

Raychem

Specification RT-555
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Raychem RT-555 TUBING Modified Fluoropolymer, Radiation Crosslinked, Flexible, Abrasion Resistant, Flame Retardant, 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 220°C (428°F). The tubing is suitable for use in wire harness systems requiring high fluid resistance.

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

<u>Military</u>	
MIL-PRF-372	Cleaning Compound, Solvent
SAE-AMS1424	Fluid, Deicing/Anti-Icing, Aircraft, SAE Type 1
MIL-PRF-2104	Lubricating Oil, Internal Combustion Engine, Combat/Tactical Service
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-PRF-5606	Hydraulic Fluid, Petroleum Base, Aircraft; Missile and Ordinance
MIL-PRF-2104	Lubricating Oil, Internal Combustion Engine, Combat/Tactical Service
MIL-PRF-7808	Lubricating Oil, Aircraft Turbine Engine, Synthetic Base
MIL-DTL-83133	Turbine Fuels, Aviation Kerosene Types, Nato F-34(JP-8), Nato F-35, JP-8 + 100

Federal

A-A-52557 Fuel Oil, Diesel for Posts, Camps and Stations

A-A-59133 Cleaning Compound, High Pressure (Steam) Cleaner (formerly P-C-437)

Ordnance Drawings

10873919 Electrolyte

2.2 OTHER PUBLICATIONS

ASTM D 412	Standard Test Methods for Vulcanized Rubber & Thermoplastic Elastomers
ASTM D 792	Specific Gravity & Density of Plastics by Displacement, Tests for
ASTM D 910	Standard Specification for Aviation Gasoline
ASTM D 2671	Standard Methods of Testing Heat-Shrinkable Tubing for Electrical Use
A CTM D 4014	Standard Consideration for Automotive Cond. Invition First

ASTM D 4814 Standard Specification for Automotive Spark-Ignition Fuel

ASTM G 21 Standard Recommended Practice for Determining Resistance of Synthetic Polymeric

Materials to Fungi

American Society for Testing and Materials (ASTM)

(Copies of ASTM publications may be obtained from the American Society for Testing and Materials, 1916 Race Street, Philadelphia, Pennsylvania 19103.)

NASA

SP-R-0022 General Specification, Vacuum Stability Requirements of Polymeric Material for Spacecraft Applications

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 black unless otherwise specified.

3.3 PROPERTIES

The tubing shall meet the requirements of Tables 1 and 3.

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 <u>Acceptance Tests</u>

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 1" through 2"

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 $23 \pm 3^{\circ}$ C $(73 \pm 5^{\circ}F)$ 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 (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. Recover these specimens fully by conditioning for 3 minutes in a 250 \pm 5°C (482 \pm 9°F) oven. Remove the specimens from the oven, allow to cool to 23 \pm 3°C (73 \pm 5°F) and re-measure. Calculate longitudinal change as follows:

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

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 (150-mm) long specimens, as supplied, in accordance with ASTM D 2671. Calculate concentricity as follows:

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

Where: C = Concentricity [Percent]

M₁ = Minimum Thickness [Inches (mm)] M₂ = Maximum Thickness [Inches (mm)]

4.3.2 <u>Tensile Strength and Ultimate Elongation</u>

Test three specimens of tubing for tensile strength and ultimate elongation in accordance with ASTM D 2671. For tubing sizes 3/8 and smaller, use full sections of tubing. For sizes 1/2 and larger, cut the specimens with Die D, ASTM D 412. Apply 1-inch (25-mm) centrally located benchmarks to the specimens. Use an initial machine jaw separation of 1 inch (25-mm) for full sections of tubing and 2 inches (51-mm) for die cut specimens. Test at a rate of jaw separation of 2.0 ± 0.2 inches $(50 \pm 5\text{-}mm)$ per minute.

4.3.3 <u>Low Temperature Flexibility</u>

Condition three specimens, each 12 inches (300 mm) in length, and a mandrel selected in accordance with Table 2, at $-65 \pm 3^{\circ}$ C ($-85 \pm 5^{\circ}$ 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 tubing 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 (150-mm) specimens of tubing for 4 hours in a $300 \pm 5^{\circ}\text{C}$ (572 $\pm 9^{\circ}F$) oven. Remove the specimens from the oven, cool to $23 \pm 3^{\circ}\text{C}$ (73 $\pm 5^{\circ}F$), 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 (150-mm) specimens prepared in accordance with 4.3.2 for 336 hours in a 250 \pm 3°C (482 \pm 5°F) oven. After conditioning, the specimens shall be removed from the oven, cooled to 23 \pm 3°C (73 \pm 5°F) and tested for tensile strength and ultimate elongation in accordance with 4.3.2.

4.3.6 Copper Stability

Slide three 6-inch (150-mm) specimens of tubing over a snug-fitting, straight, clean, bare solid or tubular copper conductor. Condition the specimens on the conductors for 24 hours in an appropriate humidity chamber at 90 to 95 percent relative humidity and $23 \pm 3^{\circ}\text{C}$ (73 $\pm 5^{\circ}F$), followed by 16 hours in a 200 $\pm 3^{\circ}\text{C}$ (392 $\pm 5^{\circ}F$) oven. After conditioning, remove the specimens from the oven and cool to $23 \pm 3^{\circ}\text{C}$ (73 $\pm 5^{\circ}F$). Remove the copper conductor from the tubing and examine the tubing and conductor. Darkening of the copper due to normal air oxidation shall not be cause for rejection. Test the tubing for ultimate elongation in accordance with 4.3.2.

4.3.7 Corrosive Effect

Test the tubing for copper mirror corrosion in accordance with ASTM D 2671, Procedure A, for 16 hours at $200 \pm 3^{\circ}\text{C}$ (392 $\pm 5^{\circ}F$). 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 8 percent of its total area.

4.3.8 Fluid Resistance

Immerse three 6-inch (150-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.

4.3.9 <u>Flammability After Fluid Exposure</u>

Flammability tests shall be performed in accordance with ASTM D 2671 Procedure C on a 22-inch (559-mm) length of the tubing that has been fully immersed for 24 hours with ends open in fluids specified in Table 3. The outside of the tubing shall be wiped to remove excess fluid and mounted in the apparatus. The inside of the tubing shall be allowed to drain for 5 minutes before flame is applied.

4.3.10 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.

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

	As Su	pplied	Recovered Dimensions							
Size	Inside D	Diameter	Inside Diameter		Wall Thickness					
No.	Mini	mum	Maxi	mum	Mini	Minimum Maximum		mum	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	1.000	25.40	.037	.94	.044	1.12	.040	1.02

TABLE 2
Mandrel Dimensions for Low Temperature Flexibility and Heat Shock Testing

	Mandrel	Mandrel Diameter		
Tubing Size	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	
Longitudinal Change	Percent	+0, -10	ASTM D 2671	
Concentricity as Supplied	Percent	60% minimum		
Tensile Strength	Psi (MPa)	4000 minimum (27.6)	Section 4.3.2	
Ultimate Elongation	Percent	200 minimum	ASTM D 2671	
2% Secant Modulus (Expanded)	Psi (MPa)	50,000 maximum (345)	ASTM D 2671	
Specific Gravity		2.0 maximum	ASTM D 792	
Low Temperature Flexibility		No cracking	Section 4.3.3	
4 hours at -65 \pm 3°C (-85 \pm 5°F)		Two cracking	Section 4.3.3	
Heat Shock		No dripping, flowing or cracking	Section 4.3.4	
4 hours at $300 \pm 5^{\circ}\text{C} (572 \pm 9^{\circ}F)$		Two dripping, nowing of cracking	5000001 4.5.4	
Heat Resistance			Section 4.3.5	
336 hours at $250 \pm 3^{\circ}\text{C}$ (482 ± 5°F)			Section 4.5.5	
Followed by test for			Section 4.3.2	
Ultimate Elongation	Percent	150 minimum	ASTM D 2671	
Vacuum Outgassing	1 CICCIII	150 mmmulii	NASA	
TML (Total Mass Loss)	Percent	1.0 maximum	Specification	
VCM (Volatile Condensible Material)	Percent	0.1 maximum	SP-R-0022A	
Copper Stability		No brittleness, glazing or severe	Section 4.3.6	
16 hours at $200 \pm 3^{\circ}\text{C}$ (392 ± 5°F)		discoloration of tubing. No	Section 4.5.0	
10 hours at 200 ± 3 C (392 ± 3 T)		pitting or blackening of copper.		
Followed by test for		pitting of blackening of copper.	Section 4.3.2	
Ultimate Elongation	Percent	150 minimum	ASTM D 2671	
ELECTRICAL	reicent	130 minimum	ASTWID 2071	
Dielectric Strength	Volts/mil	200 minimum	ASTM D 2671	
Radiation Resistance	V OILS/IIIII	200 minimum	Section 4.3.10	
Followed by tests for:			Section 4.5.10	
ronowed by tests for.				
Tensile Strength	Psi (MPa)	3500 minimum (24.1)		
Ultimate Elongation	Percent	150 minimum		
CHEMICAL	T CICCIII		Section 4.3.7	
Copper Mirror Corrosion	Percent	Copper removal 8% maximum	ASTM D 2671	
16 hours at $200 \pm 3^{\circ}\text{C}$ (392 ± 5°F)		- PP-2 20110 - CI O / O IIIM/IIII/IIII	Procedure A	
Flammability		1) 25% maximum flag burn	ASTM D 2671	
		2) No burning of cotton	Procedure C	
		3) No flaming or glowing		
		longer than 60 seconds		
After fluid immersion		1) 25% maximum flag burn	Section 4.3.9	
24 hours at 23 ± 3°C (73 ± 5°F)		2) No burning of cotton	ASTM D 2671,	
ASTM D 4814 Gasoline,		3) No flaming or glowing	Procedure C	
Automotive Combat		longer than 60 seconds		
24 hours at $50 \pm 3^{\circ}\text{C}$ (122 ± 5°F)				
A-A-52557 Fuel Oil, Diesel				
MIL-DTL-83133 Turbine Fuel,				
Aviation, Grade JP-8		D : 61 1	A CITINA CI CA 1	
Fungus Resistance		Rating of 1 or less	ASTM G 21	
Water Absorption	Percent	0.5 maximum	ASTM D 2671	
24 hours at $23 \pm 3^{\circ}\text{C} (73 \pm 5^{\circ}F)$				

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TABLE 3 Requirements (continued)

PROPERTY	UNIT	REQUIREMENT	TEST METHOD
CHEMICAL (continued)			
Fluid Resistance			Section 4.3.8
24 hours at 23 \pm 3°C (73 \pm 5°F)			
Gasoline, Aviation Grade 100			
(ASTM D 910)			
Coolanol 25*			
Followed by tests for:			
Tensile Strength	Psi (MPa)	3500 minimum (24.1)	Section 4.3.2
Ultimate Elongation	Percent	150 minimum	ASTM D 2671
Fluid Resistance			Section 4.3.8
24 hours at $50 \pm 3^{\circ}\text{C} (122 \pm 5^{\circ}F)$			
JP-8 (MIL-DTL-83133)			
Deicing Fluid (SAE-AMS 1424)			
Cleaning Compound			
(MIL-PRF-372)			
5% Salt Solution			
Fuel Oil, Diesel (A-A-52557)			
Followed by tests for:			
Tensile Strength	Psi (MPa)	3500 minimum (24.1)	Section 4.3.2
Ultimate Elongation	Percent	150 minimum	ASTM D 2671
Fluid Resistance			Section 4.3.8
24 hours at $75 \pm 3^{\circ}\text{C} (167 \pm 5^{\circ}\text{F})$			
Hydraulic Fluid (MIL-PRF-5606)			
Lubricating Oil			
(MIL-PRF-2104)			
Lubricating Oil (MIL-PRF-7808)			
Followed by tests for:			
Tensile Strength	Psi (MPa)	3500 minimum (24.1)	Section 4.3.2
Ultimate Elongation	Percent	150 minimum	ASTM D 2671

^{*}Trademark Solutia, Inc.

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