

**(R) Battery Cable**

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**1. Scope**—This SAE Standard covers low tension battery cable intended for use at a nominal system voltage of 60 V DC (25 V AC) or less in surface vehicle electrical systems. The tests are intended to qualify cables for normal applications with limited exposure to fluids and physical abuse.

**2. References**

**2.1 Applicable Publications**—The following publications form a part of this specification to the extent specified herein. Unless otherwise indicated, the latest issue of SAE publications shall apply.

**2.1.1 SAE PUBLICATIONS**—Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

SAE EA-1128—Wire Color Charts

SAE J311—Fluid for Passenger Car Type Automatic Transmission

Dictionary of Materials and Testing

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2.1.2 ASTM PUBLICATIONS—Available from ASTM, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959.

ASTM B 33—Standard Specification for Tinned Soft or Annealed Copper Wire  
ASTM B 174—Standard Specification for Bunch-Stranded Copper Conductors for Electrical Conductors  
ASTM B 263—Method for Determination of Cross-Sectional Area of Standard Conductors  
ASTM B 298—Standard Specification for Silver-Coated Soft or Annealed Copper Wire  
ASTM B 354—Definitions of Terms Relating to Uninsulated Metallic Electrical Conductors  
ASTM B 355—Standard Specification for Nickel-Coated Soft or Annealed Copper Wire  
ASTM D 412—Standard Test Methods for Vulcanized Rubber and Thermoplastic Rubbers and Thermoplastic Elastomers—Tension  
ASTM D 471—Standard Test Method for Rubber Property—Effect of Liquids  
ASTM D 573—Standard Test Method for Rubber —Deterioration in an Air Oven  
ASTM E 145—Standard Specification for Gravity—Convection and Forced-Ventilation Ovens  
ASTM F 1251—Standard Terminology Relating to Polymeric Biomaterials in Medical and Surgical Device

2.1.3 IEC PUBLICATION—Available from ANSI, 11 West 42nd Street, New York, NY 10036-8002.

IEC—Electricity, Electronics and Telecommunications, Multilingual Dictionary

**2.2 Related Publications**—The following publications are provided for information purposes only and are not a required part of this specification.

2.2.1 SAE PUBLICATIONS—Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

SAE J156—Fusible Links  
SAE J1067—Seven Conductor Jacketed Cable for Truck Trailer Connections  
SAE J1128—Low Tension Primary Cable  
SAE J1292—Automobile, Truck, Truck-Tractor, Trailer, And Motor Coach Wiring  
SAE J1654—High Voltage Primary Cable  
SAE J1673—High Voltage Automotive Wiring  
SAE J1678—Low Voltage, Ultra Thin Wall Primary Cable

2.2.2 ASTM DOCUMENTS—Available from ASTM, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959.

ASTM B 1—Standard Specification for Hard-Drawn Copper Wire  
ASTM B 3—Standard Specification for Soft or Annealed Copper Wire  
ASTM B 8—Concentric-Lay-Stranded Copper conductors, Hard, Medium-Hard, or Soft  
ASTM B 787—19 Wire Combination Unilay-Stranded Copper Conductors for Subsequent Insulation

2.2.3 IEC PUBLICATION—Available from ANSI, 11 West 42nd Street, New York, NY 10036-8002.

IEC 811-2-1—Common test methods for insulating and sheathing materials of electrical cables—Part 2: Methods specific to elastomeric compounds—Section 1: Ozone resistance test—Hot set test—Mineral oil immersion test.

2.2.4 ISO DOCUMENTS—Available from ANSI, 11 West 42nd Street, New York, NY 10036-8002.

ISO 6722—Road vehicles—Unscreened 60 V and 600 V single core cables—Test methods, dimensions and requirements  
ISO 14572—Road vehicles—Round, unscreened, 60 V and 600 V multicore sheathed cables—Basic and high performance test methods and requirements

### 3. Definitions

- 3.1 **Additional Mass (Reference “Sandpaper Abrasion Resistance” Test)**—The mass which is applied to the additional mass support rod. The combination of the forces exerted by the additional mass and the 0.63 N exerted by the remaining apparatus (bracket, additional mass support rod, and pivoting arm) is applied to the cable.
- 3.2 **Coated Wire**—Wire comprised of a given metal covered with a relatively thin application of a different metal. (ASTM B 354)
- 3.3 **Cable**—See primary cable.
- 3.4 **Conductor**—A wire or combination of wires not insulated from one another, suitable for carrying an electrical current. (ASTM B 354)
- 3.5 **Core**—See conductor.
- 3.6 **Fluid Compatibility**—The ability of a cable to resist the effects of various fluids found in surface vehicles.
- 3.7 **Hot Plate**—An electrically heated device used to test thermoset cables.
- 3.8 **Low Voltage**—Usually considered to be  $\leq 60$  V DC (25 V AC).
- 3.9 **Minimum Wall (Thickness)**—The lowest allowable insulation thickness at any point.
- 3.10 **Nominal**—A suitable approximate value used to designate or identify a component.
- 3.11 **Ozone Resistance**—The ability of a material to withstand the deteriorating effect of ozone (surface cracking). SAE, Dictionary of Materials and Testing.
- 3.12 **Plastic**—Any of numerous polymeric materials that are usually thermoplastic or thermosetting, of high molecular weight and that can be molded, cast, extruded, drawn, laminated, or otherwise fabricated into objects, powders, beads, films, filaments, fibers, or other shapes. (ASTM F 1251)
- 3.13 **Primary Cable**—The single or multi-stranded, single conductor, insulated cable used to carry electric current, by attachment to the low voltage side of an ignition coil in surface vehicles.
- 3.14 **SAE Wire Size**—A system that indicates the cross sectional area of the conductor. The Metric SAE Wire Size is the approximate area of the conductor. The English SAE Wire Size number indicates that the area of the conductor approximates the area of the American Wire Gauge for the equivalent size.
- 3.15 **Separator**—A thin layer used as a barrier to prevent mutually detrimental effects between different components of a cable such as between the conductor and insulation or between the insulation and the sheath. (IEC, Electricity, Electronics, and Telecommunications, Multilingual Dictionary)
- 3.16 **Strip Force**—The peak axial force required to overcome the adhesion between the conductor and the insulation.
- 3.17 **Strand**—See wire.
- 3.18 **Temperature Class Rating**—A class designation based on the retention of “Mechanical Properties” (tensile and elongation) after 168 h of heat aging at 30 °C above the temperature class rating.

**3.19 Thermoplastic**—A plastic capable of being softened by heating and hardened by cooling through a temperature range characteristic of the plastic and, in the softened state, capable of being repeatedly shaped by flow into articles by molding, extrusion, or forming. (IEC, Electricity, Electronics and Telecommunications, Multilingual Dictionary)

**3.20 Thermoset**—A plastic which, when cured by heat or other means, changes into a substantially infusible and insoluble product.

NOTE—Thermosets are often called thermosetting before curing and thermoset after cure. (IEC, Electricity, Electronics and Telecommunications, Multilingual Dictionary)

**3.21 Wire (Strand)**—A rod or filament of drawn or rolled metal whose length is great in comparison with the major axis of its cross section. (ASTM B 354)

**3.22 Wire Size**—See SAE wire size.

#### 4. General

**4.1 Cable Types**—See Figure 1.

Type STT	Starter or Ground, Thin wall, Thermoplastic Insulated
Type SGT	Starter or Ground, General Purpose, Thermoplastic Insulated
Type STR	Starter or Ground, Thin Wall, Thermoset Elastomer (Synthetic Rubber) Insulated
Type SGR	Starter or Ground, General Purpose, Thermoset Elastomer (Synthetic Rubber) Insulated
Type STX	Starter or Ground, Thin Wall, Cross (X) Linked Polyolefin Insulated
Type SGX	Starter or Ground, General Purpose, Cross (X) Linked Polyolefin Insulated
Type STE	Starter or Ground, Thin Wall, Thermoplastic Elastomer Insulated
Type SGE	Starter or Ground, General Purpose, Thermoplastic Elastomer Insulated

Insulation	SAE Battery Cable Types	
	Thin Wall	General Purpose
Thermoplastic	STT	SGT
Thermoset Elastomer	STR	SGR
Crosslinked Polyolefin	STX	SGX
Thermoplastic Elastomer	STE	SGE

FIGURE 1—CABLE TYPES, REFERENCE SECTION 1

- 4.2 General Test Conditions**—Test samples shall be preconditioned for at least 16 h at a room temperature of  $23^{\circ}\text{C} \pm 5^{\circ}\text{C}$ . Unless otherwise specified, all tests shall be conducted at this same temperature.
- 4.3 Tolerances**—Unless otherwise specified, all values are considered to be approximate.
- 5. General Specifications**—The finished cable shall meet the requirements for all tests specified in Figure 2 for each cable type.

Section	Description	SAE Cable Types							
		STT	SGT	STE	SGE	STR	SGR	STX	SGX
		Required				If Required			
5	General Specifications								
5.1	Conductor	*							
5.2	Insulation								
5.3	Outside Diameter	*							
5.4	Minimum Wall Thickness	*							
6	Tests								
6.1	Strand Coating	Note 1							
6.2	Solderability	*							
6.3	Mechanical Properties	*							
6.4	Dielectric	*							
6.5	Cold Bend	*							
6.6	Flame Resistance	*							
6.7	Fluid Compatibility	*							
6.8	Ozone Resistance							Note 2, 4, & 5	
6.9	Sandpaper Abrasion Resistance	*							
6.10	Hot Water Resistance							Note 2, 4, & 5	
6.11	Insulation Volume Resistivity							Note 3, & 5	
6.12	Environmental Cycling							Note 2, 4, & 5	

Notes:

- 1) This test is only required for coated copper wires.
- 2) At least one wire size shall be tested; however, for comparative purposes 19 mm<sup>2</sup> preferred.
- 3) This test is only used as part of the "Hot Water Resistance" test
- 4) This test is for initial qualification only.
- 5) The usage of "If Required" tests will be established by agreement between customer and supplier.

FIGURE 2—GENERAL SPECIFICATIONS, REFERENCE SECTION 5

- 5.1 Conductors**—The finished, uninsulated conductor, shall meet the elongation requirements specified in ASTM B 174. When tin, silver, or nickel coated wires are used, they shall withstand the applicable “Strand Coating” test specified in 6.1 and Figure 2. The cross sectional area of stranded conductors shall not be less than the values specified in Figure 3. The cross sectional area may be verified by measuring actual strand sizes or by using the weight method in ASTM B 263 with a calculated factor to account for the twist loss.

Metric		English	
SAE Wire Size mm <sup>2</sup>	Minimum Conductor Area mm <sup>2</sup>	SAE Wire Size No.	Minimum Conductor Area circular mils
13	12.1	6	24,538
19	18.3	4	37,360
32	31.1	2	62,450
40	38.1	1	77,790
50	48.3	1/0	98,980
62	59.8	2/0	125,100
81	77.6	3/0	158,600
103	98.5	4/0	205,500

**Notes:**

1. English units are not direct conversions from metric.
2. The metric wire size is the approximate nominal area of the conductor.
3. The SAE wire size number indicates that the cross sectional area of the conductor approximates the area of the American Wire Gauge for the equivalent size.

FIGURE 3—CONDUCTORS, REFERENCE 5.1

- 5.2 Insulation**—The insulation shall be homogeneous and shall be placed concentrically within commercial tolerances about the conductor. The insulation shall adhere closely to, but strip readily from, the conductors leaving them in suitable condition for terminating. A separator shall be used between uncoated conductors and insulations with a sulfur cure. Separators are optional for other constructions.
- 5.3 Outside Diameter**—The “Outside Diameter” shall be measured at five separate cross sections spaced 50 mm apart with an optical device accurate to at least 0.01 mm. Other devices may be used; however, in case of dispute, the referee shall be the optical device. A minimum of two readings shall be taken at each cross section. The sample should be rotated 90 degrees between readings. The mean of the diameter readings shall determine the finished cable diameter and shall be in accordance with Figure 4 for the various cable types.
- 5.4 Minimum Wall Thickness**—The “Minimum Wall Thickness” shall be measured at five separate cross sections spaced 400 mm apart using the equipment described in 5.3. All individual minimum wall measurements must be in accordance with Figure 4.

SAE Wire Size mm <sup>2</sup>	STT STR STX STE			SGT SGR SGX SGE		
	<u>Wall Thickness</u>		Maximum	<u>Wall Thickness</u>		Maximum
	Nominal mm	Minimum mm	OD mm	Nominal mm	Minimum mm	OD mm
13	1.09	0.76	7.80	1.52	1.06	8.60
19	1.12	0.78	9.50	1.65	1.16	10.50
32	1.12	0.78	11.00	1.65	1.16	12.00
40	1.12	0.78	12.00	1.65	1.16	13.00
50	1.12	0.78	13.00	1.65	1.16	14.50
62	1.12	0.78	14.50	1.65	1.16	16.00
81	1.12	0.78	17.00	1.98	1.39	18.50
103	1.12	0.78	18.50	1.98	1.39	20.00

Note:  
For reference only, English units are included in Appendix A.

FIGURE 4—OUTSIDE DIAMETER AND MINIMUM WALL THICKNESS, REFERENCE 5.3 AND 5.4

## 6. Tests

- 6.1 Strand Coating**—The “Strand Coating” test shall be conducted on individual strands prior to stranding and shall be conducted per ASTM B 33, B 298, or B 355. This test is not required for uncoated strands.
- 6.2 Solderability**—25 mm of insulation shall be removed from a 300 mm sample of finished cable. 12 mm of the stripped end shall be immersed into a component lead tinning flux such as Kester #2164, water soluble flux for 3 to 5 s. The stripped end shall then be immersed in solder 30 to 40% Sn, remainder Pb at 400 to 425 °C for 3 to 5 s. Other fluxes, solders, and temperatures may be used; however, in case of a dispute, the referee shall be the Kester #2164 and the solder and temperature shown in this specification. A visual inspection shall reveal no area in the immersed section which is not covered by solder.
- 6.3 Mechanical Properties**—An accelerated aging test shall be conducted in accordance with ASTM D 412, D 573, E 145 Type II except using specimens of insulation removed from finished cable. The sample shall be stretched at a rate of 50 mm/min. 500 mm/min may be used as the strain rate; however, in case of a dispute, the referee method will be a 50 mm/min strain rate. The original and conditioned samples must both be elongated at the same strain rate. The original properties shall conform to the values shown in Figure 5. Samples of insulation shall be aged 168 h in a circulating air oven. The test temperature shall be as shown in Figure 5. After aging, the tensile strength shall not be less than 80% of the original test value and the elongation shall not be less than 50% of the original test value.

STE or SGE samples may be conditioned at the test temperature for 24 h prior to taking the original measurements. The samples will then be conditioned for an additional 168 h (192 h total). The tensile strength after 192 h of conditioning shall not be less than 80% of the measured value after 24 h. The elongation after 192 h of conditioning shall not be less than 50% of the measured value after 24 h.

SAE Cable Type	Minimum Tensile Strength MPa	Minimum Elongation %	Test Temperature Ref. 6.3 °C ± 2°C	Temperature Class Rating Ref. 6.12 °C ± 2°C
STT SGT	11	125	110	80
STR SGR	7	150	110	80
STX SGX	10	150	155	125
STE SGE	11	200	150	120

**Note:**

The above accelerated aging temperatures are appropriate for insulating materials currently specified in this standard. Different test conditions may be necessary for other materials.

FIGURE 5—MECHANICAL PROPERTIES AND ENVIRONMENTAL CYCLING TEST CONDITIONS,  
REFERENCE 6.3 AND 6.12

- 6.4 Dielectric**—25 mm of insulation shall be removed from each end of a 600 mm sample of finished cable and the two ends twisted together. The loop thus formed shall be immersed in water containing 5% salt by weight at room temperature so that not more than 150 mm of each end of the sample protrudes above the solution. After being immersed for 5 h and while still immersed, the sample shall withstand the application of 1000 V rms at (50 to 60) Hz between the conductor and the solution for 1 min without failure of the insulation.
- 6.5 Cold Bend**—25 mm of insulation shall be removed from each end of a 1000 mm sample of finished cable. The sample shall be placed in a cold chamber at  $-40\text{ }^{\circ}\text{C} \pm 2\text{ }^{\circ}\text{C}$  for a period of 3 h. While the sample is still at this low temperature, it shall be wrapped around a mandrel for a minimum of 180 degrees at a uniform rate of one turn in 10 s. The mass and mandrel size shall be as specified in Figure 6. Either a revolving or stationary mandrel may be used. When a revolving mandrel is used, fasten one end of the sample to the mandrel and the specified mass to the other end. No mass is required when using a stationary mandrel. A visual inspection shall reveal no cracks or splits. The sample is to be returned to room temperature and then subjected to the dielectric test specified in 6.4.



SAE Wire Size mm <sup>2</sup>	SAE Cable Type	
	STT SGT STR SGR STX SGX STE SGE	
	Mandrel Diameter mm	Mass kg
13	250	2.7
19	250	2.7
32	250	2.7
40	460	2.7
50	460	4.5
62	460	4.5
81	460	4.5
103	460	4.5

FIGURE 6—COLD BEND AND FLUID COMPATIBILITY TEST CONDITIONS, REFERENCE 6.5 AND 6.7

- 6.6 Flame Resistance**—A 600 mm sample of finished cable shall be suspended taut at 45 degrees to a horizontal plane within a partial enclosure which allows a flow of sufficient air for complete combustion but is free from drafts. A gas burner shall be used having a 13 mm inlet, a nominal core of 10 mm, and a length of 100 mm above the primary inlets. The gas burner shall be adjusted to produce a 100 mm gas flame with an inner cone 1/2 of its height. The gas burner shall be positioned beneath the test sample and perpendicular to the axis of the test sample. The top of the inner cone of the flame shall be applied as shown in Figure 7. The time of application of the flame shall be 30 s. However, the exposure time shall not be longer than the time at which the conductor becomes visible. After removal of the gas burner flame, the test sample shall not continue to burn for more than 70 s and a minimum of 50 mm of insulation at the top of the test sample shall remain unburned.

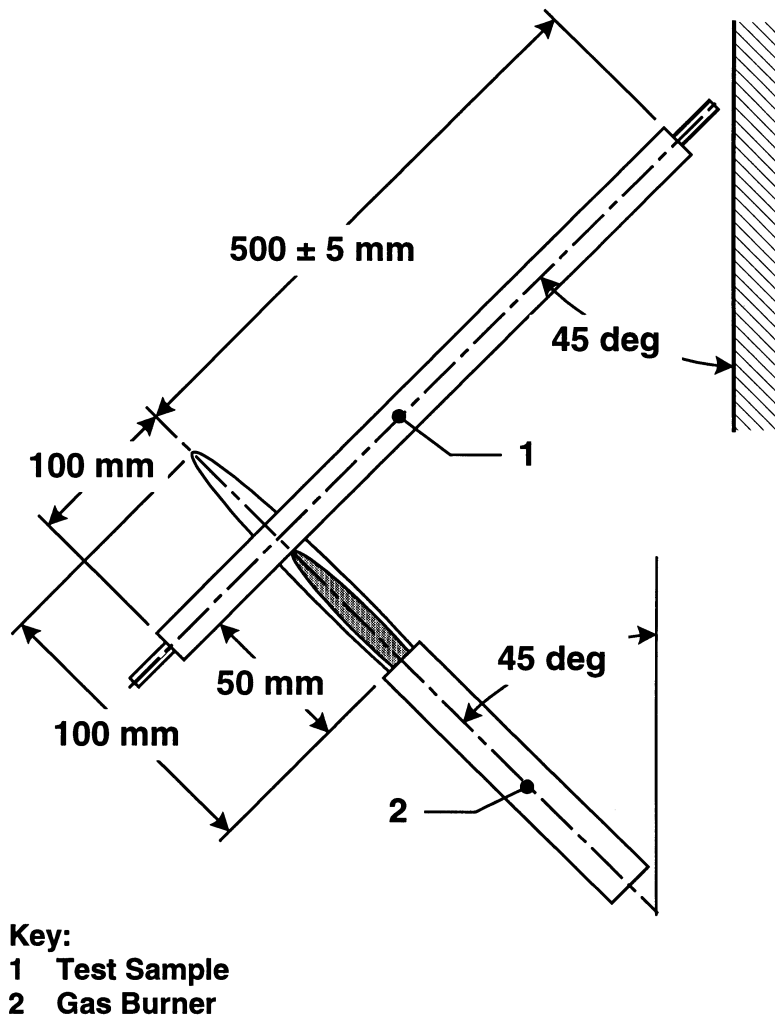


FIGURE 7—APPARATUS FOR “FLAME RESISTANCE” TEST, REFERENCE 6.6

- 6.7 Fluid Compatibility**—25 mm of insulation shall be removed from each end of 1000 mm samples of finished cable. A separate sample shall be used for each fluid. The original outside diameter shall be measured using the procedure described in 5.3. The area of the sample to be subjected to the bend test shall be immersed in the fluid shown in Figure 9 for a period of 20 h + 1, -0 h. After removal from the fluid, remove excess fluid from the sample and then condition the sample for 4 h at room temperature. After conditioning, the outside diameter of the cable shall again be measured using the procedure in 5.3. The mean of the diameter readings taken after conditioning shall be compared to the mean of the original diameter readings. The maximum diameter change shall be in accordance with Figure 9. The conditioned sample shall be wrapped around a mandrel as specified in Figure 6 for a minimum of 180 degrees at a uniform rate of one turn in 10 s. Either a revolving or stationary mandrel may be used. When a revolving mandrel is used, fasten one end of the sample to the mandrel and the specified mass to the other end. No mass is required when using a stationary mandrel. A visual inspection shall reveal no cracks or splits. If no exposed conductor is visible, subject the sample to the dielectric test specified in 6.4.

Test Fluid		Test Temp °C	Maximum OD Change %
Name	Fluid		
Engine Oil	ASTM D471, IRM-902	50 ± 3	15
Gasoline	ASTM D471, Ref. Fuel C	23 ± 5	15
Ethanol	85% Ethanol + 15% ASTM D471, Ref. Fuel C	23 ± 5	15
Diesel Fuel	90% ASTM D471, IRM 903 + 10% p-xylene	23 ± 5	15
Power Steering	ASTM D471, IRM-903	50 ± 3	30
Auto Trans	Dexron III SAE J311	50 ± 3	25
Engine Coolant	50% Distilled Water + 50% Ethylene Glycol	50 ± 3	15
Battery Acid	H <sub>2</sub> SO <sub>4</sub> , Specific Gravity = 1.260 ± .005	23 ± 5	5
Note: Solutions are determined as % by volume.			

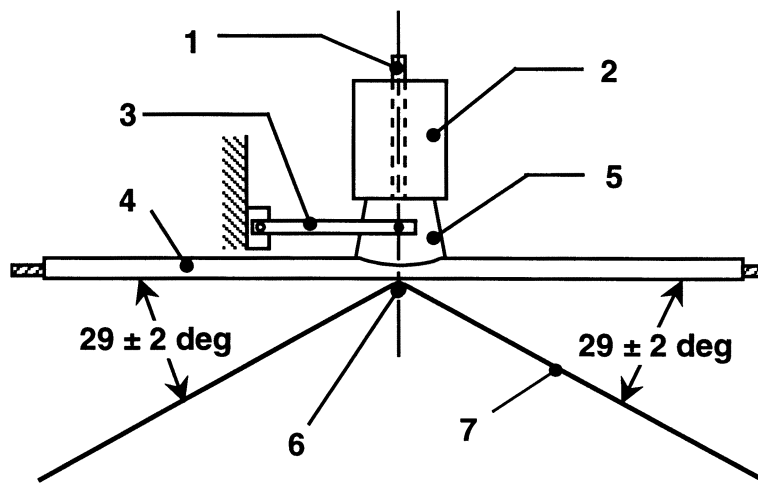
FIGURE 8—FLUID COMPATIBILITY, REFERENCE 6.7

- 6.8 Ozone Resistance**—This test is for initial qualification only. The usage of this test will be established by agreement between customer and supplier. At least one wire size shall be tested; however, for comparative purposes 19 mm<sup>2</sup> is preferred. A 300 mm sample of finished cable shall be wound a minimum of 180 degrees around the mandrel specified in Figure 11 at a uniform rate of one turn in 10 s and secured. The assembly shall then be conditioned for 192 h + 1 h, -0 h at 65 °C ± 3 °C in an atmosphere containing 100 pphm ± 5 pphm of ozone. A visual inspection shall reveal no cracks or splits.

SAE Wire Size mm <sup>2</sup>	SAE Cable Type	
	STT STR STX STE	SGT SGR SGX SGE
	Mandrel Diameter mm	Mandrel Diameter mm
13	25	25
19	25	40
32	40	40
40	40	40
50	40	40
62	40	50
81	50	50
103	50	65

FIGURE 9—OZONE RESISTANCE TEST CONDITIONS, REFERENCE 6.8

**6.9 Sandpaper Abrasion Resistance**—25 mm of insulation shall be removed from one end of a 900 mm sample of finished cable. The test sample shall then be placed taut, without stretching in a horizontal position (see Figure 10). The additional mass specified in Figure 11 and a suitable bracket shall be used to maintain the cable position over an unused area of the abrasion tape. The total weight of the bracket, support rod, and pivoting arm shall be  $0.63 \text{ N} \pm 0.05 \text{ N}$ . 150J garnet sandpaper with 10 mm conductive strips perpendicular to the edge of the sandpaper spaced a maximum of every 75 mm shall be used to abrade the insulation. The DC resistance of the conductive strips shall be  $15\,000 \, \Omega$  (when measured across the width of the sandpaper) or low enough to allow the apparatus to detect exposed conductor. The sandpaper shall be pulled under the cable at a rate of  $1500 \text{ mm/min} \pm 75 \text{ mm/min}$  until a conductive strip contacts the metallic conductor. A reading shall be taken of the length of sandpaper used to abrade through the insulation. The sandpaper shall approach and exit the test sample from below at an angle of  $29 \text{ degrees} \pm 2 \text{ degrees}$  to the axis of the cable and shall be supported by a pin  $6.9 \text{ mm} \pm 0.1 \text{ mm}$  in diameter. After each reading, the test sample shall be moved 50 mm and rotated clockwise 90 degrees. Four readings shall be obtained for each test sample. The mean of the readings will determine the abrasion resistance. The sandpaper abrasion resistance shall meet or exceed the minimum abrasion requirements in Figure 12.



**Key:**

- 1 Support Rod
- 2 Additional Mass
- 3 Pivoting Arm
- 4 Test Sample
- 5 Bracket
- 6 Tape Supporting Pin
- 7 Sandpaper Abrasion Tape

FIGURE 10—APPARATUS FOR “SANDPAPER ABRASION RESISTANCE” TEST, REFERENCE 6.9

SAE Wire Size mm <sup>2</sup>	Additional Mass kg
13	4.0
19	4.0
32	4.0
40	4.0
50	4.0
62	4.0
81	4.0
103	4.0
Note: See FIGURE 12 for minimum abrasion resistance.	

FIGURE 11—SANDPAPER ABRASION RESISTANCE ADDITIONAL MASS, REFERENCE 6.9

SAE Wire Size mm <sup>2</sup>	SAE Cable Type							
	STT mm	SGT mm	STR mm	SGR mm	STX mm	SGX mm	STE mm	SGE mm
13	250	500	TBD	TBD	250	500	300	500
19	350	650	TBD	TBD	500	1000	350	650
32	400	750	TBD	TBD	700	1500	400	750
40	450	850	TBD	TBD	900	2000	450	850
50	500	950	TBD	TBD	1100	2500	500	950
62	550	1050	TBD	TBD	1300	3000	550	1050
81	600	1150	TBD	TBD	1500	3500	600	1150
103	650	1250	TBD	TBD	1700	4000	650	1250

FIGURE 12—MINIMUM SANDPAPER ABRASION RESISTANCE, REFERENCE 6.9

**6.10 Hot Water Resistance**—This test is for initial qualification only. The usage of this test will be established by agreement between customer and supplier. At least one wire size shall be tested; however, for comparative purposes 19 mm<sup>2</sup> is preferred. 25 mm of insulation shall be removed from each end of two 2.5 m ± 0.1 m samples of finished cable. Other test sample lengths may be used; however, in case of a dispute, the referee method shall use the 2.5 m test sample length. Closely wind a minimum of three complete turns of the first test sample around a mandrel 5 times the diameter of the test sample and secure the coil as shown in Figure 13. Immerse the first test sample in a saltwater bath with 10 g/L of NaCl in distilled water at 85 °C ± 5 °C. To avoid interaction between compounds, test samples with different insulating compounds shall not be tested in the same bath. Also, a virgin saltwater bath shall be used for each test. Connect one end of the first test sample to the positive terminal of a 48 V DC power source. Connect the negative terminal to the copper electrode in the bath. After 7 days, disconnect the 48 V supply, measure the insulation resistance, and calculate the “Insulation Volume Resistivity” (see 6.11). This completes one cycle. Repeat this procedure for a total of five cycles, 35 days. After conditioning, remove the test sample from the bath, allow it to cool to room temperature, and make a visual inspection of the insulation. Ignore any damage caused by the tie, which secures the coils. If no exposed conductor is visible, perform the “Dielectric” test (see 6.4) except the voltage will be applied after immersion in the salt solution for a minimum of 10 min.

Perform the entire procedure for the second test sample with the polarity of the 48 V DC power source reversed.

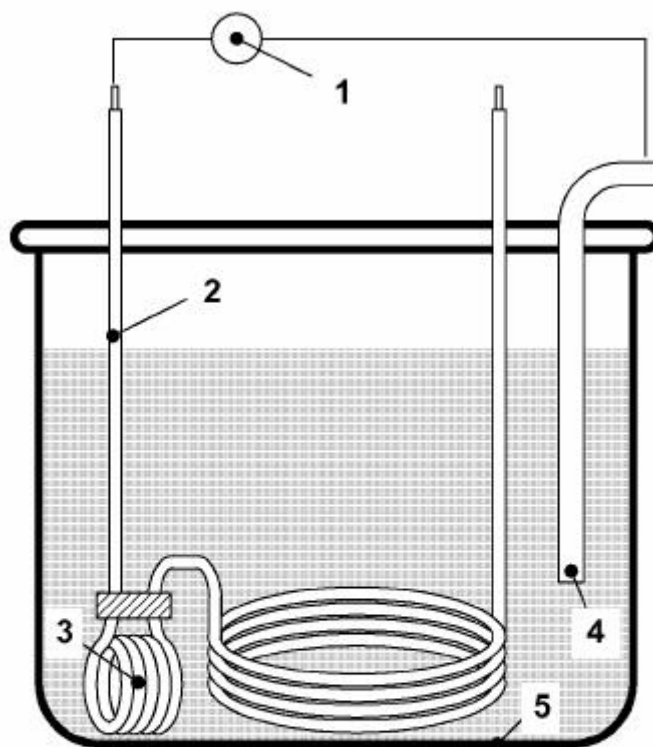
**6.11 Insulation Volume Resistivity**—This test is only used as part of the “Hot Water Resistance” test (see 6.10). While still in the saltwater bath, connect the sample to a resistance measuring device with a DC voltage of 500 V. Voltages between 100 V and 500 V are allowed, however, in case of a dispute, the referee apparatus shall be a resistance measuring device with a DC voltage of 500 V. The insulation resistance shall be measured 1 min after application of the voltage or after it reaches equilibrium, whichever comes last. Calculate the “Insulation Volume Resistivity” using the Equation 1:

$$\rho_0 = 2.725 \frac{LR}{\log \frac{D}{d}} \quad (\text{Eq. 1})$$

where:

$\rho_0$  is the “Insulation Volume Resistivity”, expressed in  $\Omega \cdot \text{mm}$   
 L is the immersed length of the test sample, expressed in mm  
 R is the measured insulation resistance, expressed in  $\Omega$   
 D is the outside cable diameter, in accordance with 5.3, expressed in mm  
 d is the conductor diameter, expressed in mm  
 log is log to the base 10

The “Insulation Volume Resistivity” shall not be less than 10<sup>9</sup>  $\Omega \cdot \text{mm}$ .

**Key:**

- 1 48 V DC Power Source
- 2 Test Sample
- 3 Closely Wound Turns of Test Sample
- 4 Copper Electrode
- 5 Non-Conductive Vessel

FIGURE 13—APPARATUS FOR “HOT WATER RESISTANCE” TEST, REFERENCE 6.10

**6.12 Environmental Cycling**—This test is for initial qualification only. The usage of this test will be established by agreement between customer and supplier. At least one wire size shall be tested; however, for comparative purposes 19 mm<sup>2</sup> is preferred. 25 mm of insulation shall be removed from each end of two 600 mm samples of finished cable. Wind a minimum of 180 degrees around a mandrel 1.5 times  $\pm$  0.3 times the diameter of the sample at a uniform rate of one turn in 10 s and secure the ends. Condition the sample according to the temperature and relative humidity shown in Figure 14. The “Temperature Class Rating” is shown in Figure 5. The cycle begins with the sample at  $-40^{\circ}\text{C} \pm 2^{\circ}\text{C}$  and  $5\% \pm 5\%$  relative humidity. Completion of the schedule shown in Figure 14 will constitute one cycle. Repeat the cycle for a total of 40 cycles. While still on the mandrel, remove the test sample from the chamber, allow it to cool at room temperature for 30 min, and unwind it from the mandrel. Make a visual inspection of the insulation. Ignore any damage caused by the ties, which secure the ends. If no exposed conductor is visible, perform the “Dielectric” test (see 6.4) except the voltage will be applied after immersion in the salt solution for a minimum of 10 min.

## 7. Reference Information

**7.1 Color Code**—The purpose of the “color code” is to provide visual information during the building and servicing of wiring assemblies. Cables of different colors shall be distinguishable from each other.

**7.1.1 RECOMMENDED COLORS**—The color of the cable should match as closely as possible the central color specified in Appendix C. The “Light” and “Dark” color limits are for guidelines only.

**7.1.2 STRIPES**—When additional color coding is required, various colored stripes may be applied longitudinally, spirally, or by other manner agreed upon by the supplier and user. The color standards do not apply to stripes.

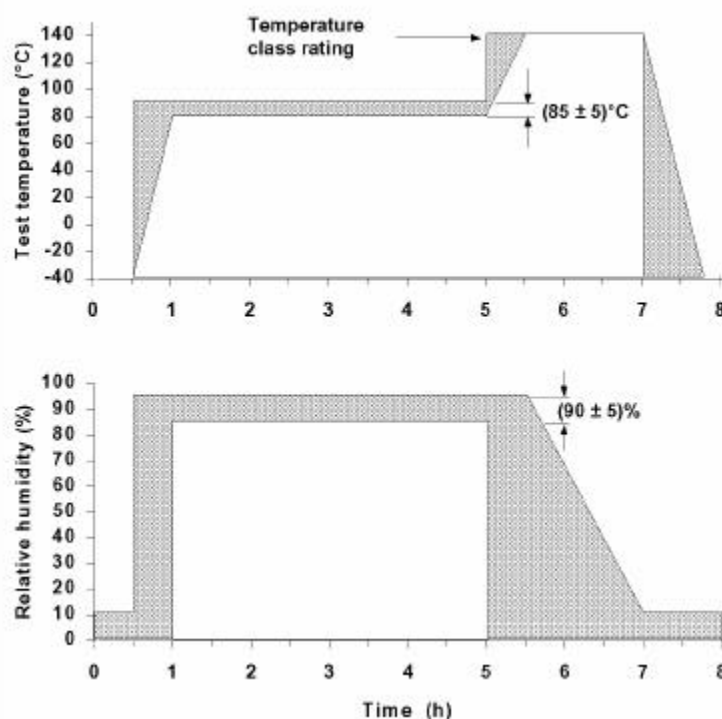


FIGURE 14—PROCEDURE FOR “ENVIRONMENTAL CYCLING” TEST, REFERENCE 6.12

## 8. Notes

**8.1 Marginal Indicia**—The change bar (|) located in the left margin is for the convenience of the user in locating areas where technical revisions have been made to the previous issue of the report. An (R) symbol to the left of the document title indicates a complete revision of the report.

PREPARED BY THE SAE CABLE TASK FORCE OF THE SAE ELECTRICAL  
DISTRIBUTION SYSTEMS STANDARDS COMMITTEE



## APPENDIX A

FOR INFORMATION ONLY  
 OUTSIDE DIAMETER AND MINIMUM WALL THICKNESS  
 ENGLISH UNITS  
 REFERENCE 5.3 AND 5.4

SAE Wire Size No.	STT STR STX STE			SGT SGR SGX SGE		
	Wall Thickness Nominal in	Minimum in	Maximum OD in	Wall Thickness Nominal in	Minimum in	Maximum OD in
6	0.043	0.030	0.305	0.060	0.042	0.340
4	0.044	0.031	0.375	0.065	0.045	0.420
2	0.044	0.031	0.433	0.065	0.045	0.505
1	0.044	0.031	0.472	0.065	0.045	0.557
1/0	0.044	0.031	0.512	0.065	0.045	0.600
2/0	0.044	0.031	0.571	0.065	0.045	0.655
3/0	0.044	0.031	0.669	0.078	0.055	0.750
4/0	0.044	0.031	0.728	0.078	0.055	0.810

**Note:**  
 English units for dimensions are included for information purposes only. They do not constitute a requirement for this standard.

FIGURE A1—OUTSIDE DIAMETER AND MINIMUM WALL THICKNESS (ENGLISH UNITS),  
 REFERENCE 5.3 and 5.4

## APPENDIX B

**RECOMMENDED COLORS**  
**REFERENCE SAE EA-1128, WIRE COLOR CHARTS**

Color	Light	Central	Dark
Red	2.5R 4.2/11.2	3.3R 3.8/11.0	4.4R 3.4/10.4
Orange	8.75R 6.0/11.5	8.75R 5.75/12.5	8.75R 5.5/13.5
Brown	10R 3.5/1.0	0.8YR 3.0/1.0	4.6YR 2.5/1.0
Tan	5YR 6.25/4.0	5YR 5.9/4.3	5YR 5.5/4.6
Yellow	8.4Y 8.5/8.3	8.2Y 8.5/9.8	8Y 8.5/11.2
Lt Green	0.5G 6.25/6.3	0.5G 5.6/7.0	0.5G 5.1/7.5
Dk Green	2.2BG 4.75/9.4	1.3BG 4.25/9.4	0.5BG 3.75/9.4
Lt Blue	9B 5.4/5.0	9B 5.0/5.0	9B 4.7/5.0
Dk Blue	4.6PB 3.8/10.2	5.2PB 3.3/9.8	5.6PB 2.75/9.4
Purple	4.4P 3.9/6.7	3.9P 3.4/6.7	3.4P 2.8/6.7
Pink	7RP 6.1/11.5	7.2RP 5.6/12.1	7.7RP 5.2/12.5
Gray	N6.3/(10GY,0.2)	N5.7/(10GY,0.2)	N5.2/(10GY,0.2)
White	Not Applicable	5Y 9/1	5Y 8.5/1
Black	N3	N 2.25	Not Applicable
Notes: 1. Comparison must be made by a person with normal color sensitivity, under cool white fluorescent lighting. The surface being inspected and the tolerance set must be in the same plane. Cable samples must be placed flat, overlapping the color standard. 2. FMII, measured under CIE illuminant C, 2 deg observer. 3. The "Light" and "Dark" color limits are for guidelines only.			

FIGURE B1—RECOMMENDED COLORS, REFERENCE SAE EA-1128 WIRE COLOR CHARTS

## APPENDIX C

## SOURCES FOR SAE REFERENCE MATERIALS

Fluid	Supplier	Packaging
Engine Oil ASTM D471 IRM 902 Oil	R. E. Carol, Inc. P. O. Box 5806 Trenton, NJ 08638-0806 Contact: Customer Service Phone: (800)-257-9365 Fax: (609)-695-0102	5 Gal Can
	Penreco 4426 East Washington Blvd. Los Angeles, CA 90023 Phone: (213)-268-4271 Fax: (213)-268-7972	5 Gal Can
Power Steering ASTM D471 IRM 903 Oil	R. E. Carol, Inc. P. O. Box 5806 Trenton, NJ 08638-0806 Contact: Customer Service Phone: (800)-257-9365 Fax: (609)-695-0102	5 Gal Can
	Penreco 4426 East Washington Blvd. Los Angeles, CA 90023 Phone: (213)-268-4271 Fax: (213)-268-7972	5 Gal Can
Automatic Trans Fluid SAE J311, <b>Dexron III</b> Citgo Part No. 33123	Citgo Petroleum 699 Heights Rd. Lake Orion, MI 48362 Contact: Dave LaRocca Phone: (800)-331-4068	55 Gal Drum or Quart
Kester #2164 Flux	Kester Solder 515 East Touhy Avenue Des Plaines, IL 60018-2675 Contact: Julie Courtney Phone: (847) 699-4628 Fax: (847) 699-5548	Pint Quart or Gallon
Sandpaper Abrasion Tape	Glowe-Smith Industrial, Inc. 812 Youngstown Kingsville Rd. Vienna, Ohio 44473 Contact: Terry Dillman Phone: (330) 539-5085 Fax: (330) 539-7750	Single Roll ≥ 2 Rolls ≥ 6 Rolls ≥ 11 Rolls ≥ 51 Rolls

FIGURE C1—SOURCES FOR SAE REFERENCE MATERIALS

## SAE J1127 Revised MAY2000

**Rationale**—This document was revised to include the following:

- a. The maximum system voltage was changed to 60 V DC (25 V AC).
- b. A “Definitions” section was added.
- c. An additional fluid was added to the “Fluid Compatibility” section.
- d. “Hot Water Resistance” and “Environmental Cycling” tests were added.
- e. Revised Color Code Section to clarify reason for color code and the use of the limits as guidelines.
- f. Move text out of figure drawings and into legends.

**Relationship of SAE Standard to ISO Standard**—This document covers similar products to those in ISO 6722.

**Application**—This SAE Standard covers low tension battery cable intended for use at a nominal system voltage of 60 V DC (25 V AC) or less in surface vehicle electrical systems. The tests are intended to qualify for normal applications with limited exposure to fluids and physical abuse.

### Reference Section

SAE J156—Fusible Links

SAE J311—Fluid for Passenger Car Type Automatic Transmission

SAE J1067—Seven Conductor Jacketed Cable for Truck Trailer Connections

SAE J1128—Low Tension Primary Cable

SAE J1292—Automobile, Truck, Truck-Tractor, Trailer, And Motor Coach Wiring

SAE J1673—High Voltage Automotive Wiring

SAE J1678—Low Voltage, Ultra Thin Wall Primary Cable

SAE J1654—High Voltage Primary Cable

SAE EA-1128—Wire Color Charts

Dictionary of Materials and Testing

ASTM B 1—Standard Specification for Hard-Drawn Copper Wire

ASTM B 3—Standard Specification for Soft or Annealed Copper Wire

ASTM B 8—Concentric-Lay-Stranded Copper conductors, Hard, Medium-Hard, or Soft

ASTM B 33—Standard Specification for Tinned Soft or Annealed Copper Wire

ASTM B 174—Standard Specification for Bunch-Stranded Copper Conductors for Electrical Conductors

ASTM B 263—Method for Determination of Cross-Sectional Area of Standard Conductors

ASTM B 298—Standard Specification for Silver-Coated Soft or Annealed Copper Wire

ASTM B 354—Definitions of Terms Relating to Uninsulated Metallic Electrical Conductors

ASTM B 355—Standard Specification for Nickel-Coated Soft or Annealed Copper Wire

ASTM B 787—19 Wire Combination Unilay-Stranded Copper Conductors for Subsequent Insulation

ASTM D 412—Standard Test Methods for Vulcanized Rubber and Thermoplastic Rubbers and Thermoplastic Elastomers—Tension

ASTM D 471—Standard Test Method for Rubber Property—Effect of Liquids

ASTM E 145—Standard Specification for Gravity—Convection and Forced-Ventilation Ovens

ASTM F 1251—Standard Terminology Relating to Polymeric Biomaterials in Medical and Surgical Device

IEC 811-2-1—Common test methods for insulating and sheathing materials of electrical cables—Part 2: Methods specific to elastomeric compounds—Section 1: Ozone resistance test—Hot set test—Mineral oil immersion test.

IEC—Electricity, Electronics and Telecommunications, Multilingual Dictionary

ISO 6722—Road vehicles—Unscreened 60 V and 600 V single core cables—Test methods, dimensions and requirements

ISO 14572—Road vehicles—Round, unscreened, 60 V and 600 V multicore sheathed cables—Basic and high performance test methods and requirements

**Developed by the SAE Cable Task Force**

**Sponsored by the SAE Electrical Distribution Systems Standards Committee**