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SPECIFICATION: **RW-1001**
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THERMOFIT® AP2000 TUBING
HEAT-SHRINKABLE CROSSLINKED MODIFIED POLYOLEFIN, ADHESIVE LINER

1. SCOPE

This specification covers the requirements for one type of dual wall extruded and crosslinked tubing, with an adhesive liner, whose diameter will reduce to a predetermined size upon the application of heat in excess of 115 °C *(239 °F)*. This tubing is intended for environmental corrosion and mechanical protection of automotive brake, fuel and power steering lines.

2. MATERIAL

The outer jacket shall be fabricated from modified polyolefin and shall be crosslinked. The inner jacket shall be a meltable adhesive.

The dual wall tubing shall be homogeneous, free from flaws, defects, bubbles, pinholes, seams, cracks or inclusions and each wall shall be uniform.

TABLE 1

AP2000 Tubing Dimensions and Applicable Pipe Sizes

AP2000 Part Number	Applicable Standard Pipe Size	Inside Diameter				Installed Wall Thickness, nominal	
		As Supplied, min.		Recovered, max.			
	mm	mm	(in)	mm	(in)	mm	(in)
AP2000 -6	4.76	6.0	(.24)	4.7	(.18)	1.0	(.039)
AP2000 -8	6.35	8.0	(.32)	6.1	(.24)	1.0	(.039)
AP2000 -10	8.0	10.0	(.40)	7.4	(.29)	1.0	(.039)
AP2000 -15	10.0	15.0	(.59)	7.4	(.29)	1.0	(.039)

NOTE: The primary unit of measure is metric. Inch-pound units of measure have been rounded to ensure suitability for applications based on the metric values.

TABLE 2

Requirements

PROPERTY	UNIT	REQUIREMENTS	TEST METHOD
PHYSICAL			
Dimensions	mm *(in.)*	In accordance with Table 1	ASTM D 2671
Longitudinal Change	Percent	0 to -10	Section 5.3.1
Tensile Strength	MPa (psi)	12.0 min (1706)	ASTM D 2671
Ultimate Elongation	Percent	300 min	Section 5.3.2
Heat Aging 24 h at 120 °C *(248 °F)* followed by:			
Tensile Strength	MPa (psi)	12.0 min (1706)	ASTM D 2671 Section 5.3.2
Ultimate Elongation	Percent	270 min	
Deformation Resistance	Percent	50 min	Section 5.3.3
Impact Brittleness at -35 °C *(-31 °F)*	---	No cracking	ASTM D 746 Section 5.3.4
Drop Impact Resistance	---	No cracking	Section 5.3.5
CHEMICAL			
Stress Cracking Resistance 24 h at 50 °C *(122°F)* in 10 percent IGEPAL	---	No cracking	ASTM D 1693 Section 5.3.6
Fluid Resistance 72 h at 25 °C *(78 °F)* Sulfuric Acid (1.28 Specific Sodium Hydroxide (0.1N) Motor Vehicle Brake Fluid Unleaded Gasoline		No cracking	ASTM D 2671 Section 5.3.7

3. 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.

3.1 AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

D 746 Standard Test Method for Brittleness Temperature of Plastics and Elastomers by Impact

D 1693 Standard Test Method for Environmental Stress - Cracking of Ethylene Plastics

D 2671 Standard Methods of Testing Heat-Shrinkable Tubing for Electrical Use

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

3.2 JAPANESE INDUSTRIAL STANDARDS COMMITTEE (JIS)

C3005Testing Methods for Rubber or Plastic Insulated Wires and Cables

(Copies of JIS standards typically may be obtained through the national standards organization in most countries.

In the U. S., JIS standards may be obtained through the American National Standards Institute (ANSI), 1430 Broadway, New York, NY 10018. In the UK, they may be obtained through the British Standards Institution (BSI), 2 Park Street, London W1A 2BS)

3.3 SOCIETY OF AUTOMOTIVE ENGINEERS, INC. (SAE)

J1703 Motor Vehicle Brake Fluid

(Copies of SAE publications may be obtained from the Society of Automotive Engineers, Inc., 400 Commonwealth Drive, Warrendale, PA 15096)

3.4 UNDERWRITERS LABORATORIES, INC. (UL)

224 Extruded Insulating Tubing

(Copies of UL publications may be obtained from Underwriters Laboratories, Inc., P. O. Box 75330, Chicago, IL 60675-5330)

4. REQUIREMENTS

4.1 COLOR

The tubing shall be black.

4.2 PROPERTIES

Tubing dimensional requirements and applicable standard pipe sizes are described in Table 1. Other requirements are described in Table 2.

5. QUALITY ASSURANCE PROVISIONS

5.1 CLASSIFICATION OF TESTS

5.1.1 Qualification Tests

Qualification tests shall consist of all tests listed in this specification. Qualification sizes shall be AP2000-6 and AP2000-10.

5.1.2 Acceptance Tests

Acceptance tests are those performed on a production lot basis and include the dimensions listed in Table 1 and longitudinal change.

5.2 SAMPLING INSTRUCTIONS

5.2.1 Qualification Test Samples

Qualification test samples shall consist of 15 m *(50 ft)* of tubing of the size specified.

5.2.2 Acceptance Test Samples

Acceptance test samples shall consist of not less than 5 m *(16 ft)* 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.

5.3 TEST PROCEDURES

Unless otherwise specified, perform tests on specimens which have been fully recovered by conditioning for 3 min at 200 °C *(392 °F)* . Prior to all testing, condition the test specimens (and measurement gauges, when applicable) for at least 3 h at 23 °C *(73 °F)* . Use mechanical convection type ovens in which air passes the specimens at a velocity of 30 to 60 m *(100 to 200 ft)* per min.

Apply -35 °C, ambient and 50 °C temperature tolerances of ± 3 °C *(± 5 °F)* , and air circulating oven tolerances of ± 4 °C *(+ 7°F)* at 120-140 °C and ± 5 °C *(± 9 °F)* at 200 °C.

5.3.1 Dimensions

5.3.1.1 As Supplied and Free-Recovered Tubing Dimensions

Measure three 150 ± 1 mm *(6 ± 0.04 in.)* specimens of tubing, as supplied, for length and inside diameter in accordance with ASTM D 2671. Condition the specimen for 3 min at 200 °C *(392 °F)* oven, remove from the oven and cool to 23 °C *(73 °F)*, and remeasure for length, inside diameter and total wall thickness.

5.3.1.2 Longitudinal Change

Calculate longitudinal change as follows:

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

Where:

C	=	Longitudinal Change
L_0	=	Length Before Conditioning
L_1	=	Length After Conditioning

5.3.1.3 Installed Wall Thickness

For the purpose of qualification, obtain installed total wall thickness from samples recovered onto the specified pipe (Table 1) in an air circulating oven for 5 min at 200 °C *(392 °F)*.

For the purpose of process control and acceptance testing, the installed wall thickness may be obtained either a) directly from samples recovered onto the specified pipe or, b) by mathematically correlating the free-recovered wall thickness with the installed wall thickness and measuring the free-recovered wall thickness.

In the event of dispute, the installed wall thickness shall be the referee measurement.

5.3.2 Tensile Strength and Ultimate Elongation

Determine the tensile strength and ultimate elongation on fully recovered tubing in accordance with ASTM D 2671. Set the grips of the testing machine 50 mm *(2 in.)* apart and apply a rate of jaw separation of 50 mm *(2 in.)* per min.

Determine tensile strength based on the cross-sectional area of the jacket only. Use a suitable optical method (e.g., microscope or optical comparator) to measure the thickness of the outer wall for this calculation.

5.3.3 Deformation Resistance

Cut three sections of recovered tubing such that the area of the tubing, when flattened, is 1 cm^2 and test each specimen individually. The initial wall thickness is twice the free-recovered wall thickness. Cover the specimen with a flat metal plate weighing approximately 30 g and condition in an air circulating oven at 140 °C *(284 °F)* for 1 h. Place a preheated 2 kg load on the test assembly for 5 min at temperature and then measure the final wall thickness.

The deformation resistance is the ratio of the final thickness to the initial thickness expressed as a percentage. The result is the average of the three measurements.

NOTE: A fixturing device should be used to ensure that the specimens deform uniformly in the oven; ensure that the specimens experience a load of at least 2 kg/cm^2. One example of a suitable fixturing device is described in UL224.

5.3.4 Low Temperature Impact Brittleness

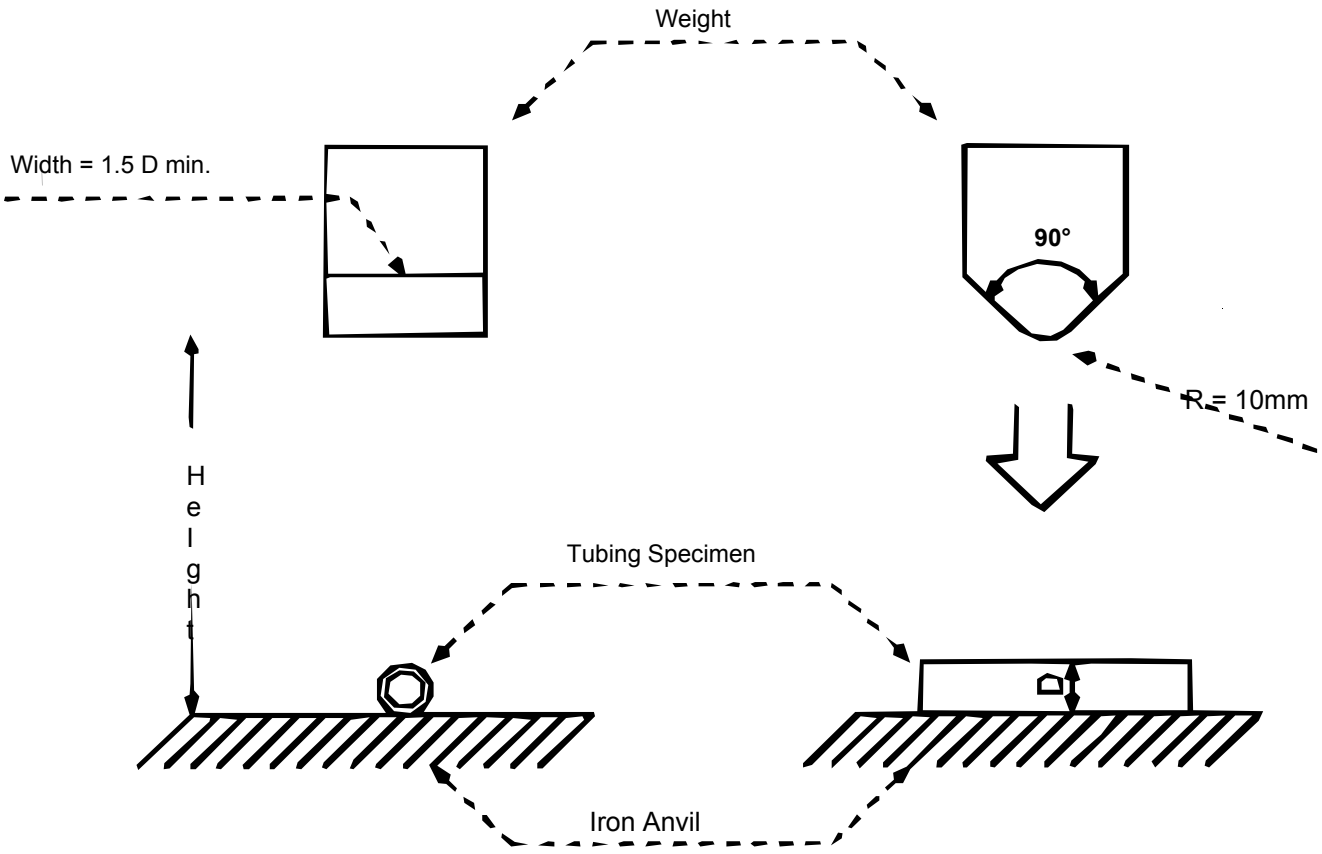
Perform this test on five specimens in accordance with ASTM D 746 using tubing jacket material crosslinked to the same degree as that in the finished product. Use specimens 6.35 ± 0.51 mm *(0.25 ± 0.02 in.)* wide, 1.91 ± 0.125 mm *(0.075 ± 0.005 in.)* thick, and at least 35 mm *(1.37 in.)* long.

5.3.5 Drop Impact Resistance

Select three 150 mm *(6 in.)* fully recovered tubing specimens and evaluate for drop impact resistance using the method described in JIS C3005.

Perform the test at 23 °C *(73 °F)* on each specimen using the test configuration shown in Figure 1. Use a 250 gm *(0.55 lb)* weight and a 2 m *(79 in.)* drop height.

Examine the tubing for cracking with normal vision.



D = the outside diameter of the specimen

Figure 1. - Drop Impact Test Configuration.

5.3.6 Stress Cracking Resistance

Ten tubing specimens are notched (a "controlled imperfection"), fixtured and tested in accordance with ASTM D 1693 for 24 h at 50 °C *(122 °F)* using a 10 percent IGEPAL solution as the test reagent.

The specimens are examined for evidence of cracking with normal vision without magnification. Extension of the controlled imperfection shall not constitute a failure.

5.3.7 Fluid Resistance

Immerse three specimens in the fluids specified in Table 2 for 72 h at 25 °C *(78 °F)* in the manner specified in ASTM D 2671. After immersion, lightly wipe the specimens and air dry for 30 to 60 min at room temperature.

Examine the specimens for evidence of cracking with normal vision without magnification.

6. PREPARATION FOR DELIVERY

6.1 FORM

The tubing shall be supplied on spools unless otherwise specified.

6.2 PACKAGING

Packaging shall be in accordance with good commercial practice.

6.3 MARKING

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