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Specification	**RT-1148**
This Issue:	Issue 8
Date:	Oct 6, 2005
Replaces:	Issue 7

Tyco Modified Fluoroelastomer Tubing
Flexible, Abrasion Resistant, Heat-Shrinkable

1.0 Scope

This specification covers the requirements for one type 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).*

2.0 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-DTL-83133	Turbine Fuels, Aviation, Kerosene Types, Nato F-34 (JP-8), Nato F-35 and JP-8+100
SAE-AMS-1424	Anti-Icing and Deicing - Defrosting Fluid
MIL-PRF-46170	Hydraulic Fluid, Rust Inhibited, Fire-resistant, Synthetic Hydrocarbon Base

Federal

A-A-59133	Commercial Item Description Cleaning Compound, High Pressure (Steam) Cleaner
A-A-52557	Fuel Oil, Diesel; for Posts, Camps and Stations

2.2 Other Publications

American Society for Testing & Materials (ASTM)

D 4814	Automotive Spark-Ignition Engine Fuel Std. Spec. for
D 257	Standard Test Methods for D-C Resistance or Conductance of Insulating Materials
D 2240	Test Method for Rubber Property -- Durometer Hardness
D 2671	Method of Testing Heat-Shrinkable Tubing for Electrical Use
G-21	Standard Recommended Practice for Determining Resistance to Synthetic Polymeric Materials to Fungi

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

3.0 Requirements

3.1 Material

The tubing shall be fabricated from thermally stabilized, modified fluoroelastomer 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 black.

3.3 Properties

The tubing shall meet the requirements of Table 3.

4.0 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. Acceptance tests shall consist of the following: Dimensions, Longitudinal Change, Tensile Strength, Tensile Stress, Ultimate Elongation, Heat Shock and 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.

Range of Sizes

1/4 through 3/4
7/8 through 3

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, 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 ± 3°C *(73 ± 5°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

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)]

4.3.2 Tensile Strength, Tensile Stress and Elongation

Test three specimens of tubing for tensile strength, tensile stress and elongation in accordance with ASTM D 2671. 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. The specimens shall have1 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 *(508 ± 50 mm)* per minute.

4.3.3 Low Temperature Flexibility

Condition three specimens, each 12 inches *(300 mm)* in length and a mandrel selected in accordance with Table 2, at -65 ± 5°C *(-85 ± 9°F)* for 4 hours. For tubing sizes 3/4 or less, the specimens shall be whole sections of tubing recovered on a stranded wire (nearest AWG which is larger than the sleeving maximum inside diameter after unrestricted shrinkage). For tubing sizes larger than 3/4, the specimens shall be 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 around the mandrel for not less than 360 degrees in 10 ± 2 seconds then visually examine the specimens for evidence of cracking.

4.3.4 Heat Shock

Three 6 inch *(152 mm)* specimens of tubing shall be conditioned for 4 hours in a 225 ± 5°C *(437 ± 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 2. 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

Three 6 inch *(152 mm)* specimens of tubing shall be conditioned for 168 hours in a 150 ± 3°C *(302 ± 5°F)* oven. After conditioning, remove the specimens from the oven, cool to room temperature and test for ultimate elongation in accordance with 4.3.2.

4.3.6 Copper Stability

Three 6 inch *(152 mm)* specimens of tubing shall be slid over snug- fitting, straight, clean, bare copper mandrels, either solid or tubular. The specimens on the mandrels shall be conditioned for 24 hours in a desiccator or similar humidity chamber at 90 to 95 percent relative humidity and 25 ± 3°C *(77 ± 5°F)*.

The specimens on the mandrels then shall be conditioned for 168 hours in a 150 ± 2°C *(302 ± 4°F)* oven. After conditioning, the specimens shall be removed from the oven and cooled to 23 ± 3°C *(73 ± 5°F)*.

The copper mandrels shall then be removed from the tubing and the tubing and copper mandrels shall be examined. Darkening of the copper due to normal air oxidation shall not be cause for rejection. The tubing shall be tested for ultimate elongation in accordance with 4.3.2.

4.3.7 Dielectric Strength

The dielectric strength shall be determined by following the ASTM D 2671 procedure for dielectric breakdown. When dielectric breakdown occurs the thickness measurements for calculating dielectric strength shall be made adjacent to the point of breakdown and the dielectric strength shall be calculated in volts per mil.

4.3.8 Corrosive Effect

The tubing shall be tested for copper mirror corrosion in accordance with ASTM D 2671, Procedure A. The specimens shall be conditioned for 16 hours at 175 ± 3°C *(347 ± 5°F)*.

4.3.9 Fluid Resistance

Six specimens, three 6 inch *(152 mm)* tubing specimens, which shall be weighed prior to immersion and three tensile specimens prepared and measured in accordance with 4.3.1, shall be immersed for 24 hours in each of the test fluids listed in Table 3 at the temperature specified. The volume of the fluid shall not be less than 20 times that of the specimens. After conditioning, all the specimens shall be lightly wiped and air dried for 45 ± 15 minutes at 23 ± 3°C *(73 ± °F)*. The three specimens intended for the tensile strength and elongation tests shall then be tested in accordance with 4.3.2. The other three specimens shall be weighed before and after immersion and the weight change calculated as a percentage.

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.

5.0 Preparation For Delivery

5.1 Form

Unless otherwise specified, the tubing shall be supplied on spools.

5.2 Packaging

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

5.3 Marking

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

TABLE 1
TUBING DIMENSIONS

Size	Expanded As Supplied		Recovered Dimensions -- After Heating							
	Inside Diameter Minimum		Inside Diameter Maximum		Wall Thickness					
					Minimum		Maximum		Nominal	
	in.	*mm.*	in.	*mm.*	in.	*mm.*	in.	*mm.*	in.	*mm.*
1/4	0.250	*6.35*	0.125	*3.18*	0.028	*0.71*	0.042	*1.06*	0.035	*0.88*
3/8	0.375	*9.53*	0.187	*4.75*	0.028	*0.71*	0.042	*1.06*	0.035	*0.88*
1/2	0.500	*12.70*	0.250	*6.35*	0.028	*0.71*	0.042	*1.06*	0.035	*0.88*
5/8	0.625	*15.87*	0.312	*7.92*	0.035	*0.88*	0.049	*1.24*	0.042	*1.06*
3/4	0.750	*19.05*	0.375	*9.53*	0.035	*0.88*	0.049	*1.24*	0.042	*1.06*
7/8	0.875	*22.22*	0.437	*11.09*	0.035	*0.88*	0.055	*1.39*	0.045	*1.14*
1	1.000	*25.40*	0.500	*12.70*	0.038	*0.96*	0.060	*1.52*	0.049	*1.24*
1-1/4	1.250	*31.75*	0.625	*15.87*	0.040	*1.00*	0.070	*1.77*	0.055	*1.39*
1-1/2	1.500	*38.10*	0.750	*19.05*	0.040	*1.00*	0.070	*1.77*	0.055	*1.39*
2	2.000	*50.80*	1.000	*25.40*	0.048	*1.21*	0.082	*2.08*	0.065	*1.63*
3	3.000	*76.20*	1.500	*38.10*	0.048	*1.21*	0.082	*2.08*	0.065	*1.63*

TABLE 2
Mandrel Dimensions

Tubing	Mandrel Diameter	
	in.	mm.
1/4 to 3/8 inclusive	5/16	7.9
1/2 to 3 inclusive	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	-10 to +2	ASTM D 2671
Tensile Strength	psi *(MPa)*	2500 *(17.2)* minimum	Section 4.3.2
Tensile Stress at 100% elongation	psi *(MPa)*	1500 *(10.3)* maximum	ASTM D 2671
Ultimate Elongation	percent	350 minimum	
Specific Gravity		1.5 maximum	ASTM D 2671
Hardness	Shore A	80 ± 10	ASTM D 2240
Low Temperature Flexibility 4 hours at -65 ± 5°C *(-85 ± 9°F)*	---	No cracking	Section 4.3.3
Heat Shock 4 hours at 225 ± 5°C *(437 ± 9°F)*	---	No dripping, flowing or cracking	Section 4.3.4
Heat Resistance 168 hours at 150 ± 3°C *(302 ± 5°F)* Followed by test for:	---	---	Section 4.3.5
Tensile Strength Ultimate Elongation	psi percent	2000 *(13.8)* minimum 300 minimum	Section 4.3.2
Copper Stability 168 hours at 150 ± 2°C *(302 ± 4°F)* Followed by test for:		No brittleness, glazing or cracking of tubing; no pitting or blackening of copper	Section 4.3.6
Ultimate Elongation	percent	200 minimum	Section 4.3.2
ELECTRICAL			
Dielectric Strength	Volts/mil *(Volts/mm)*	300 *(11,800)* minimum	Section 4.3.7
Volume Resistivity	ohm-cm	10^{10} minimum	ASTM D 257
CHEMICAL			
Flammability	seconds	Self-extinguishing within 15 seconds; no dripping or flowing; no burning or charring of indicator	ASTM D 2671
Corrosive Effect 16 hours at 175 ± 3°C *(347 ± 5°F)*		Noncorrosive	Section 4.3.8 ASTM D 2671
Fungus Resistance		Rating of 1 or less	ASTM G 21
Fluid Resistance 24 hours at 25 ± 3°C *(77 ± 5°F)* in: Cleaning Compound (A-A-59133) Gasoline Automotive (ASTM D 4814) JP-8 Fuel (MIL-DTL-83133) Water Followed by tests for:	---	---	Section 4.3.9
Tensile Strength	psi *(MPa)*	1800 *(11.0)* minimum	Section 4.3.2
Ultimate Elongation	percent	300 minimum	
Weight Increase	percent	20 maximum	Section 4.3.9

TABLE 3
Requirements

CHEMICAL (Continued) Fluid Resistance 24 hours at 50 ± 3°C *(122 ± 5°F)* in: Deicing Fluid (SAE-AMS-1424) Hydraulic Fluid (MIL-PRF-46170) Diesel Fuel (A-A-52557) 5% Salt Solution (ASTM D 632) Followed by tests for: Tensile Strength Ultimate Elongation Weight Increase	--- psi *(MPa)* percent percent	--- 1800 *(11.0)* minimum 300 minimum 10 maximum	Section 4.3.9 Section 4.3.2 Section 4.3.9
Fluid Resistance 24 hours at 100 ± 3°C *(212 ± 5°F)* in: Hydraulic Fluid (MIL-PRF-46170) Followed by tests for: Tensile Strength Ultimate Elongation Weight Increase	--- psi *(MPa)* percent percent	--- 1800 *(11.0)* minimum 300 minimum 10 maximum	Section 4.3.9 Section 4.3.2 Section 4.3.9

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