

SPECIFICATION: RW 3028
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**THERMOFIT® MARKER SYSTEM
FRSP**

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1. SCOPE

This specification covers the requirements and performance of the FRSP Marker Tubing. This heat shrink polymeric marker tubing is typically used to identify wires, cables, and other elongated substrates. FRSP is typically printed using thermal transfer or dot matrix printers. The print permanence achieved depends on the printer and ribbon used, and is outside of the scope of this specification.

1.1 CLASSIFICATION

1.1.1 Flattened Heat Shrink Polymeric Marker Tubing

FRSP shall be fabricated from modified radiation crosslinked polymer tubing, flattened and supplied on spools.

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 PUBLICATIONS

ASTM D 2671 Heat-shrinkable Tubing for Electrical Use

UL 224 Standard For Extruded Insulating Tubing

ISO-846 Plastics - evaluation of the action of microorganisms

3. REQUIREMENTS

3.1 MATERIAL

The FRSP shall be fabricated from irradiated, thermally stabilized, modified polyolefin compound. It shall be homogeneous and essentially free from flaws, defects, pinholes, bubbles, seams, cracks or inclusions.

3.2 COLOR

The markers shall be white or yellow.

3.3 FORM

FRSP shall be continuous lengths of flattened heat shrink tubing supplied on spools in accordance with Figure 1.

3.4 PROPERTIES

The sleeves 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 finished FRSP or FRSP materials 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 every batch, unless otherwise specified, and shall consist of the following:

Appearance
Dimensions
Longitudinal Change

4.2 SAMPLING INSTRUCTIONS

4.2.1 Qualification Test Samples

Qualification test samples shall consist of the appropriate quantity of finished FRSP or FRSP material necessary to run all tests. Qualification of any one size shall qualify all sizes.

4.2.2 Acceptance Test Samples

Acceptance test samples shall consist of the appropriate number of finished FRSP samples necessary to run the specified tests, from each batch. A batch shall consist of all materials of the same size, from the same production run and offered to inspection at the same time.

4.3 TEST PROCEDURES

Unless otherwise specified, the FRSP shall be recovered for 3 minutes at $200 \pm 5^{\circ}\text{C}$ ($392 \pm 9^{\circ}\text{F}$). Where required by test method limitations, testing shall be done on expanded tubing prior to flattening.

4.3.1 Dimensions, Dimensional Recovery and Longitudinal Change

The test method shall be specified in ASTM D 2671. The inside diameter of three finished specimens shall be measured. Mark two gauge marks 44.5 mm (1.75 ins.) apart on each sample. These specimens shall be recovered in an oven at $200 \pm 5^{\circ}\text{C}$ ($392 \pm 9^{\circ}\text{F}$) for 3 minutes \pm 15 seconds and the distance between gauge marks and inside diameter of each shall be measured. The longitudinal change shall be expressed as a percentage of the original gauge mark distance. The recovered inside diameter and recovered wall thickness shall be determined.

4.3.2 Camber

Camber is defined as a bow in the flattened tubing due to non-uniform stress in the expanded wall. Cut a 37" length of flattened tubing. Be sure to keep the sample straight. While handling samples, do not induce a curve by twisting or pulling at an angle. Place sample inside a clamp. Align sample along the straight edge of the camber gauge. The loose end must not touch anything and hang freely. Sample must be exactly parallel to the straight edge of the camber gauge. Measure the camber at each one-foot division as indicated on the gauge. Each section is 3 inches long and has vertical dividers every 0.100-inch. The maximum any size can be off center at any one of the horizontal measurements is 1.2 inches.

4.3.3 Tensile Strength and Ultimate Elongation.

Test three specimens for tensile strength and ultimate elongation in accordance with ASTM D 2671, using 25-mm (1-inch) bench marks, a 50-mm (2-inch) initial jaw separation and a jaw separation speed of 508-mm (20 inches) per minute.

4.3.4 Low Temperature Flexibility

Recover three specimens over a stranded AWG wire (nearest gauge which is larger than the sleeving maximum I.D. nominal after unrestricted shrinkage). Condition the specimens for 4 hours at $-30 \pm 2^{\circ}\text{C}$ ($-22 \pm 4^{\circ}\text{F}$). While at this temperature, bend the tubular specimens 90 degrees, in approximately 2 seconds, over a similarly conditioned mandrel, selected in accordance with Table 1. Examine the specimens for cracks.

**TABLE 1
MANDREL DIMENSIONS FOR
BEND TESTING**

Part Number	Diameter of Mandrel (Inches, Millimeters)	
	Inches	Millimeters
FRSP 1/8" to FRSP 3/8"	5/16	7.9
FRSP 1/2" to FRSP 3/4"	3/8	9.5
FRSP 1"	7/16	11.1

4.3.5 Heat Shock

The test method shall be as specified in UL 224. The test conditions will be 1 hr. at $136 \pm 2^{\circ}\text{C}$ ($277 \pm 4^{\circ}\text{F}$). No dripping, flowing, or cracking.

4.3.6 Heat Aging

Shrink three specimens on a stranded AWG wire (nearest gauge which is larger than the sleeving maximum I.D. nominal after unrestricted shrinkage). Condition the specimens for 168 hours at $158 \pm 2^{\circ}\text{C}$ ($316 \pm 4^{\circ}\text{F}$) in a convection oven, with an air velocity of 30 to 60 m /min. (100 to 200 ft./min.) past the specimens. Remove the specimens from the oven, and allow to cool to room temperature. Test the specimens for mandrel bend in accordance with Section 4.3.5.1.

4.3.6.1 Mandrel Bend

Bend the specimens recovered on the stranded wire 90 degrees around a mandrel specified in Table 1. Examine the specimens for cracks.

4.3.7 Surface Roughness

Test five samples for surface roughness using a Taylor Hobson Surtronic 3+ or similar with standard pick-up. A cut off of 2.5mm should be used. Each sample measured should be taken from a different position along the length of the spool. The average Ra of the five samples should be reported.

4.3.8 Dielectric Strength

The test method shall be as specified in ASTM D 2671.

4.3.9 Corrosive Effect

Test two specimens in accordance with ASTM D 2671, Procedure A for 16 hours at $158 \pm 2^{\circ}\text{C}$ ($316 \pm 4^{\circ}\text{F}$). 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.

4.3.10 Flammability

The test method shall be as specified in UL 224 All Tubing Flame Test. Burn time shall not exceed 1 minute, and not more than 25% of indicator flag shall be burned or charred. No dripping or flowing.

4.3.11 Water Absorption

The test method shall be as specified in ASTM D 2671. The test conditions shall be 24 hours at $23 \pm 3^{\circ}\text{C}$ ($73 \pm 5^{\circ}\text{F}$).

4.3.12 Fungus resistance

Fungus resistance testing shall be conducted in accordance with accordance with ISO 846 B with an incubation time of 56 days.

4.3.12.1 Tensile Strength

After conditioning per section 4.3.12, test for tensile strength in accordance with section 4.3.3.

4.3.12.2 Ultimate Elongation

After conditioning per section 4.3.12, test for ultimate elongation in accordance with section 4.3.3.

4.3.12.3 Dielectric Strength

After conditioning per section 4.3.12, test for dielectric strength in accordance with section 4.3.8.

4.3.13 Fluid Resistance

Prepare three 152 mm (6 inch) long samples for each fluid listed in Table 3 by recovering them in an oven at $200 \pm 5^{\circ}\text{C}$ ($392 \pm 9^{\circ}\text{F}$) for 3 minutes \pm 15 seconds. Allow the samples to cool to room temperature. Immerse samples for 24 hours at $23 \pm 3^{\circ}\text{C}$ ($73 \pm 5^{\circ}\text{F}$). After immersion, lightly wipe the specimens and allow to air dry 30-60 minutes at room temperature. Test the specimens for Tensile Strength and Ultimate Elongation in accordance with Section 4.3.2.

4.4 REJECTIONS AND RETEST

Failure of any sample to conform to any of the requirements of this specification sheet shall be cause for rejection of the lot represented. Product rejected may be replaced or reworked to correct the defects and resubmitted for acceptance.

5. PREPARATION FOR DELIVERY

5.1 FORM

FRSP shall be supplied as lengths on spools.

5.2 PACKAGING

FRSP shall be supplied on cardboard spools per Figure 2. Sizes 3/32" to 1/2" shall be supplied 100m (328 ft.) per spool. Sizes 3/4" and 1" shall be supplied 50m (164 ft) per spool. Packages shall contain a maximum of 2 lengths per spool. Minimum length shall be 15m (49.2 ft). Multiple lengths shall be adjoined by aligning the length ends and taping the ends together using red tape, no tube overlap is permissible.

5.3 STORAGE CONDITIONS

FRSP should be stored in a clean dry location. Maximum storage temperature is 40°C (104°F).

5.4 PACKAGE MARKING

Each container of FRSP shall be identified with the product designation, size, quantity, manufacturer's identification lot number and date of manufacture.

**FIGURE #1
Camber Gage**

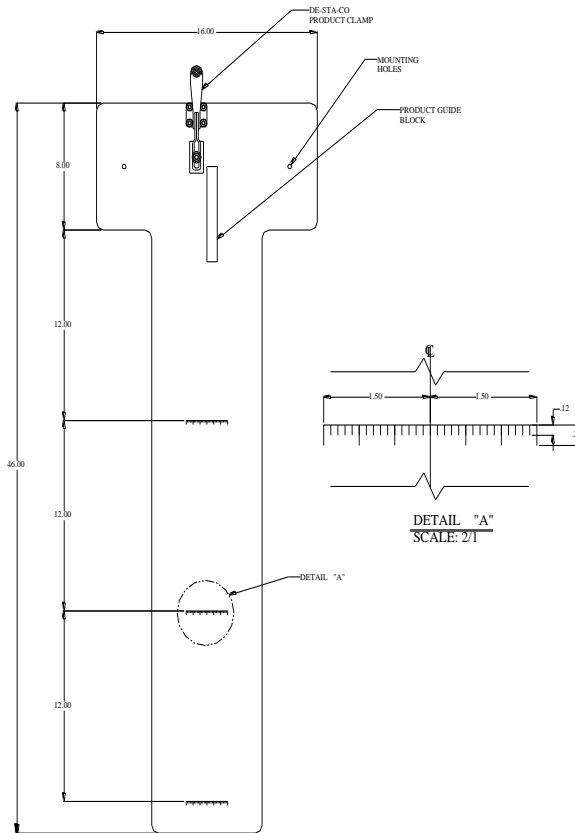


FIGURE #2

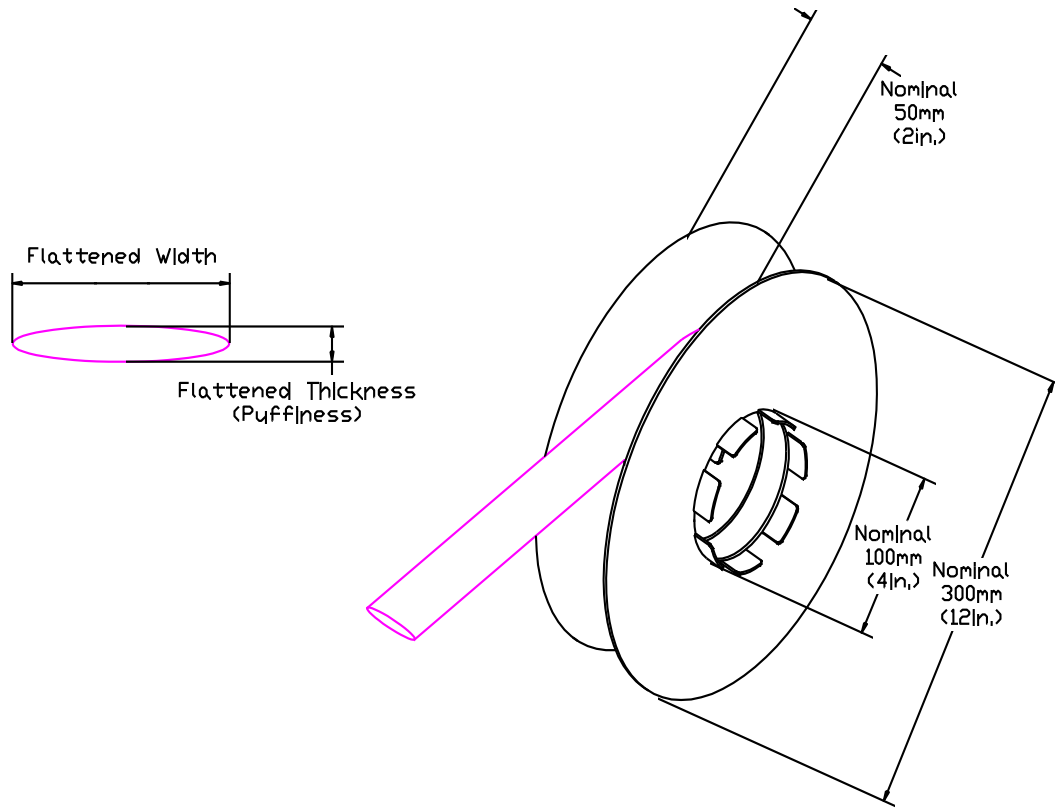


TABLE 2

TUBING SIZE CONFIGURATION DIMENSIONS IN mm, (INCHES)						
Part Number	Minimum Expanded Inside Dia.	Maximum Recovered inside Dia.	Recovered Wall Thickness	Flattened Width	Flattened Thickness (Puffiness)	Nominal Weight (g/cm)
FRSP-1/8"	3.18 (0.125)	1.07 (0.042)	0.58 +/- 0.08 (0.023 +/- 0.003)	6.35 +/- 0.51 (0.250 +/- 0.020)	1.21 +/- 0.57 (0.0475 +/- 0.0225)	0.036
FRSP-3/16"	4.75 (0.187)	1.57 (0.062)	0.58 +/- 0.08 (0.023 +/- 0.003)	8.51 +/- 0.51 (0.335 +/- 0.020)	1.21 +/- 0.57 (0.0475 +/- 0.0225)	0.047
FRSP-1/4"	6.35 (0.250)	2.11 (0.083)	0.58 +/- 0.08 (0.023 +/- 0.003)	11.18 +/- 0.51 (0.440 +/- 0.020)	1.21 +/- 0.57 (0.0475 +/- 0.0225)	0.062
FRSP-3/8"	9.53 (0.375)	3.18 (0.125)	0.61 +/- 0.08 (0.024 +/- 0.003)	16.26 +/- 0.76 (0.640 +/- 0.030)	1.14 +/- 0.64 (0.045 +/- 0.025)	0.089
FRSP-1/2"	12.70 (0.500)	4.22 (0.166)	0.61 +/- 0.08 (0.024 +/- 0.003)	21.34 +/- 0.89 (0.840 +/- 0.035)	1.14 +/- 0.64 (0.045 +/- 0.025)	0.120
FRSP-3/4"	19.05 (0.750)	6.35 (0.250)	0.61 +/- 0.08 (0.024 +/- 0.003)	31.75 +/- 1.27 (1.250 +/- 0.050)	1.14 +/- 0.64 (0.045 +/- 0.025)	0.181
FRSP-1"	25.40 (1.000)	8.46 (0.333)	0.64 +/- 0.08 (0.025 +/- 0.003)	41.91 +/- 1.52 (1.650 +/- 0.060)	1.14 +/- 0.64 (0.045 +/- 0.025)	0.239

TABLE 3
Requirements

PROPERTY	UNIT	REQUIREMENT	TEST METHOD
Dimensions	mm (inches)	In accordance with Table 2 In accordance with Table 2	Section 4.3.1 ASTM D 2671
Camber	inches	1.20 max. @ 3 foot intervals	Section 4.3.2
Longitudinal Change 3 min. at 200 ± 5°C (392 ± 9°F)	Percent	0 to -20	Section 4.3.1 ASTM D 2671
Tensile Strength 508 mm/min. (20 in./min)	MPa (psi)	8.27 minimum (1,200) minimum	Section 4.3.3 ASTM D 2671
Ultimate Elongation 508 mm/min. (20 in./min)	Percent	150 minimum	Section 4.3.3 ASTM D 2671
Low Temperature Flexibility 4 hours at -30 ± 2°C (-22 ± 4°F)	---	No cracking	Section 4.3.4
Heat Shock 1 hr. at 136 ± 2°C (277 ± 4°F)	---	No dripping, flowing, or cracking	Section 4.3.5 UL 224
Heat Aging 168 hrs at 158 ± 2°C (316 ± 4°F) Followed by test for: Mandrel Bend	---	No cracking	Section 4.3.6 Section 4.3.6.1
Surface Roughness Ra	µm (mil)	4.5 maximum (0.177) maximum	Section 4.3.7
Dielectric Strength	MV/m (Volts/mil)	19.7 minimum (500 minimum)	Section 4.3.8 ASTM D 2671
Corrosive Effect 16 hours at 158 ± 2°C (316 ± 4°F)	---	5% transparent area maximum	Section 4.3.9 ASTM D 2671 Procedure A
Flammability	---	Burn time shall not exceed one minute, and not more than 25% of indicator flag shall be burned or charred. No dripping or flowing.	Section 4.3.10 UL 224 - All Tubing Flame Test
Water Absorption 24 hours at 23 ± 3°C (73 ± 5°F)	Percent	0.5 maximum	Section 4.3.11 ASTM D 2671
Fungus Resistance 56 day incubation Followed by test for:			Section 4.3.12 ISO 846 B
Tensile Strength	MPa (psi)	8.27 (1,200) minimum	Section 4.3.12.1 ISO 846 B
Ultimate Elongation	Percent	150 minimum	Section 4.3.12.2 ISO 846 B
Dielectric Strength	KV / mm (Volts / mil)	19.7 minimum (500) minimum	Section 4.3.12.3 ISO 846 B

<p>Fluid Resistance 24 hours at 23 ± 3°C (73 ± 5°F) HydroFlouroCarbon Solvent Vertrel XF Isopropyl Alcohol Gasoline (unleaded) Diesel Fuel, DF2 Auto Engine Oil, SF 10W-40 (SAE J 183, SAE J 300) Motor Vehicle Brake Fluid, (SAE J 1703)</p>	<p>---</p>	<p>---</p>	<p>Section 4.3.13</p>
<p>Ethylene Glycol Followed by test for: Tensile Strength 508 mm/min. (20 in./min) Ultimate Elongation 508 mm/min. (20 in./min)</p>	<p>MPa (psi) Percent</p>	<p>6.89 minimum (1,000) minimum 100 minimum</p>	<p>Section 4.3.3 ASTM D 2671 Section 4.3.3 ASTM D 2671</p>