

**CABLE, ELECTRIC, MODIFIED POLYESTER
INSULATED COPPER OR COPPER ALLOY****1. SCOPE****1.1 GENERAL**

This specification covers finished cable, insulated with an extruded, flame retarded, modified polyester material. The finished cable defined by this specification is intended for use in surface vehicle low voltage circuits.

1.2 CLASSIFICATION

Products in accordance with this specification shall be the following type and as specified in the applicable specification sheet.

Finished Cable: A single stranded wire, insulated as specified in the applicable specification sheet.

1.2.1 Temperature Index

Products in accordance with this specification have a temperature index rating of at least 3000 hours at 150°C (*TI 3 kh/150°C*) when tested in accordance with ASTM D 3032.

2. APPLICABLE DOCUMENTS

The following documents form a part of this specification to the extent specified herein. Unless otherwise indicated, the issue in effect on date of invitation for bids or request for proposal shall apply.

2.1 AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

B46.1-1978 Surface Texture (Surface Roughness, Waviness, and Lay)

(Copies of ANSI publications may be obtained from Global Engineering Documents, 15 Inverness Way East, Englewood, CO 80112; or at www.global.ih.com.)

2.2 AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

B 1	Standard Specification for Hard Drawn Copper Wire
B 3	Specification for Soft or Annealed Copper Wire
B 33	Specification for Tinned Soft or Annealed Copper Wire for Electrical Purposes
B 193	Standard Test Method for Resistivity of Electrical Conductor Materials
B 471	Standard Test Method for Rubber Property - Effect of Liquids
B 624	Standard Specification for High-Strength, High-Conductivity Copper-Alloy Wire for Electronic Application
B 975	Specification for Diesel Fuel Oils
D 3032	Standard Test Methods for Hookup Wire Insulation

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

2.3 FEDERAL TEST METHOD STANDARDS

FED-STD-228 Cable and Wire, Insulated; Methods of Testing

(Copies of FED-STD-228 may be obtained from the Naval Publications and Forms Center, 5801 Tabor Avenue, Philadelphia, Pennsylvania 19120; or at www.global.ihs.com.)

2.4 INTERNATIONAL ORGANIZATION FOR STANDARDIZATION (ISO)

ISO 6722/1 Road Vehicles - Unscreened low-tension cables - Part 1:
General requirements and test methods.

(Copies of ISO publications may be obtained from Global Engineering Documents, 2805 McGaw Avenue, Irvine, California 92714; or at www.iso.ch.)

2.5 SOCIETY OF AUTOMOTIVE ENGINEERS, INC. (SAE)

J1128 Low Tension Primary Cable

(Copies of SAE publications may be obtained from SAE, 400 Commonwealth Drive, Warrendale, Pennsylvania 15096-0001; or at www.sae.org.)

2.6 RAYCHEM DOCUMENTS

Wire and Cable Division

Level 3 QC Procedures: QC/3/082

3. REQUIREMENTS

3.1 SPECIFICATION SHEETS

The requirements for the individual cables furnished under this specification shall be as specified herein and in accordance with the applicable specification sheet. In the event of conflict, the requirements of the specification sheet shall govern.

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3.2 MATERIALS

Materials not specifically designated herein shall be of the quality and form best suited for the purpose intended. Unless otherwise specified, the materials shall meet the following requirements:

3.2.1 Stranded Wire Materials

Stranded wire material shall be hard drawn copper in accordance with ASTM B 1, bare annealed copper in accordance with ASTM B 3, tinned annealed copper in accordance with ASTM B 33, high strength copper alloy in accordance with ASTM B 624, or as specified by the applicable specification sheet.

3.2.2 Insulating Materials

The extruded insulation material shall be a proprietary modified polyester.

3.3 FINISHED CABLE

Finished cable shall conform to the requirements of Table I, to those of the applicable specification sheet, and to the following, as applicable.

TABLE I. PROPERTIES OF FINISHED CABLE

Examination or Test	Requirement	Test Method	Test Type
Abrasion Resistance	Specification Sheet	4.4.1	Q
Cold Bend	3.3.1	4.4.2	Q
Color	3.3.2 and Table III	SAE J1128	P
Concentricity	Specification Sheet	ASTM D 3032, Section 16	P
Conductor Resistance	Specification Sheet	QC/3/082	V
Dielectric Test	3.3.3	SAE J1128	Q
Dimensions	Specification Sheet	ASTM D 3032, Section 15	P
Flammability	Specification Sheet	SAE J1128	Q
Immersion (Fluid Resistance)	3.3.4	4.4.4	Q
Insulation-Continuity Proof Testing	Specification Sheet	ASTM D 3032, Section 13, Method A	100%
Insulation Tensile Strength and Ultimate Elongation	Specification Sheet	4.4.5.1	Q
		4.4.5.2	P
Materials and Construction	3.2 and Specification Sheet	4.4.3	P
Pinch Test	Specification Sheet	4.4.6	Q
Shrinkage	Specification Sheet	4.4.7	P
Strip Force	Specification Sheet	4.4.8	Q
Temperature Index	1.2.1	ASTM D 3032, Section 14	Q
Thermal Stability	Specification Sheet	4.4.9	Q
Weight	Specification Sheet	4.4.10	P
Workmanship	3.3.5	4.4.3	P

P = In Process or Lot Test
 100% = 100% Finished Product Test

Q = Qualification Test
 V = Vendor Test

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3.3.1 Cold Bend

When tested in accordance with 4.4.2 herein, there shall be no cracking and no breakdown of the finished cable insulation.

3.3.2 Color

Finished cable insulation color shall be in accordance with Table III and SAE J1128. Insulation color shall be designated by the following codes:

TABLE III. FINISHED CABLE COLORS

Code	Solid Color
0	Black
1	Brown
1L	Tan
2	Red
2L	Pink
3	Orange
4	Yellow
5L	Light Green
5D	Dark Green
6L	Light Blue
6D	Dark Blue
7	Purple
8	Gray
9	White

3.3.3 Dielectric Test

When finished cable is tested in accordance with the Dielectric Test of SAE J1128, there shall be no dielectric breakdown.

3.3.4 Immersion (Fluid Resistance)

When tested in accordance with 4.4.4 herein, the finished cable sample shall meet the requirements specified in Table II therein.

3.3.5 Workmanship

All details of workmanship shall be in accordance with high-grade wire and cable manufacturing practice. The insulation shall be free of cracks, splits, irregularities, and imbedded foreign material.

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4. QUALITY ASSURANCE PROVISIONS

4.1 RESPONSIBILITY FOR INSPECTION

The supplier is responsible for the performance of all inspection tests specified herein. The supplier may utilize his own or any other inspection facility and services acceptable to the buyer. Inspection records of the examinations and tests shall be kept complete and available to the buyer as required.

4.2 QUALIFICATION INSPECTION

Qualification inspection shall consist of all tests in Table I. Requalification testing shall be performed any time changes in materials or processes occur that are deemed to have the potential for significantly altering the performance of the product.

4.2.1 Sampling for Qualification Inspection

Samples of cable for qualification shall be taken from production lots which have been manufactured under the most current Quality Control Plan.

4.3 QUALITY CONFORMANCE INSPECTION

Quality conformance inspection consists of a matrix of tests and inspections that assure that raw materials and manufacturing processes are consistent and result in products that conform to specification requirements. The classification and frequency of testing shall be determined in accordance with the requirements of the individual specifications to which the product is supplied.

4.3.1 Inspection Definitions

- a. Vendor Control (V) - Requirements for raw materials such as conductor and insulation materials over which the vendor has control and responsibility.
- b. Process Control (P) - Inspections performed on samples taken from the lots of cable. Inspections may be performed on finished cable or after the process which establishes the specified characteristic. The Quality Control Plan establishes the frequency of inspection based on process control data.
- c. One hundred percent (100%) - Test performed on the total length of each cable. Tests may be performed on the finished product or "in process" as applicable.
- d. Qualification (Q) - Test performed only at the time of initial qualification or requalification.

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4.4 TEST METHODS

4.4.1 Abrasion Resistance

Abrasion resistance shall be quantified as the number of scrape cycles required for a blade to abrade through the insulation of a finished cable and contact the stranded wire within. The blade, polished to an 18 finish per ANSI B46.1-1978, shall be a 90-degree wedge of tungsten carbide with its edge rounded to a radius of 0.0050 ± 0.0005 inch ($.127 \pm .0127$ mm). The cable sample shall be fully supported so as not to bow or otherwise deflect from the force of the blade. Means shall be provided to apply an adjustable downward force through the blade onto the cable. The cable shall be scraped longitudinally along its axis while in contact with the blade, and an electrical detection circuit and counter mechanism shall be used to stop the test and record the number of cycles when electrical contact has occurred. One such fixture is shown in Figure 1. However, the methods and fixture described in ISO 6722/1 are also satisfactory for use.

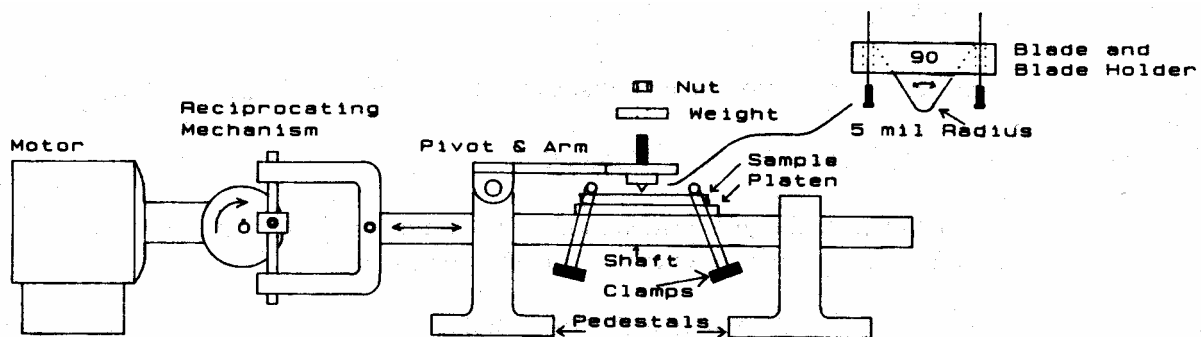


FIGURE 1. SCRAPE ABRASION TESTER

4.4.1.1 Abrasion Procedure

One inch (25 mm) of insulation shall be removed from a minimum 60-inch (152 -cm) cable sample and connected to the detection circuit. The cable shall be firmly clamped in the fixture, and a force of 7.33 Newtons (1.649 lbf) shall be carefully applied to the surface of the insulation through the blade. The fixture stroke length shall be 20 ± 1 mm (0.79 ± 0.04 inch) and the frequency shall be 40 ± 1 cycles per minute (2 scrapes = 1 cycle). Eight tests shall be performed, with the cable advanced in the fixture 6 inches (152 mm) and rotated 90 degrees. The average number of cycles to electrical contact shall equal or exceed the minimum requirement specified on the applicable specification sheet.

4.4.2 Cold Bend

Cold Bend shall be performed in accordance with the Cold Bend Test of SAE J1128 for Type SXL, except the test temperature shall be -55°C .

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4.4.3 Examination of Product

All samples shall be examined carefully to determine conformance to this specification and to the applicable specification sheets with regard to requirements not covered by specific test methods.

4.4.4 Immersion (Fluid Resistance)

One 12 inch (300 mm) finished cable sample shall be prepared for each fluid listed in Table II. The sample shall be immersed to within 1-1/2 inch (40 mm) from the end of the insulation in the fluids for the times and temperatures specified therein. Upon removal from the test fluids, the sample shall be blotted with an absorbent tissue and changes in outer diameter of the cable measured per ASTM D 3032.

Changes in diameter shall be defined as follows and shall not exceed the amount specified in Table II below.

$$\% \text{ Change} = 100 \times \frac{(D_1 - D_0)}{D_0}$$

Where: D_1 = post-immersion outer diameter
 D_0 = pre-immersion outer diameter

TABLE II. FLUIDS TABLE

Test Fluid	Temperature (°C)	Time (hours)	Max. Dia. Change (%)
ASTM D 471, Oil #1	150	24	5
ASTM D 471, IRM 902	150	24	5
ASTM D 471, IRM 903	150	24	5
Gasoline, ASTM D 471, Fuel C	25	24	5
Diesel Fuel, ASTM D 975, Fuel 2D	70	24	5
Power Steering Fluid	50	24	5
Transmission Fluid, Dexron® II	150	24	5
Brake Fluid, (DOT Type 3)	50	24	5
Methyl Alcohol	65*	24	5
Ethyl Alcohol	78*	24	10

*Reflux temperature at atmospheric pressure.

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4.4.5 Insulation Tensile Strength and Ultimate Elongation

4.4.5.1 Qualification

Testing of insulation tensile strength and ultimate elongation shall be performed in accordance with ASTM D 3032, Section 17, with the following conditions and exceptions:

- a. Crosshead speed (jaw separation rate) shall be 2 inches (*50 mm*) per minute.
- b. Initial jaw separation shall be 1 inch (*25 mm*).

4.4.5.2 Process Control

Testing of ultimate elongation shall be performed in accordance with ASTM D 3032, Section 17, with the following exceptions:

- a. Crosshead speed (jaw separation rate) shall be 20 inches (*500 mm*) per minute.
- b. Initial jaw separation shall be 1 inch (*25 mm*).
- c. One specimen shall be tested.

4.4.6 Pinch Test

The pinch test shall be performed in accordance with the Pinch Test of SAE J1128. Test apparatus which provides the same constant rate of force may be substituted. (Note: If the apparatus used to perform the test applies the force directly to the sample instead of through a lever arm, the values obtained are to be divided by 10 in order to normalize the values to the data measured by the apparatus of SAE J1128.) The arithmetic average of four readings shall define the pinch resistance of the cable under test. This value shall be at least the minimum value specified on the applicable specification sheet.

4.4.7 Shrinkage

A 36 inch (*900 mm*) specimen of finished cable, while at normal room temperature ($23 \pm 5^\circ\text{C}$), shall be cut in half. The length the cut ends of the insulation creep back from the stranded wire shall be measured and shall not exceed the value listed in the applicable specification sheet.

4.4.8 Strip Force

Strip force testing shall be performed per ASTM D 3032, Section 27, with the following conditions and exceptions:

- a. The portion of undisturbed insulation (insulation slug) left on the test specimen shall be 2 inches (*50.8 mm*).
- b. Tester speed shall be 10 inches (*254 mm*) per minute.
- c. A minimum of three samples shall be tested, and the mean value of the peak (maximum) strip force reported. This value shall equal or exceed the value specified on the applicable specification sheet.

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4.4.9 Thermal Stability

A minimum of five tensile specimens shall be prepared per ASTM D 3032, Section 17. These samples shall be aged in an air-circulating oven at $165^{\circ} +2^{\circ}$, -0°C for 168 hours. Upon removal from the aging oven, the samples shall be conditioned at $20 \pm 5^{\circ}\text{C}$ for a minimum of four hours and tested for retention of tensile strength and ultimate elongation per 4.4.5. Minimum requirements shall be as stated on the applicable specification sheet.

4.4.10 Weight

The weight of each lot of finished cable shall be determined by Procedure I (4.4.10.1). Lots failing to meet the weight requirement of the applicable specification sheet when tested in accordance with Procedure I shall be subjected to Procedure II (4.4.10.2). All barrels failing to meet the requirements of the applicable specification sheet when tested to Procedure II shall be rejected.

4.4.10.1 Procedure I

A length of cable, sufficient to produce a measured weight to at least 3 significant figures, shall be weighed and converted to the weight per unit length shown on the applicable specification sheet.

4.4.10.2 Procedure II

The net weight of the finished cable in each barrel shall be obtained by subtracting the weight of the barrel from the gross weight of the barrel containing the finished cable. The net weight of the cable in each barrel shall be divided by the accurately determined length of finished cable in that barrel and the resultant figure converted to pounds per 1000 feet (*kg/km*).

5. PREPARATION FOR DELIVERY

5.1 CONTINUOUS LENGTHS

For any shipment of cable, the minimum continuous (unspliced) length shall be 1000 feet (*305 m*).

5.2 PACKAGING

Unless otherwise specified on the purchase order, all cable shall be supplied in barrels. Each barrel shall be identified with the following information:

Raychem Part Number
Lot Number
Quantity in Feet (*or Meters*)
Raychem

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6. NOTES**6.1 ORDERING DATA**

Procurement documents should specify the following:

- a. Title, number, and date of this specification
- b. Applicable specification sheet part number
- c. Quantity
- d. Special preparation for delivery requirements, if applicable

6.2 ALTERNATIVE UNITS OF MEASURE

Where units of measure in this specification are followed by italicized alternative units of measure in parentheses, these alternative units may be substituted.

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