above 3/4

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.

4.2 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 ± 3ºC *(73 ± 5ºF)* 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 ± 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 250 ± 5ºC *(482 ± 9ºF)* oven. Remove the specimens from the oven, allow to cool to 23 ± 3ºC *(73 ± 5ºF)* and re-measure. Calculate longitudinal change 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)*]

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

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4.3.2 Tensile Strength 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 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

a) Condition three specimens, each 12 inches *(305 mm)* in length, and a mandrel selected in accordance with Table 2, at -65 ± 3°C *(-85 ± 5°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). 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.

b) 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. 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 300 ± 5ºC *(572 ± 9ºF)* oven. Remove the specimens from the oven, cool to 23 ± 3ºC *(73 ± 5ºF)*, 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 4.3.2 for 336 hours in a 250 ± 3ºC *(482 ± 5ºF)* oven. After conditioning, the specimens shall be removed from the oven, cooled to 23 ± 3ºC *(73 ± 5ºF)* 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 200 ± 3ºC *(392 ± 5ºF)*. 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.

4.3.7 Fluid Resistance

Immerse three 6 inch *(152 mm)* specimens of tubing, prepared and measured in accordance with 4.3.2, completely in each listed fluid for the time and temperature specified in Table 3. Use a volume of fluid not less than 20 times that of the specimens. After immersion, lightly wipe the specimens and air-dry for 30 to 60 minutes at room temperature. Test the specimens from each fluid for tensile strength and ultimate elongation in accordance with 4.3.2.

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 4.3.2 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.

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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 Thicknesses 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	*3.18*	.062	*1.57*	.010	*.25*	.016	*.41*	.012	*.30*
3/16	.187	*4.75*	.093	*2.36*	.011	*.28*	.018	*.46*	.014	*.36*
1/4	.250	*6.35*	.125	*3.18*	.013	*.33*	.020	*.51*	.016	*.41*
3/8	.375	*9.53*	.187	*4.75*	.016	*.41*	.023	*.58*	.019	*.48*
1/2	.500	*12.70*	.250	*6.35*	.016	*.41*	.023	*.58*	.019	*.48*
5/8	.625	*15.88*	.313	*7.95*	.019	*.48*	.026	*.66*	.022	*.56*
3/4	.750	*19.05*	.375	*9.53*	.024	*.61*	.031	*.79*	.027	*.69*
1	1.000	*25.40*	.500	*12.70*	.028	*.71*	.035	*.89*	.031	*.79*
1-1/4	1.250	*31.75*	.625	*15.88*	.030	*.76*	.037	*.94*	.033	*.84*
1-1/2	1.500	*38.10*	.750	*19.05*	.034	*.86*	.041	*1.04*	.037	*.94*
2	2.000	*50.80*	1.00	*25.40*	.037	*.94*	.044	*1.12*	.040	*1.02*

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*

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TABLE 3
Requirements

PROPERTY	UNIT	REQUIREMENTS	TEST METHOD
PHYSICAL			
Dimensions	inches *(mm)*	In accordance with Table 1	Section 4.3.1
Longitudinal Change	Percent	+0, -10	ASTM D 2671
Concentricity as Supplied	Percent	60 minimum	
Tensile Strength	psi *(MPa)*	4000 *(27.6)* minimum	Section 4.3.2
Ultimate Elongation	Percent	300 minimum	ASTM D 2671
Secant Modulus, 2%, (Expanded)	psi *(MPa)*	50,000 *(345)* maximum	ASTM D 2671
Specific Gravity	---	2.0 maximum	ASTM D 792
Low Temperature Flexibility 4 hours at -65 ± 3°C *(-85 ± 5°F)*	---	No cracking	Section 4.3.3
Heat Shock 4 hours at 300 ± 5ºC *(572 ± 9ºF)*	---	No dripping, flowing or cracking	Section 4.3.4
Heat Resistance 336 hours at 250 ± 3ºC *(482 ± 5ºF)* Followed by test for Tensile Ultimate Elongation	--- psi *(MPa)* Percent	--- 2000 *(13.8)* minimum 150 minimum	Section 4.3.5 Section 4.3.2 ASTM D 2671
ELECTRICAL			
Dielectric Strength	Volts/mil *(kV/mm)*	200 *(7.9)* minimum	ASTM D 2671
Volume Resistivity	ohm-cm	10^{11} minimum	ASTM D 2671
CHEMICAL			Section 4.3.6
Copper Mirror Corrosion 16 hours at 200 ± 3ºC *(392 ± 5ºF)*	--- ---	Non corrosive 1) 25% maximum flag burn 2) No burning of cotton 3) No flaming or glowing longer than 60 seconds	ASTM D 2671 Procedure A Section 4.3.8 ASTM D 2671, Procedure C
Flammability			
Fungus Resistance	---	Rating of 1 or less	ASTM G 21
Water Absorption 24 hours at 23 ± 3ºC *(73 ± 5ºF)*	Percent	0.5 maximum	ASTM D 2671

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TABLE 3
Requirements (continued)

PROPERTY	UNIT	REQUIREMENT	TEST METHOD
CHEMICAL (continued)			
Fluid Resistance	---	---	Section 4.3.7
24 hours at 23 ± 3ºC *(73 ± 5ºF)*			
Turbine fuel, JP-8 (MIL-DTL-83133)			
Followed by tests for:			
Tensile Strength	psi *(MPa)*	3500 *(24.1)* minimum	Section 4.3.2
Ultimate Elongation	Percent	250 minimum	ASTM D 2671
Weight Increase	Percent	3 maximum	SC-X-15111D
Fluid Resistance	---	---	Section 4.3.7
24 hours at 50 ± 3ºC *(122 ± 5ºF)*			
Bore Cleaner, (MIL-PRF-372)			
Fuel Oil, Diesel (A-A-52557A)			
5% Salt Solution (ASTM D 632)			
Lubricating Oil (MIL-PRF-2104)			
Deicing Fluid (SAE-AMS1424)			
Lubricating Oil (MIL-PRF-23699)			
Lube, Arctic (MIL-PRF-46167)			
Cleaning Compound (A-A-59133 Type I)			
Electrolyte, (P/N 10873919)			
Followed by tests for:			
Tensile Strength	psi *(MPa)*	3500 *(24.1)* minimum	Section 4.3.2
Ultimate Elongation	Percent	250 minimum	ASTM D 2671
Weight Increase	Percent	3 maximum	SC-X-15111D
Fluid Resistance	---	---	Section 4.3.7
24 hours at 71 ± 3ºC *(160 ± 5ºF)*			
Hydraulic Fluid (MIL-PRF-46170)			
Followed by tests for:			
Tensile Strength	psi *(MPa)*	3500 *(24.1)* minimum	Section 4.3.2
Ultimate Elongation	Percent	250 minimum	ASTM D 2671
Weight Increase	Percent	3 maximum	SC-X-15111D
NUCLEAR			Section 4.3.9
Radiation Resistance			
Followed by tests for:			
Tensile Strength	psi *(MPa)*	3000 *(20.7)* minimum	
Ultimate Elongation	percent	150 minimum	

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