



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

Raychem

Specification
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Replaces:

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RW-175 TUBING
Poly(Vinylidene Fluoride),
Modified, Irradiated, Heat-Shrinkable

1. SCOPE

This specification covers the requirements for one type of electrical insulating, extruded tubing whose diameter will reduce to a predetermined size upon the application of heat in excess of 175°C (347°F).

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-G-5572	Gasoline, Aviation, Grades 80/87, 100/130 and 115/145
MIL-H-5606	Hydraulic Fluid, Petroleum Base, Aircraft, Missile and Ordnance
MIL-T-5624	Turbine Fuel, Aviation, Grades JP-4 and JP-5
MIL-L-7808	Lubricating Oil, Aircraft Turbine Engine, Synthetic Base
MIL-A-8243	Anti-icing and Deicing - Defrosting Fluid

2.2 OTHER PUBLICATIONS

ISO 846	Plastics – Evaluation of the action of microorganisms.
ASTM D 2671	Standard Methods of Testing Heat-Shrinkable Tubing for Electrical Use
ASTM E 595	Standard Methods of Test for Total Mass Loss and Collected Volatile Condensable Materials from Outgassing in a Vacuum Environment

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

3. REQUIREMENTS

3.1 MATERIAL

The tubing shall be fabricated from modified poly(vinylidene fluoride) compounded to produce a

3.2 COLOR

The tubing described herein shall be supplied in a standard unpigmented state, transparent to translucent light tan (clear) in color, unless otherwise specified.

3.3 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 samples submitted for qualification as a satisfactory product and shall consist of all tests listed in this specification. Qualification of any size within each size range specified below shall qualify all sizes within that size range:

<u>Size Ranges</u>		
3/64	through	3/16
1/4	through	2

4.1.2 Acceptance Tests

Acceptance tests are those performed on tubing submitted for acceptance under contract. Acceptance tests shall consist of the following tests: dimensional recovery, longitudinal change, tensile strength, ultimate elongation, secant modulus 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 tubing of the size specified.

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 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

Unless otherwise specified, tests shall be performed 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. Prior to all testing, the test specimens (and measurement gauges, when applicable) shall be conditioned for at least 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 and Longitudinal Change

Three 6-inch (*150-mm*) specimens of tubing, as supplied, shall be measured for length $\pm 1/32$ inch (± 1 mm) and inside diameter in accordance with ASTM D 2671. These specimens shall be conditioned for 3 minutes in a $200 \pm 5^\circ\text{C}$ ($392 \pm 9^\circ\text{F}$) oven, removed from the oven and cooled to $23 \pm 3^\circ\text{C}$ ($73 \pm 5^\circ\text{F}$), and remeasured for length, inside diameter and wall thickness. Longitudinal change shall be calculated as follows:

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

Where: C = Longitudinal Change [percent]
 L0 = Length Before Conditioning [inches (*mm*)]
 L1 = Length After Conditioning [inches (*mm*)]

4.3.2 Tensile Strength and Ultimate Elongation

The tensile strength and ultimate elongation of the tubing shall be determined in accordance with ASTM D 2671 using 1 inch (*25 mm*) bench marks and a 1 inch (*25 mm*) initial jaw separation. The speed of jaw separation shall be $2 \pm .2$ inches (50 ± 5 mm) per minute.

4.3.3 Low Temperature Flexibility

For tubing of expanded diameter $1/4$ inch (*6 mm*) or greater, three strip specimens $1/4$ inch (*6 mm*) wide and 12 inches (*300 mm*) long shall be cut from the expanded tubing. For tubing of expanded diameter less than $1/4$ inch (*6 mm*) three tubular specimens, 12 inches (*300 mm*) long, shall be cut from the expanded tubing. The specimens shall be recovered in accordance with Section 4.3 and conditioned with appropriate mandrels for 4 hours at $-55 \pm 2^\circ\text{C}$ ($-67 \pm 4^\circ\text{F}$). The mandrel diameter shall be 10 times the specimen thickness, $\pm 10\%$. For tubular specimens, the specimens thickness shall be equivalent to the outside diameter. While at the specified temperature, and without removing the specimens from the cold chamber, the specimens shall be wrapped for 360 degrees around the mandrel in approximately 2 seconds. Any side cracking, caused by flattening of the specimens on the mandrel, shall be disregarded.

4.3.4 Heat Shock

Three 6-inch (*150-mm*) specimens of tubing shall be conditioned for 4 hours in a $300 \pm 5^\circ\text{C}$ ($572 \pm 9^\circ\text{F}$) oven. After this conditioning, the specimens shall be removed from the oven, cooled to $23 \pm 3^\circ\text{C}$ ($73 \pm 5^\circ\text{F}$), wrapped 180 degrees around a mandrel selected in accordance with Table 2, and then visually examined 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

Three 12-inch (*300-mm*) specimens of tubing shall be conditioned for 168 hours in a $250 \pm 5^\circ\text{C}$ ($482 \pm 9^\circ\text{F}$) 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 ultimate elongation in accordance with Section 4.3.2.

4.3.6 Corrosive Effect

4.3.6.1 Copper Mirror Corrosion

The tubing shall be tested for copper mirror corrosion in accordance with ASTM D 2671, Procedure A, for 16 hours at $175 \pm 3^{\circ}\text{C}$ ($347 \pm 5^{\circ}\text{F}$). Evidence of corrosion shall be the removal of copper from a mirror, leaving an area of transparency greater than 5 percent of its total area.

4.3.6.2 Corrosion in Contact with Copper

The tubing shall be tested for corrosion in contact with copper in accordance with ASTM D 2671, Procedure B, for 16 hours at $175 \pm 3^{\circ}\text{C}$ ($347 \pm 5^{\circ}\text{F}$). After conditioning, the tubing shall be tested for ultimate elongation in accordance with Section 4.3.2. Examine the copper for evidence of pitting or blackening.

4.3.7 Fluid Resistance

Six 6-inch (*150-mm*) specimens of tubing, prepared and measured in accordance with ASTM D 2671, shall be completely immersed in each of the fluids listed in Table 3 for 24 ± 2 hours at $23 \pm 3^{\circ}\text{C}$ ($73 \pm 5^{\circ}\text{F}$). The volume of the fluid shall be not less than 20 times that of the specimens. After immersion, the specimens shall be lightly wiped and air dried for 30 to 60 minutes at room temperature. Three specimens then shall be tested for dielectric strength and the other three for tensile strength.

4.4 REJECTION AND RETEST

Failure of a 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 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 FORM

The tubing shall be supplied in lengths of $1200 +25, -0 \text{ mm}$ ($48 +1, -0$ inches) 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 product designation, size, quantity, manufacturer's identification and lot number.

**TABLE 1
Tubing Dimensions**

Size	As Supplied		As Recovered							
	Inside Diameter Minimum		Inside Diameter Maximum		Wall Thickness					
					Minimum		Maximum		Nominal	
	in.	mm.	in.	mm.	in.	mm.	in.	mm.	in.	mm.
3/64	.046	1.17	.023	0.58	.008	0.20	.012	0.31	.010	0.25
1/16	.063	1.60	.031	0.79	.008	0.20	.012	0.31	.010	0.25
3/32	.093	2.36	.046	1.17	.008	0.20	.012	0.31	.010	0.25
1/8	.125	3.18	.062	1.58	.008	0.20	.012	0.31	.010	0.25
3/16	.187	4.75	.093	2.36	.008	0.20	.012	0.31	.010	0.25
1/4	.250	6.35	.125	3.18	.011	0.28	.015	0.38	.013	0.33
3/8	.375	9.53	.187	4.75	.011	0.28	.015	0.38	.013	0.33
1/2	.500	12.70	.250	6.35	.011	0.28	.015	0.38	.013	0.33
3/4	.750	19.05	.375	9.53	.014	0.36	.020	0.51	.017	0.43
1	1.000	25.40	.500	12.70	.016	0.41	.022	0.56	.019	0.48
1-1/2	1.500	38.10	.750	19.05	.017	0.43	.023	0.58	.020	0.51
2	2.000	50.80	1.000	25.40	.017	0.43	.023	0.58	.020	0.51

**TABLE 2
Mandrel Dimensions**

Tubing Size	Mandrel Diameter	
	in	mm.
3/64 through 3/16	5/16	7.9
1/4 through 2	3/4	19.1

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 maximum	ASTM D 2671
Tensile Strength	psi (<i>MPa</i>)	5000 minimum (34.5)	Section 4.3.2
Ultimate Elongation	Percent	150 minimum	ASTM D 2671
Secant Modulus (expanded)	psi(<i>MPa</i>)	1 x 10 ⁵ minimum (690)	ASTM D 2671
Specific Gravity		1.8 maximum	ASTM D 2671
Low Temperature Flexibility 4 hours at -55 ± 2°C (-67 ± 4°F)	---	No cracking	Section 4.3.3
Heat Shock 4 hours 300 ± 5°C(572 ± 9°F)	---	No dripping, flowing, or cracking	Section 4.3.4
Heat Resistance 168 hours at 250 ± 5°C (482 ± 9°F) Followed by test for: Ultimate Elongation	---	---	Section 4.3.5
	Percent	50 minimum	
Vacuum Outgassing TML (Total Mass Loss) VCM (Volatile Condensable Material)	Percent Percent	1.0 maximum 0.1 maximum	ASTM E 595
ELECTRICAL			
Dielectric Strength Sizes 3/64 through 1/2 Sizes 3/4 through 2	Volts/mil (Volts/mm)	800 minimum (31,500) 600 minimum (23,600)	ASTM D 2671
Volume Resistivity	ohm-cm	10 ¹³ minimum	ASTM D 2671
CHEMICAL			
Corrosive Effect Copper Mirror 16 hours at 175 ± 3°C (347 ± 5°F)	---	Non Corrosive	Section 4.3.6.1 ASTM D 2671 Procedure A
Copper Contact 168 hours at 175 ± 3°C(347 ± 5°F) Followed by test for: Ultimate Elongation	---	No pitting or blackening of copper	Section 4.3.6.2 ASTM D 2671 Procedure B
	Percent	100 minimum	Section 4.3.2
Flammability Average Time of Burning	Seconds	15 maximum	ASTM D 2671 Procedure A
Fungus Resistance Followed by tests for: Tensile Strength Ultimate Elongation Dielectric Strength Sizes 3/64 through 1/2 Sizes 3/4 through 2			ISO 846 Method B
	psi (<i>Mpa</i>) percent	5000 minimum (34.5) 150 minimum	Section 4.3.2 ASTM D 2671
	Volts per mil (volts per mm)	800 minimum (31,500) 600 minimum (23,600)	ASTM D 2671
Water Absorption 24 hours at 23 ± 3°C(73 ± 5°F)	Percent	0.5 maximum	ASTM D 2671

TABLE 3
Requirements
 (continued)

PROPERTY	UNIT	REQUIREMENT	TEST METHOD
CHEMICAL (continued) Fluid Resistance 24 hours at $23 \pm 3^{\circ}\text{C}$ ($73 \pm 5^{\circ}\text{F}$) JP-4 Fuel (MIL-T-5624) Skydrol* 500 Hydraulic Fluid (MIL-H-5606) Aviation Gasoline 100/130 (MIL-G-5572) Salt Water (5% salt) Anti-icing Fluid(MIL-A-8243) Lubricating Oil (MIL-L-7808) Followed by tests for: Dielectric Strength Sizes 3/64 through 1/2 Sizes 3/4 through 2 Tensile Strength	---	---	Section 4.3.7
	Volts/mil (Volts/mm)	700 minimum (27,600) 500 minimum (19,700)	ASTM D 2671
	psi(MPa)	5000 minimum (34.5)	Section 4.3.2 ASTM D 2671

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