FL2500 Heat Shrink Tubing Specification

108-120015

Raychem FL2500 Tubing
Fully Flame-Retardant, Adhesive-Lined, Polyolefin
Heat-Shrinkable Tubing

FL2500 dual wall tubing comprises a tough crosslinked, flame-retardant, polyolefin tubing lined with a flame-retardant adhesive to provide the optimum solution for applications where full flame retardancy is preferred or specified. Rated to 135°C for 3000 hours, it is suitable for use in the automotive harness market and other harsh environments.
FL2500 with its high-performance adhesive lining offers an economical and highly-effective method for permanently sealing and protecting splices, fusible links, terminals, and in-line components. As the tubing is heated and shrinks down onto its substrate, the adhesive lining melts and flows to fill all voids and create a complete seal against moisture, oils, chemicals, etc.
FL2500 has a 4:1 shrink ratio and is available in a comprehensive range of sizes to meet most component sealing requirements, and is compatible with a wide range of application equipment.
RoHS and REACH compliant.
Continuous operating temperature -40 to 135°C (-40 to 275°F).

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1. SCOPE

This Quality Assurance Specification establishes the quality standard for FL2500. The objective of this document is to specify tests that will qualify the performance of FL2500 for protecting, insulating and sealing components in an under-the-hood automotive environment. This specification covers the requirements for a dual wall, flame retarded, electrically insulating, extruded tubing, whose diameter will reduce to a predetermined size upon application of heat in excess of 135ºC *(275ºF)*.

2. APPLICABLE DOCUMENTS

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

2.1. AMERICAN SOCIETY FOR TESTING AND MATERIAL (ASTM)

ASTM D149	Standard Test Method for Dielectric Breakdown Voltage and Dielectric Strength of Solid Electrical Insulating Materials at Commercial Power Frequencies
ASTM D257	Standard Test Methods for DC Resistance or Conductance of Insulating Materials
ASTM D471	Standard Test Method for Rubber Property—Effect of Liquids
ASTM D975	Standard Specification for Diesel Fuel Oils
ASTM D2671	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 or via the ASTM website at http://www.astm.org).

2.2. SAE International

SAE J1128	Low Voltage Primary Cable

(Copies of SAE publications may be obtained from: SAE International by phone: 877-606-7323 (inside the US and Canada), +1 724-776-4970 (outside USA), fax 724-776-0790, Email: CustomerService@SAE.org or via the SAE website at http://standards.sae.org/)

3. REQUIREMENTS

3.1. DIMENSIONS

The dimensions shall be in accordance with FL2500 SCD.

3.2. MATERIALS

The tubing components shall be essentially free from pinholes, bubbles, cracks, defects and inclusions and shall be constructed as a dual walled heat shrinkable tubing having

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a flame retarded hot melt adhesive inner wall with an outer wall of an irradiated, flame retarded polyolefin material.

3.3. COLOR

The jacket color shall be black. Inner adhesive wall shall be white.

3.4. MARKING

Marking is FL-0, FL-1, FL-2, FL-3 and FL-4.

3.5. PROPERTIES

The tubing shall meet the requirements of Table 1.

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:

Dimensions
Tensile Strength
Ultimate Elongation
Heat Shock

4.2. SAMPLING INSTRUCTIONS

4.2.1. Qualification Test Samples

Qualification test samples shall consist of 45 m *(150 feet)* of tubing of FL-2 (qualifies FL-0, FL-1, FL-2, FL-3 and FL-4).

4.2.2. Acceptance Test Samples

Acceptance test samples shall consist of not less than 5 m *(16 feet)* of tubing selected at random from each lot of tubing or on a skip-lot basis per a statistically justified control plan determined by QA.

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4.2.3. Lot Formation

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 recovered by heating for 3 minutes in a 200 ± 5ºC *(392 ± 9ºF)* oven. Condition the test specimens (and measurement gauges when applicable) for 3 hours at 23 ± 3ºC *(73 ± 5ºF)*. For referee purposes, condition the test specimens at 50 ± 5 percent relative humidity for 3 hours prior to testing. Use mechanical convection type ovens in which air passes the specimens at a velocity of 30 to 60 m *(100 to 200 feet)* per minute.

4.3.1. Dimensions and Longitudinal Change

Measure three 150 mm *(6 inch)* specimens of tubing, as supplied, for length ± 1 mm *(± 1/32 inch)* and inside diameter in accordance with ASTM D 2671. Condition the specimens with adhesive for 3 minutes in a 200 ± 5°C *(392 ± 9°F)* oven, cool to 23 ± 3°C *(73 ± 5°F)*, then re-measure. Prior to and after conditioning, the dimensions of the tubing shall be in accordance with FL2500 SCD and the longitudinal change shall be in accordance with Table 1. Calculate the longitudinal change as follows:

$$LC = \frac{(L_1 - L_0)}{L_0} \times 100$$

Where: LC = Longitudinal Change [percent]
L_0 = Length Before Conditioning [mm (inches)]
L_1 = Length After Conditioning [mm (inches)]

4.3.2. Tensile Strength and Ultimate Elongation

Perform the tests in accordance with ASTM D2671 using a jaw separation speed of 50 ± 5 mm *(2.0 ± 0.2 inches)* per minute. Calculate the tensile strength based on the wall thickness of the jacket only.

4.3.3. Immersion Leak Resistance

Prepare 3 test assemblies insulated with FL2500-2 as follows: Construct a 3-wire to 3-wire inline splice in any suitable manner (crimped, soldered, twisted or welded). Splice an AWG 14 and two AWG 12 wires to an AWG 14 and two AWG 12 wires. Each wire shall be approximately 12 inches long. The wire insulation shall be crosslinked polyolefin (TXL) and the conductor shall be bare copper. Shrink a 2.5-inch length of FL2500-2 over the splice area using a forced air oven set at 150 ± 3°C (302 ± 5°F) for 5 minutes. Allow the test assemblies to cool to room temperature and immerse them, except for the ends, in a 5% salt solution for 24 hours at room temperature. Apply 50 volts d-c to the immersed specimens and measure the leakage current.

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4.3.4. Thermal Cycling

Prepare 3 splice assemblies in accordance with Sec. 4.3.3 and subject them to 5 thermal cycles. One cycle consists of 30 minutes in a 5% saline solution at 5 ± 5°C and in a hot air circulating oven for 30 minutes at 130 ± 5°C with a maximum of 2 minutes between temperatures. Specimens shall then be allowed to cool to room temperature for one hour minimum and shall be measured for leakage current in accordance with Sec. 4.3.3.

4.3.5. Thermal Aging

Prepare 3 splice assemblies in accordance with Sec. 4.3.3. and hold for 168 hours at 130 ± 5°C. The specimens shall then be allowed to cool to room temperature for one hour minimum and shall be measured for leakage current in accordance with Sec. 4.3.3.

4.3.6. Flammability

Prepare 6 splice assemblies in accordance with Sec. 4.3.3. Suspend a 600 mm *(24 in.)* sample of the finished spliced cable taut in a horizontal position within a partial enclosure which allows a flow of air sufficient for complete combustion, but is free from drafts. Use a flame spreader apparatus as described in SAE J1128. Position the top of the 50 mm *(2 in.)* vertical flame so that the top of the flame just touches the suspended specimen, with the flame spreader parallel to the axis of the spliced cable. Test 3 separate specimens with the flame in each of two positions: 1) Center the flame spreader under the edge of the heat-shrinkable tubing such that the flame is applied to approximately 25 mm *(1 in.)* of tubing and 25 mm *(1 in.)* of wire on the side with the single wire and 2) Center the flame spreader under the center of the approximately 50 mm *(2 in.)* long splice. Apply the flame for 15 seconds, as described in SAE J1128. After removal of the Bunsen burner flame, the splice and adhesive shall not continue to burn for more than 30 seconds.

4.3.7. Fluid Resistance

Prepare 9 splice assemblies in accordance with Sec. 4.3.3. and immerse 3 assemblies in each of the fluids specified for the time and temperature given. Measure current leakage in accordance with Sec. 4.3.3.

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 Quality.

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5. PREPARATION FOR DELIVERY

5.1. FORM

5.1.1. The tubing shall be supplied in cut pieces, unless otherwise specified.

5.2. PACKAGING

5.2.1. Packaging shall be in accordance with good commercial practice.

5.3. MARKING

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

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APPENDIX

Table 1
Properties

Property	Unit	Requirement	Test Method
Dimensions	mm *(inches)*	FL2500 SCD	ASTM D 2671
Tensile Strength	MPa *(psi)*	10.4 *(1,500)* min	ASTM D 2671 Sec 4.3.2
Ultimate Elongation	Percent	300 min	ASTM D 2671 Sec 4.3.2
Secant Modulus (Expanded Form)	MPa *(psi)*	242 *(35,000)* min	ASTM D 2671 Note 1
Longitudinal Change	Percent	+0, -10	ASTM D 2671 Sec 4.3.1
Concentricity (Expanded Form)	Percent	60 min	ASTM D 2671
Dielectric Strength (Jacket Only) Note 2	Volts/mm *(Volts/mil)*	19,700 *(500)* min	ASTM D 149
Volume Resistively	ohm-cm	1 x 10^{13} min	ASTM D 257
Immersion Leak Resistance	micro-amps	0.25 max	Sec 4.3.3
Thermal Cycling 5 cycles 5°C to 130°± 5°C	micro-amps	0.25 max	Sec 4.3.4
Heat Shock 4 hrs. at 250°C	--	No dripping, flowing, or cracking of jacket	ASTM D 2671
Thermal Aging 168 hrs. at 130°± 5°C followed by Immersion Leak Resistance, Sec. 4.3.3	micro-amps	0.25 max	Sec. 4.3.5
Flame Test	--	Self-extinguishing within 30 seconds	SAE J1128 Sec 4.3.6
Fluid Resistance 24 hrs. at 25°C ± 3°C ASTM D471 Reference Fuel C ASTM D975 Diesel Fuel	micro-amps	0.25 max	Sec. 4.3.7
1hr. at 100°C ± 3°C ASTM D471 IRM 903 (formally #3 Oil)			

Note 1: Calculate Secant based on Jacket thickness only.

Note 2: Remove adhesive manually prior to testing.

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