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

Raychem

Specification	**RW-3037**
This Issue:	Issue 2
Date:	July 26, 2006
Replaces:	Issue 1

Raychem Fluoroelastomer Tubing
Flexible, Fluid Resistant, Heat-Shrinkable

1. SCOPE

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

RW-200
RW-200-E

2. APPLICABLE DOCUMENTS

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

2.1 GOVERNMENT FURNISHED DOCUMENTS

Military

MIL-PRF-5606 Hydraulic Fluid, Petroleum Base, Aircraft, Missile & Ordnance (NATO code H 515)
MIL-PRF-7808 Lubricating Oil, Aircraft Turbine Engine, Synthetic Base (NATO code O-148)
MIL-DTL-83133 Turbine Fuels, Aviation, Kerosene Types (NATO F-34 (JP-8), NATO F-35 and JP-8+100)

(Copies of military specifications may be obtained online at http://assist.daps.dla.mil/quicksearch).

2.2 OTHER PUBLICATIONS

American Society for Testing & Materials (ASTM)

D 412	Test Methods for Rubber Properties in Tension
D 570	Test Method for Water Absorption of Plastics
D 792	Test Methods for Specific Gravity and Density of Plastics by Displacement
D 876	Methods of Testing Nonrigid Vinyl Chloride Polymer Tubing Used for Electrical Insulation
D 910	Standard Specification for Aviation Gasoline
D 2240	Test Method for Rubber Property -- Durometer Hardness
D 2671	Method of Testing Heat-Shrinkable Tubing for Electrical Use
D 5423	Specification for Forced-Convection Laboratory Ovens for Evaluation of Electrical Insulation

(Copies of ASTM publications may be obtained online at http://www.ASTM.org).

International specifications

IEC 60216-4-1 (2006)	Electrical insulating materials – Thermal endurance properties – Part 4-1: Ageing ovens – Single-chamber ovens
IEC 60684-2 (2005)	Flexible insulating sleeving Part 2: Methods of test
ISO 37 (2005)	Rubber, vulcanized or thermoplastic. Determination of tensile stress-strain properties
ISO 1817 (2005)	Rubber, vulcanized – Determination of the effects of liquids

(Copies of IEC publications may be obtained online at http://www.iec.ch and copies of ISO publications may be obtained online at http://www.iso.org).

© 2006 Tyco Electronics Corporation. All rights reserved

3. REQUIREMENTS

3.1 MATERIAL

The tubing shall be fabricated from a crosslinked, thermally stabilized, fluoroelastomer composition. It shall be homogeneous and essentially free from flaws, defects, pinholes, bubbles, seams, cracks and inclusions.

3.2 COLOR

The tubing shall be black.

3.3 PROPERTIES

The tubing shall meet the requirements of Table 4.

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 satisfactory products 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, unless otherwise specified by the design authority. Acceptance tests shall consist of the following:

Visual
Dimensions
Longitudinal Change
Tensile Strength
Tensile Stress at 200% Elongation
Ultimate Elongation
Heat Shock
Hardness

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 will qualify all sizes in the same range for each product type.

Range of Sizes
1/8 through 3/4
7/8 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 compound batch or the first tubing lot of each type from the compound batch. Physical property tests performed at this time shall qualify subsequent tubing lots produced from this compound batch. 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 which have been fully recovered by conditioning in accordance with 4.3.1. In cases of dispute the tests shall be carried out at a temperature of 23 ± 2°C (*73±5°F*) and at 50 ± 5% relative humidity. All ovens shall be of the mechanical convection type in which air passes the specimens.

If this document is printed it becomes uncontrolled. Check for the latest revision.
© 2006 Tyco Electronics Corporation. All rights reserved

4.3.1 Dimensions and Longitudinal Change

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. Condition these specimens for 10 minutes in a 200 ± 5°C *(392 ± 9°F)* oven or equivalent, cool to 23 ± 3°C *(73 ± 5°F)* and then remeasure. Calculate longitudinal change as follows:

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

Where: C = Longitudinal Change [Percent]
L_0 = Length before Conditioning [inches (mm)]
L_1 = Length after Conditioning [inches (mm)]

Alternatively, measure the dimensions in accordance with IEC 60684-2 clause 3 and longitudinal change in accordance with IEC 60684-2 clause 9

4.3.2 Tensile Strength, Tensile Stress and Elongation

Test three specimens of tubing for tensile strength, tensile stress (stress modulus) and elongation in accordance with ASTM D 2671, or IEC 60684-2 clause 19. For tubing sizes 3/8 and smaller, the specimens shall be full sections of tubing; for sizes 1/2 and larger, the specimens shall be cut with die D of ASTM D 412, or type 2 ISO 37. The specimens shall have 1 inch *(25 mm)* bench marks, centrally located. The testing machine shall have an initial jaw separation of 1 inch *(25 mm)* for full sections of tubing and 2 inches *(51 mm)* for die-cut specimens. The rate of jaw separation shall be 20 ± 2 inches *(500 ± 50 mm)* per minute.

4.3.3 Low Temperature Flexibility

Condition three specimens, each 12 inches *(305 mm)* in length with the appropriate size mandrel at – 55 ± 3°C for 4 hours and test in accordance with IEC 60684-2 clause 14.

For strips, the mandrel shall be no more than 10 times the wall thickness. Full section tubing is tested unfilled and the mandrel shall be no more than 10 times the outer diameter.

4.3.4 Heat Shock

Condition three 6 inch *(152 mm)* specimens of tubing for 4 hours in a 300 ± 5°C *(572 ± 9°F)* oven. After conditioning, remove the specimens from the oven, cool to room temperature and bend through 180 degrees in 2 to 4 seconds over a mandrel selected in accordance with Table 3. Visually examine the specimens 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 of tubing, prepared in accordance with 4.3.2, for 168 hours in a 250 ± 3°C *(482 ± 5°F)* oven that meets the requirements of IEC 60216-4-1 or ASTM D5423, Type 1. After conditioning, remove the specimens from the oven, cool to room temperature and test for ultimate elongation in accordance with 4.3.2.

If this document is printed it becomes uncontrolled. Check for the latest revision.
© 2006 Tyco Electronics Corporation. All rights reserved

4.3.6 Long Term Ageing
The tubing shall be tested in accordance with IEC 60684-2, clause 50, using an oven that meets the requirements of IEC 60216-4-1 or ASTM D5423, Type 1.

4.3.7 Corrosive Effect

4.3.7.1 Copper Mirror Corrosion
The tubing shall be tested for copper mirror corrosion in accordance with ASTM D 2671, Procedure A, or IEC 60684-2 clause 33, for 16 hours at 175 ± 3°C *(347 ± 5°F).* For tubing sizes 1/8 and larger, specimens shall consist of 1/4 x 1 inch *(6 x 25 mm)* strips cut longitudinally. Evidence of corrosion shall be the removal of copper from a mirror, leaving an area of transparency greater than 8 percent of its total area.

4.3.7.2 Corrosion in Contact with Copper
The tubing shall be tested for corrosion in contact with copper for 168 hours at 175 ± 3°C *(347 ± 5°F)* in accordance with ASTM D 2671, Procedure B, or IEC 60684-2 clause 32.

4.3.8 Fluid Resistance
Completely immerse three specimens of tubing, prepared and measured in accordance with 4.3.2, in each listed fluid for 24 ± 2 hours at the temperatures specified in Table 4. The volume of the fluid shall be not less than 20 times that of the specimens. After immersion, lightly wipe the specimens and air dry for 45 ± 15 minutes at room temperature then test specimens for tensile strength and ultimate elongation in accordance with 4.3.2.

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 defect and then resubmitted for acceptance. Before resubmitting, full particulars concerning the rejection and the action taken to correct the defect shall be furnished the inspector.

5. PREPARATION FOR DELIVERY

5.1 PACKAGING
The tubing shall be packaged in accordance with good commercial practice unless otherwise specified. Individual sizes shall be neatly bundled or boxed.

5.2 MARKING
Each bundle or container of tubing shall be permanently and legibly marked with the size, color, quantity, manufacturer's identification, specification number and a lot number.

Table 1 Dimensions
Type RW-200

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.*
1/8	0.125	*3.18*	0.062	*1.57*	0.026	*0.65*	0.035	*0.90*	0.031	*0.78*
3/16	0.187	*4.75*	0.094	*2.39*	0.028	*0.70*	0.042	*1.07*	0.035	*0.89*
1/4	0.250	*6.35*	0.125	*3.18*	0.028	*0.70*	0.042	*1.07*	0.035	*0.89*
3/8	0.375	*9.53*	0.187	*4.75*	0.028	*0.70*	0.042	*1.07*	0.035	*0.89*
1/2	0.500	*12.7*	0.250	*6.35*	0.028	*0.70*	0.042	*1.07*	0.035	*0.89*
5/8	0.625	*15.9*	0.312	*7.92*	0.034	*0.86*	0.050	*1.27*	0.042	*1.07*
3/4	0.750	*19.1*	0.375	*9.53*	0.034	*0.86*	0.050	*1.27*	0.042	*1.07*
7/8	0.875	*22.2*	0.437	*11.1*	0.038	*0.97*	0.060	*1.52*	0.049	*1.25*
1	1.000	*25.4*	0.500	*12.7*	0.038	*0.97*	0.060	*1.52*	0.049	*1.25*

If this document is printed it becomes uncontrolled. Check for the latest revision.
© 2006 Tyco Electronics Corporation. All rights reserved

1-1/4	1.250	*31.8*	0.625	*15.9*	0.040	*1.00*	0.070	*1.78*	0.055	*1.40*
1-1/2	1.500	*38.1*	0.750	*19.1*	0.040	*1.00*	0.070	*1.78*	0.055	*1.40*
2	2.000	*50.8*	1.000	*25.4*	0.048	*1.22*	0.082	*2.08*	0.065	*1.65*

Table 2 Dimensions
Type RW-200-E

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.*
1/8	0.125	*3.18*	0.062	*1.57*	0.026	*0.65*	0.035	*0.90*	0.031	*0.78*
3/16	0.187	*4.75*	0.094	*2.39*	0.026	*0.65*	0.040	*1.00*	0.033	*0.83*
1/4	0.250	*6.35*	0.125	*3.18*	0.028	*0.70*	0.040	*1.00*	0.034	*0.85*
3/8	0.375	*9.53*	0.187	*4.75*	0.031	*0.80*	0.045	*1.15*	0.038	*0.97*
1/2	0.500	*12.7*	0.250	*6.35*	0.035	*0.90*	0.053	*1.35*	0.044	*1.13*
5/8	0.625	*15.9*	0.312	*7.92*	0.037	*0.95*	0.059	*1.50*	0.049	*1.25*
3/4	0.750	*19.1*	0.375	*9.53*	0.043	*1.10*	0.067	*1.70*	0.055	*1.40*
7/8	0.875	*22.2*	0.437	*11.1*	0.045	*1.15*	0.075	*1.90*	0.060	*1.52*
1	1.000	*25.4*	0.500	*12.7*	0.053	*1.35*	0.080	*2.00*	0.067	*1.68*
1-1/4	1.250	*31.8*	0.625	*15.9*	0.053	*1.35*	0.090	*2.30*	0.072	*1.83*
1-1/2	1.500	*38.1*	0.750	*19.1*	0.075	*1.90*	0.095	*2.40*	0.085	*2.15*
2	2.000	*50.8*	1.000	*25.4*	0.091	*2.30*	0.130	*3.30*	0.111	*2.80*

Table 3
Mandrel Dimensions

Tubing	Mandrel Diameter	
	in.	mm.
1/8 to 3/8 inclusive	3/8	9.5
1/2 to 2 inclusive	7/16	11.1

If this document is printed it becomes uncontrolled. Check for the latest revision.
© 2006 Tyco Electronics Corporation. All rights reserved

Table 4
Requirements

PROPERTY	UNIT	REQUIREMENT	TEST METHOD
PHYSICAL Dimensions	inches *(mm)*	In accordance with Tables 1 & 2	Section 4.3.1
Longitudinal Change	percent	+1, -20 maximum	ASTM D 2671 IEC 60684-2
Tensile Strength	psi *(MPa)*	1800 *(12.4)* minimum	Section 4.3.2
Tensile Stress at 200% elongation	psi *(MPa)*	2000 *(13.8)* maximum	ASTM D 2671
Ultimate Elongation	percent	250 minimum	IEC 60684-2
Specific Gravity		2.0 maximum	ASTM D 792
Hardness	Shore A	80 ± 10	ASTM D 2240
Low Temperature Flexibility 4 hours at – 55 ± 3°C *(-67 ± 5°F)*	---	No cracking	Section 4.3.4 IEC 60684-2
Heat Shock 4 hours at 300 ± 5°C *(572 ± 9°F)*	---	No dripping, flowing or cracking	Section 4.3.5
Heat Resistance 168 hours at 250 ± 3°C *(482 ± 5°F)* Followed by test for:	---	---	Section 4.3.6
Ultimate Elongation	percent	200 minimum	Section 4.3.2 ASTM D 2671 IEC 60684-2
Long Term Ageing 3000 hours at 200 ± 3°C *(392 ± 5°F)* Followed by test for:	---	-	Section 4.3.7
Ultimate Elongation	percent	125 minimum	Section 4.3.2 ASTM D 2671 IEC 60684-2
ELECTRICAL Dielectric Strength	Volts/mil *(KV/mm)*	200 *(7.9) minimum* for recovered wall thicknesses 0.060 inches (1.5 mm) and below. 150 *(6.0)* minimum for recovered wall thicknesses above 0.060 inches (1.5 mm)	ASTM D 2671
Volume Resistivity	Ohm-cm	10^{10} minimum	ASTM D 2671 IEC 60684-2

If this document is printed it becomes uncontrolled. Check for the latest revision.
© 2006 Tyco Electronics Corporation. All rights reserved

Table 4
Requirements (continued)

CHEMICAL Corrosive Effect			
Copper Mirror Corrosion 16 hours at 175 ± 3°C *(347 ± 5°F)*	---	Copper Removal 8%, maximum	Section 4.3.8.1 ASTM D 2671 Procedure A IEC 60684-2
Copper Stability 168 hours at 175 ± 3°C *(347 ± 5°F)* Followed by test for		No brittleness, glazing, cracking or severe discoloration of tubing. No pitting or blackening of copper.	Section 4.3.8.2 ASTM D 2671 Procedure B IEC 60684-2
Ultimate Elongation	Percent	150 minimum	Section 4.3.2
Flammability	seconds	Self-extinguishing within 15 seconds; no dripping or flowing; no burning or charring of indicator	ASTM D 876 IEC 60684-2 Method C
Water Absorption 24 hours at 25°C *(77°F)*	percent	0.5 maximum	ASTM D 570 Procedure A IEC 60684-2
Fluid Resistance 24 hours at 23 ± 3°C *(73 ± 5°F)* in: Aviation Gasoline ASTM D 910 or ISO 1817 liquid B 24 hours at 93 ± 3°C *(200 ± 5°F)* in: JP-8 Fuel (MIL-DTL-83133/ NATO code F34) Lubricating Oil (MIL-PRF-7808/ NATO code O-148) Hydraulic Fluid (MIL-PRF-5606/ NATO code H 515) Water Followed by tests for: Tensile Strength Ultimate Elongation	--- psi *(MPa)* percent	--- 1600 *(11.0)* minimum 250 minimum	Section 4.3.9 Section 4.3.2

If this document is printed it becomes uncontrolled. Check for the latest revision.
© 2006 Tyco Electronics Corporation. All rights reserved