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Specification	**RT-350**
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THERMOFIT® RNF-100 TUBING
Polyolefin, Flexible, Heat-Shrinkable

1. SCOPE

This specification covers the requirements for two types of flexible electrical insulating, extruded tubing whose diameter will reduce to a predetermined size upon the application of heat in excess of 121°C *(250°F)*.

1.1 TYPE 1

Type 1 tubing shall be flame-retardant and shall be black, white, red, yellow, or blue unless otherwise specified.

1.2 TYPE 2

Type 2 tubing shall not be flame-retardant and shall be clear.

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

ASTM D 910	Gasoline, Aviation, Grades 80/87, 100, and 115/145
MIL-PRF-5606	Hydraulic Fluid, Petroleum Base, Aircraft, Missile and Ordnance
MIL-T-83133	Turbine Fuel, Aviation, Grade JP-8
MIL-STD-104	Limits for Electrical Insulation Color

2.2 OTHER PUBLICATIONS

American Society for Testing and Materials (ASTM)

D 910	Standard Spec. for Aviation Gasolines
D 2671	Standard Methods of Testing Heat-Shrinkable Tubing for Electrical Use

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

International Organization for Standardization (ISO)

ISO 846 Plastics – Evaluation of the action of Microorganisms

(Copies of ISO publications may be obtained from the International Organization for Standardization, 1, rue de Varembé, CH-1211 Geneva 20, Switzerland or via the ISO website at http://www.iso.ch/iso/en/ISOOnline.frontpage)

3. REQUIREMENTS

3.1 MATERIALS

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

3.2 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 be: dimensions, longitudinal change, tensile strength, ultimate elongation, secant modulus, flammability (Type 1 only), 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 black, white and clear tubing. Qualification of black and white shall qualify all colors. Clear shall be qualified separately. 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 1
1-1/4 through 5

4.2.2 Acceptance Test Sample

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

Condition test specimens and measurement gauges at 23 ± 3°C *(73 ± 5°F)* and ambient relative humidity prior to all testing, whether before or after heat shrinking. Unless otherwise specified, perform tests on specimens which have been fully recovered by conditioning for 3 minutes in a 200 ± 5°C *(392 ± 9°F)* oven. 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. Condition the specimens for 3 minutes in a 200 ± 5°C *(392 ± 9°F)* oven, cool to 23 ± 3°C *(73 ± 5°F)* and then remeasure. Prior to and after conditioning, the dimensions of the tubing shall be in accordance with Table 1 and the longitudinal change shall be in accordance with Table 3. 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 Conditioning [Inches *(mm)*]
L_1 = Length After Conditioning [Inches *(mm)*]

4.3.2 Tensile Strength and Ultimate Elongation

Determine the tensile strength and ultimate elongation of the tubing in accordance with ASTM D 2671 using 1-inch *(25-mm)* bench marks, a 1-inch *(25-mm)* initial jaw separation, and jaw separation speed of 20 ± 2 inches *(500 ± 50 mm)* per minute.

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 on spools or in lengths of 48 +1, -0 inches *(1220 +25.4, -0 mm)* 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 size, quantity, manufacturer's identification, specification number, 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*	.013	*0.33*	.019	*0.48*	.016	*0.40*
1/16	.063	*1.60*	.031	*0.79*	.014	*0.35*	.020	*0.50*	.017	*0.43*
3/32	.093	*2.36*	.046	*1.17*	.017	*0.43*	.023	*0.58*	.020	*0.50*
1/8	.125	*3.17*	.062	*1.57*	.017	*0.43*	.023	*0.58*	.020	*0.50*
3/16	.187	*4.74*	.093	*2.36*	.017	*0.43*	.023	*0.58*	.020	*0.50*
1/4	.250	*6.35*	.125	*3.17*	.022	*0.56*	.028	*0.71*	.025	*0.64*
3/8	.375	*9.50*	.187	*4.74*	.022	*0.56*	.028	*0.71*	.025	*0.64*
1/2	.500	*12.70*	.250	*6.35*	.022	*0.56*	.028	*0.71*	.025	*0.64*
3/4	.750	*19.05*	.375	*9.50*	.027	*0.69*	.033	*0.84*	.030	*0.76*
1	1.000	*25.40*	.500	*12.70*	.030	*0.76*	.040	*1.01*	.035	*0.88*
1-1/4	1.250	*31.75*	.625	*14.30*	.034	*0.86*	.046	*1.17*	.040	*1.01*
1-1/2	1.500	*38.10*	.750	*19.05*	.034	*0.86*	.046	*1.17*	.040	*1.01*
2	2.000	*50.80*	1.000	*25.40*	.038	*0.96*	.052	*1.32*	.045	*1.14*
3	3.000	*76.20*	1.500	*38.10*	.042	*1.06*	.058	*1.47*	.050	*1.27*
4	4.000	*101.60*	2.000	*50.80*	.046	*1.16*	.064	*1.63*	.055	*1.39*
5	5.000	*127.00*	2.500	*63.50*	.051	*1.30*	.069	*1.75*	.060	*1.52*

TABLE 2
Mandrel Dimensions for Bend Testing

Tubing Size	Mandrel Diameter	
	in.	*mm.*
3/64 to 1/4 inclusive	5/16	*7.9*
3/8 to 5 inclusive	3/8	*9.5*

TABLE 3
Requirements

		REQUIREMENT		
PROPERTY	**UNIT**	**TYPE 1**	**TYPE 2**	**TEST METHOD**
PHYSICAL Dimensions	Inches *(mm)*	In accordance with Table 1	In accordance with Table 1	Section 4.3.1 ASTM D 2671
Longitudinal Change	Percent	+0, -5	+0, -5	
Tensile Strength	psi *(MPa)*	1500 minimum *(10.3)*	1500 minimum *(10.3)*	Section 4.3.2 ASTM D 2671
Ultimate Elongation	Percent	200 minimum	200 minimum	
Secant Modulus (Expanded)	psi *(MPa)*	2.5 x 10^4 maximum *(172)*	2.5 x 10^4 maximum *(172)*	ASTM D 2671
Specific Gravity	---	1.35 maximum	1.0 maximum	ASTM D 2671
Low Temperature Flexibility 4 hours at -55 ± 1°C *(-67 ± 2°F)*	---	No cracking	No cracking	Table 2 ASTM D 2671 Procedure C
Heat Shock 4 hours at 250 ± 3°C *(482 ± 5°F)*	---	No dripping, flowing or cracking	No dripping, flowing or cracking	Table 2 ASTM D 2671
Heat Resistance 168 hours at 175 ± 2°C *(347 ± 4°F)* Followed by test for:	---	---	---	ASTM D 2671
Ultimate Elongation	Percent	150 minimum	150 minimum	
Color	---	MIL-STD-104	---	MIL-STD-104
Color Stability 48 hours at 175 ± 2°C *(347 ± 4°F)*	---	MIL-STD-104	---	ASTM D 2671
ELECTRICAL Dielectric Strength	Volts/mil *(volts/mm)*	500 minimum *(19,680)*	500 minimum *(19,680)*	NOTE 1 ASTM D 2671
Volume Resistivity	ohm-cm	10^{14} minimum	10^{16} minimum	ASTM D 2671
CHEMICAL Copper Mirror Corrosion 16 hours at 175 ± 2°C *(347 ± 4°F)*	- --	No removal of copper	No removal of copper	ASTM D 2671 Procedure A
Copper Contact Corrosion 168 hours at 160 ± 2°C *(320 ± 4°F)*	---	No pitting or blackening of copper	No pitting or blackening of copper	ASTM D 2671 Procedure B
Copper Stability 168 hours at 160 ± 2°C *(320 ± 4°F)* Followed by test for:	---	No brittleness, glazing, cracking, or severe discoloration of tubing	No brittleness, glazing, cracking, or severe discoloration of tubing	
Ultimate Elongation	Percent	200 minimum	200 minimum	

TABLE 3
Requirements
(continued)

PROPERTY	UNIT	TYPE 1	TYPE 2	TEST METHOD
CHEMICAL (continued) Flammability	---	Self-extinguishing within 1 minute, 25% maximum flag burn	---	ASTM D 2671 Procedure B
Water Absorption 24 hours at 23°C *(73°F)*	Percent	0.5 maximum	0.2 maximum	ASTM D 2671
Fluid Resistance 24 hours at 23°C *(73°F)* in: JP-8 Fuel (MIL-T-83133) Skydrol* 500 Hydraulic Fluid (MIL-PRF-5606) Aviation Gasoline (100) (ASTM D 910) Water Followed by tests for:	---	---	---	ASTM D 2671
Dielectric Strength	Volts/mil *(volts/mm)*	400 minimum *(15,760)*	400 minimum *(15, 760)*	
Tensile Strength	psi *(MPa)*	1000 minimum *(6.9)*	1000 minimum *(6.9)*	
Fungus Resistance Followed by tests for:				ISO 846 Method B
Tensile Strength	psi *(Mpa)*	1500 minimum *(10.3)*	1500 minimum *(10.3)*	Section 4.3.2 ASTM D 2671
Ultimate Elongation	percent	200 minimum	200 minimum	ASTM D 2671
Dielectric Strength	Volts per mil *(volts per mm)*	500 minimum *(19,680)*	500 minimum *(19,680)*	

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NOTE 1: Recover the specimens on the metal mandrels for 10 minutes, minimum, at 175 ± 3°C *(347 ± 5°F)* or until the tubing is completely shrunk on the mandrels.