tyco Electronics

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

Raychem

Specification	**RT-218**
This Issue:	Issue 4
Date:	July 3, 1997
Replaces:	Issue 3

THERMOFIT® RT-218 TUBING
Modified Polyvinylidene Fluoride, Low Outgassing, 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 175ºC *(347ºF)*.

2. APPLICABLE DOCUMENTS

This specification takes precedence over documents referenced herein. Unless otherwise specified, the latest issue of reference documents applies. The following documents form a part of this specification to the extent specified herein.

2.1 GOVERNMENT-FURNISHED DOCUMENTS

Military

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

American Society for Testing and Materials (ASTM)

D-149	Tests for Dielectric Breakdown Voltage and Dielectric Strength of Electrical Insulating Materials at Commercial Power Frequencies
D-257	Standard Methods of Test for D-C Resistance or Conductance of Insulating Materials
D-638	Standard Method of Test for Tensile Properties of Plastics
D-792	Standard Method of Test for Specific Gravity and Density of Plastics
D-876	Testing Non-rigid Vinyl Chloride Polymer Tubing
D-2671	Standard Methods of Testing Heat Shrinkable Tubing
G 21	Standard Recommended Practice for Determining Resistance of Synthetic Polymeric Materials to Fungi

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

Underwriters Laboratories

UL 224	Standard for Extruded Insulating Tubing

(Copies of UL publications may be obtained from Underwriters Laboratories Inc., 1285 Walt Whitman Road, Melville, Long Island, New York 11746.)

3. REQUIREMENTS

3.1 MATERIALS

The tubing shall be fabricated from thermally stabilized, modified polyvinylidene fluoride and shall be crosslinked by irradiation. It shall be homogeneous and essentially free from flaws, defects, pinholes, bubbles, seams, cracks, and inclusions.

3.2 COLOR

The tubing shall be white, 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 tubing 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 tubing submitted for acceptance under contract. Acceptance tests shall consist of the following: dimensions, longitudinal change, tensile strength, ultimate elongation, heat shock and flammability.

4.2 SAMPLING INSTRUCTIONS

4.2.1 Qualification Test Samples

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

Range of Sizes
3/64 through 1/4
3/8 through 2

For Fungus Resistance test, any size shall qualify all sizes.

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, perform tests on specimens which have been fully recovered for 3 minutes in a 200 ± 5ºC *(392 ± 9ºF)* oven. Prior to all testing, condition the test specimens (and measurement gauges, when applicable) for 3 hours at 23 ± 3ºC *(73 ± 5ºF)* and 50 ± 5 percent relative humidity. Use mechanical convection type ovens 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

Measure three 6-inch *(150-mm)* specimens of tubing, as supplied, for length ± 1/32 inch *(± 1 mm)*, and inside diameter in accordance with ASTM D 2671. Recover and condition the specimens in accordance with Section 4.3, measure the wall thickness and remeasure the length and inside diameter. Calculate the longitudinal change as follows:

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

Where: C = Longitudinal Change [Percent]
L_0 = Length Before Recovery
L_1 = Length After Recovery

4.3.2 Tensile Strength and Ultimate Elongation

Determine the tensile strength and ultimate elongation in accordance with ASTM D 2671 using 1-inch *(25-mm)* bench marks and a 1-inch *(25-mm)* initial jaw separation. Use a rate of jaw separation of 2.0 ± 0.2 inches *(50 ± 5 mm)* per minute.

4.3.3 Secant Modulus

The secant modulus of the tubing shall be tested in accordance with ASTM D 671 using specimens in the as-supplied condition

4.3.4 Low Temperature Flexibility

For tubing of expanded diameter 1/4 inch (6 mm) or greater, cut three strip specimens, 1/4 inch *(6 mm)* wide and 12 inches *(300 mm)* long, from the expanded tubing. For tubing of expanded diameter less than 1/4 inch *(6 mm)*, cut three tubular specimens, 12 inches *(300 mm)* long, from the expanded tubing. Recover the specimens in accordance with Section 4.3 and condition with appropriate mandrels for 4 hours at -55 ± 2ºC *(-67 ± 4ºF)*. Use mandrels with a diameter 10 times the specimen thickness, ± 10 percent. For tubular specimens, use the outside diameter as the specimen thickness. While at the specified temperature, and without removing the specimens from the cold chamber, wrap the specimens 360 degrees around the mandrel in approximately 2 seconds. Visually examine for evidence of cracking. Disregard any side cracking caused by flattening of the specimens on the mandrel.

4.3.5 Heat Shock

Condition three 6-inch (150-mm) specimens of tubing for 4 hours in a 300 ± 5ºC *(482 ± 9ºF)* oven. Remove the specimens from the oven, examine for evidence of dripping or flowing, cool to 23 ± 3ºC *(73 ± 5ºF)*, wrap 180 degrees around a mandrel selected in accordance with Table 2, and then visually examine for evidence of cracking. Disregard side cracking caused by flattening of the specimen on the mandrel.

4.3.6 Heat Resistance

Three specimens prepared and measured in accordance with 4.3.2 shall be conditioned for 168 hours in a 225 ± 3°C (437 ± *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 and elongation in accordance with 4.3.2.

4.3.7 Dielectric Strength

The dielectric strength of the tubing shall be measured under oil in accordance with ASTM D 149. Five 6-inch *(1S0-mm)* specimens of tubing shall be recovered over a metal mandrel by conditioning for 3 minutes in a 200 + 3°C (392 ± *5°F)* oven. The mandrel diameter shall be slightly larger than the fully re covered inside diameter of the tubing being tested. The metal mandrel shall serve as one electrode, and a 1-inch *(25-mm)* wide strip of lead 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 at the point of breakdown.

4.3.8 Corrosive Effect

The tubing shall be tested for copper mirror corrosion in accordance with ASTM D 2671, Method A. using the time and temperature specified in Table III. For tubing sizes 1/8 and larger, specimens shall consist of 1/8 x l-inch (*3x 2S-mm)* strips cut longitudinally. 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.

4.3.9 Flammability

Flammability shall be tested by the following methods.

4.3.9.1 UL Subject 224, VW-1

Five 26-inch *(660-mm)* specimens shall be tested in accordance with UL Subject 224, VW-I.

4.3.9.2 ASTM D 876

Five 22-inch *(660-mm)* specimens shall be tested in accordance with ASTM D 876

4.3.10 Vacuum Outgassing

Three 0.5 ± .05 gram specimens shall be recovered for 3 minutes at 200°C and then tested for percent total weight loss and percent volatile condensable materials. The conditions for testing are: exposure time, 24 hours; sample temperature 130 ± 3°C; condensing surface temperature, 18 ± 3°C; and pressure**,** not greater than 1 x 10^{5} torr. The vacuum shall be provided by a diffusion pump, liquid nitrogen trap vacuum system. The apparatus shall consist of a glass sample chamber, refluxing liquid heat source and a polished stainless steel plate in close contact with a copper cold finger cooled internally by circulating water. The axis of the exit of the sample chamber shall be perpendicular to and approximately 15-mm from the cooled condensing plate. A Cahn RG micro balance or equivalent shall be used for weighing. The specimen shall be weighed before and after conditioning and total weight loss calculated and the condensing plate shall be weighed before and after to calculate percent volatile condensable material.

4.3.11 Fluid Resistance

Six specimens shall be immersed in each of the fluids listed in Table III for 24 hours at 25 ± 2°C (77 + 4°F) Three of the specimens in each fluid shall be prepared and measured in accordance with 4.3.2, and three shall be 6-in-(150-mm) lengths of tubing which have been fully recovered in accordance with 4.3.1. The volume of the fluid shall not be less than 20 times that of the specimens. After conditioning the specimens shall be removed from the fluids, lightly wiped and then air dried for 30 to 60 minutes at 23 ± °C *(73 ± 4°F)*. The three specimens intended for the tensile strength test shall then be tested in accordance with 4.3.2. The other three specimens shall then be slipped onto a tight fitting metal mandrel and tested for dielectric strength in accordance with 4.3.7.

4.4 REJECTION AND RETEST

Failure of any 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 defects and resubmitted for acceptance. Before resubmitting, full particulars concerning previous rejection and action taken to correct the defects shall be furnished to the inspector.

5. PREPARATION FOR DELIVERY

5.1 FORM

The tubing shall be supplied in lengths of 48 =1,-0 inches *(1220 +25,-0 mm)*, unless otherwise specified.

5.2 PACKAGING

Packaging shall be in accordance with good commercial practice. The shipping container shall not be less than 125-pound-test fiberboard.

5.3 MARKING

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

TABLE 1
Tubing Dimensions

Size	Expanded As Supplied		Recovered Dimension -- After Heating							
	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	*0.30*	.010	*0.25*
1/16	.063	*1.60*	.031	*0.79*	.008	*0.20*	.012	*0.30*	.010	*0.25*
3/32	.093	*2.36*	.046	*1.17*	.008	*0.20*	.012	*0.30*	.010	*0.25*
1/8	.125	*3.17*	.062	*1.57*	.008	*0.20*	.012	*0.30*	.010	*0.25*
3/16	.187	*4.74*	.093	*2.36*	.008	*0.20*	.012	*0.30*	.010	*0.25*
1/4	.250	*6.35*	.125	*3.17*	.009	*0.23*	.015	*0.38*	.012	*0.30*
3/8	.375	*9.53*	.187	*4.74*	.009	*0.23*	.015	*0.38*	.012	*0.30*
1/2	.500	*12.70*	.250	*6.35*	.009	*0.23*	.015	*0.38*	.012	*0.30*
3/4	.750	*19.05*	.375	*9.50*	.014	*0.36*	.020	*0.51*	.017	*0.43*
1	1.000	*25.40*	.500	*12.70*	.016	*0.40*	.022	*0.56*	.019	*0.48*
1 1/2	1.500	*38.10*	.750	*19.05*	.016	*0.40*	.022	*0.56*	.019	*0.48*
2	2.000	*50.80*	1.000	*25.40*	.017	*0.43*	.023	*0.58*	.020	*0.50*
10	.093	*2.36*	.031	*.79*	.008	*0.20*	.012	*0.30*	.010	*0.25*
11	.100	*2.54*	(See	Note 1)	.026	*0.64*	.030	*0.76*	.028	*0.71*

Note 1: Recovered I.D. for size 11 is .027 +/- .003 inches (0.69 +/- .08 mm)

TABLE 2
Mandrel Dimensions for Heat Shock

Tubing Size	Diameter of Mandrel	
	in.	*mm.*
3/64 to 3/16	5/16	*7.9*
1/4 to 2	3/4	*19.0*

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 maximum	ASTM D 2671
Tensile Strength	psi *(kPa)*	5000 minimum *(34,300)*	Section 4.3.2
Ultimate Elongation	Percent	200 minimum	ASTM D 2671
Secant Modulus	psi*(kPa)*	8 x 10^4 minimum *(5.5 x 10^5)*	Section 4.3.3 ASTM D 2671
Specific Gravity		1.9 maximum	ASTM D 792
Low Temperature Flexibility 4 hours at -55 ± 2ºC *(-67 ± 4ºF)*	---	No cracking	Section 4.3.4 ASTM D-2671
Heat Shock 4 hours 300 ± 5ºC*(572 ± 9ºF)*	---	No dripping, flowing, or cracking	Section 4.3.5 ASTM D-2671
Heat Resistance 168 hours at 225 ± 5ºC *(437 ± 5ºF)* Followed by test for:	---	---	Section 4.3.6
Tensile Strength	psi *(kPa)*	3000 minimum *(20.600)*	
Ultimate Elongation	Percent	150 minimum	
Vacuum Outgassing TML (Total Mass Loss) VCM (Volatile Condensable Material)	 Percent Percent	 1.0 maximum 0.1 maximum	Section 4.3.10
ELECTRICAL			
Dielectric Strength	Volts/mil *(Volts/mm)*	600 minimum *(23,500)*	Section 4.3.7 ASTM D 149
Volume Resistivity	ohm-cm	10^{12} minimum	ASTM D 257
CHEMICAL			
Corrosive Effect Copper Mirror 16 hours at 200 ± 3ºC *(392 ± 5ºF)*	---	Non Corrosive	Section 4.3.8 ASTM D 2671
Flammability Average Time of Burning	 Seconds	Pass, VW-1 rating 15 maximum and self-extinguishing	Section 4.3.9.1 U.L.Subj. 224 Section 4.3.9.2 ASTM D 876
Fungus Resistance	---	Rating of 1 or less	ASTM G 21
Fluid Resistance 24 hours at 23 ± 3ºC *(73 ± 5ºF)* 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:			Section 4.3.11
Dielectric Strength	Volts/mil *(Volts/mm)*	600 minimum *(23,500)*	Section 4.3.7 ASTM D 149
Tensile Strength	psi *(kPa)*	2000 minimum *(13.720)*	Section 4.3.2 ASTM D 2671

* Trademark, Monsanto Company