SURFACE VEHICLE STANDARD

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High-Tension Ignition Cable

RATIONALE

Updating some of the test criteria to be more in line with the test results obtained from the materials being used today in ignition cables, especially those in Class C cables.

1. SCOPE

The specifications contained in this SAE Standard pertain to high-tension ignition cable used in road vehicle engine ignition systems.

2. REFERENCES

2.1 Applicable Documents

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 UL Publications

Available from UL, 333 Pfingsten Road, Northbrook, IL 60062-2096, Tel: 847-272-8800, www.ul.com.

UL 1581 Reference Standard for Electrical Wires, Cables, and Flexible Cords

2.2 Related Publications

The following publications are provided for information purposes only and are not a required part of this SAE Technical Report.

2.2.1 ASTM Publications

Available from ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959, Tel: 610-832-9585, www.astm.org.

ASTM D471 Standard Test Method for Rubber Property - Effect of Liquids

TO PLACE A DOCUMENT ORDER: **Tel: 877-606-7323 (inside USA and Canada)**
Tel: +1 724-776-4970 (outside USA)
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SAE WEB ADDRESS: **http://www.sae.org**

For more information on this standard, visit
https://www.sae.org/standards/content/J2031_202008

2.2.2 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or +1 724-776-4970 (outside USA), www.sae.org.

SAE J2032 Ignition Cable Assemblies

3. CABLE DIMENSIONS

The average overall diameter of finished cable shall be 5 mm, 7 mm, or 8 mm. Other sizes are acceptable and dimensional control for these will be as agreed on by manufacturer and customer. Allowable tolerance for either size shall be ±0.3 mm. The average overall diameter shall be determined by taking the average of five sets of measurements along a 1 m length of finished cable. Each set of measurements shall consist of the determination of the maximum and minimum diameter at the point of measurement.

4. TEST REQUIREMENTS

When tested according to the methods outlined, the ignition cables covered by this document shall be capable of complying with the applicable requirements specified herein. Test methods and requirements for cable constructions other than those specified previously will be as agreed on by manufacturer and customer. Figure 1 defines the applicability of the test and provides specific performance criteria.

NOTE: Wherever the term “room temperature” is used, it shall be defined as 23 °C ± 5 °C.

NOTE: Wherever the term “full draft, circulating-air oven” is used, the air shall be completely exchanged at least eight times per hour, but no more than 20 times per hour.

4.1 Spark Test

When agreed upon by the manufacturer and customer, an AC spark test shall be performed on 100% of production of each ignition wire to which it is applicable (see Figure 1). Apparatus shall consist of a voltage source, electrode, voltmeter, fault-current device or system, and the necessary electrical connections. The recommended apparatus and test method shall be that described in UL 1581, Section 900. Test potential shall be 25 kV for 5 mm, 25 kV for 7 mm cable, and 30 kV for 7 mm high energy or 8 mm cable.

NOTE: This test is not a qualification test but an in-process test carried out under production conditions. Alternate methods for this test may be considered provided that insulation faults are detected with the same degree of certainty.

4.2 High Potential Test

See A.1 in Appendix A for test apparatus. Immerse an approximate 1200 mm specimen for 4 hours in a salt solution (3% m/m of NaCl in water) at room temperature with the ends twisted together and emerging approximately 400 mm above the surface of the solution. Apply a test voltage of 20 kV (rms) for 30 minutes between the conductor and the solution.

NOTE: The applied potential is to be increased from near zero at an essentially uniform rate not to exceed 500 V/s.

The cable shall not break down. Then increase the voltage at a rate not exceeding 500 V/s to the following levels:

5 mm cable - 25 kV (rms)
7 mm cable - 30 kV (rms)
7 mm high energy cable - 35 kV (rms)
8 mm cable - 35 kV (rms)

Cable breakdown shall not occur below the voltage indicated.

TEST	DESCRIPTION	CLASS / TYPE	A		B		C		D		E		F	
			1 & 2	3 & 4	1 & 2	3 & 4	1 & 2	3 & 4	1 & 2	3 & 4	1 & 2	3 & 4	1 & 2	3 & 4
4.1	SPARK TEST		APPLY	DO NOT APPLY	APPLY	DO NOT APPLY	APPLY	DO NOT APPLY	APPLY	DO NOT APPLY	APPLY	DO NOT APPLY	APPLY	DO NOT APPLY
4.2	HIGH POTENTIAL TEST		TO BE APPLIED											
4.3	CAPACITANCE		CAPACITANCE SHALL BE AGREED ON BETWEEN CABLE MANUFACTURER AND USED.											
4.4	CORONA RESISTANCE													
	5 MM CABLE		15 KV (RMS) 50 or 60 Hz											
	7 MM CABLE		15 KV (RMS) 50 or 60 Hz											
	7 MM H. E. CABLE		18 KV (RMS) 50 or 60 Hz											
	8 MM CABLE		18 KV (RMS) 50 or 60 Hz											
4.5	DEFORMATION TEST TEST TEMPERATURE		70 C +/-2		105 C +/-2		120 C +/-2		NOT APPLICABLE		NOT APPLICABLE		NOT APPLICABLE	
4.6	THERMAL OVERLOAD TEST													
	TEST TEMPERATURE		105 C +/-2		120 C +/-2		155 C +/-2		180 C +/-2		220 C +/-2		250 C +/-2	
	MAX CHANGE IN RES.		+50%, -80%		+50%, -80%		+50%, -80%		+50%, -80%		+50%, -80%		+50%, -80%	
4.7	TEST for SHRINKAGE													
	TEST TEMPERATURE		155 C +/-2		155 C +/-2		NOT APPLICABLE		NOT APPLICABLE		NOT APPLICABLE		NOT APPLICABLE	
	MAX. SHRINKAGE		2%		2%									
4.8	RES. to FLAME PROPAGATION													
	EXPOSURE TIME		30 SEC.		30 SEC.		TO BE APPLIED		15 SEC.		15 SEC.		15 SEC.	
	EXTINCTION TIME		30 SEC.		30 SEC.		TO BE APPLIED		70 SEC.		70 SEC.		70 SEC.	
4.9	LOW TEMPERATURE TEST TEST TEMPERATURE		-20 C +/-3		-20 C +/-3		-30 C +/-3		-30 C +/-3		-40 C +/-3		-50 C +/-3	
4.10	MECHANICAL STRENGTH TEST													
4.10.1	RESISTIVE CABLES		N/A	50%	N/A	50%	N/A	50%	N/A	50%	N/A	50%	N/A	50%
4.10.2	REACTIVE CABLES		N/A	NO DISCONTINUITY	N/A	NO DISCONTINUITY	N/A	NO DISCONTINUITY	N/A	NO DISCONTINUITY	N/A	NO DISCONTINUITY	N/A	NO DISCONTINUITY
4.11	STRIPPING of INSULATION		TO BE APPLIED											
4.12	RESISTANCE to OIL		TO BE APPLIED											
4.13	RESISTANCE to FUEL		TO BE APPLIED											
4.14	ACCELERATED LIFE TEST													
4.14.1	RES. to SALT WATER		TO BE APPLIED											
4.14.2	RES. to OIL		TO BE APPLIED											
4.14.3	RES. to FUEL		TO BE APPLIED											
4.14.4	HIGH TEMPERATURE TEST TEMPERATURE RES.		90 C +/-2		105 C +/-2		120 C +/-2		155 C +/-2		180 C +/-2		220 C +/-2	
4.14.5	LOW TEMPERATURE RES. TEST TEMPERATURE RES.		-10 C +/-3		-15 C +/-3		-20 C +/-3		-20 C +/-3		-30 C +/-3		-40 C +/-3	

TYPE 1: CABLES WITH COPPER CONDUCTORS
TYPE 2: CABLES WITH STEEL CONDUCTORS
TYPE 3: CABLES WITH RESISTIVE CONDUCTORS
TYPE 4: CABLES WITH REACTIVE CONDUCTORS

NOTE: "H.E." = HIGH ENERGY

Figure 1 - Test applicability and performance criteria

4.3 Capacitance

Soak an approximate 1200 mm specimen in a salt solution (3% m/m NaCl in water) at 70 °C ± 2 °C for 24 hours with each end of the cable emerging approximately 100 mm above the surface of the solution. Measure the capacitance between the conductor and the solution. Immerse the same specimen in tap water at 23 °C ± 2 °C for 1 hour with each end of the cable emerging approximately 100 mm above the surface of the water. Again, measure the capacitance between the conductor and the water. The frequency applicable to both measurements shall be 1000 Hz. Measured capacitance values shall not exceed those agreed on between the cable manufacturer and the user.

4.4 Corona Resistance

Affix an approximate 1200 mm specimen to a mandrel as specified in A.2 in Appendix A. Apply the test potential specified in Figure 1 for a period of 8 hours.

NOTE: The applied potential is to be increased from near zero at an essentially uniform rate not to exceed 500 V/s.

There shall be no breakdown of the cable, nor shall the surface of the specimen exhibit any cracks, fractures, or other defects.

4.5 Deformation Test

Determine the average thickness of the covering(s) over the conductor of an approximate 100 mm specimen of finished cable. Mount the specimen into the test apparatus shown in A.3 in Appendix A and load with the following mass:

5 mm cable - 312 g (include mass of test frame)
7 mm cable - 450 g (include mass of test frame)
7 mm high energy cable - 450 g (include mass of test frame)
8 mm cable - 510 g (include mass of test frame)

Place the test unit into a full draft, circulating air oven maintained at the temperature specified in Figure 1 for a period of 4 hours. Remove the test unit from the oven and cool within 10 seconds by immersing in cold water. Remove the specimen and measure the depth of the indentation in the area of the application of the load using an optical device. The value of this measurement shall not exceed 50% of the original average thickness of the covering(s).

4.6 Thermal Overload Test

Suspend an approximate 500 mm specimen, when a 12.5 mm mandrel is used, or an approximate 800 mm specimen, when a 38 mm mandrel is used, vertically for 48 hours in a full draft, circulating-air oven maintained at the temperature specified in Figure 1. Upon completion of the aging, remove the specimen from the oven and allow to cool to room temperature. Subject the specimen to winding test as defined in A.4 in Appendix A. On completion of the windings, there shall be no evidence of cracks, fractures, or other defects. For resistive cables, measure the resistance of the cable at room temperature before and after the test. The allowable change in resistance shall not exceed the values specified in Figure 1.

4.7 Test for Shrinkage

This test shall apply where shrinkage of the conductor covering(s) is important with respect to the attachment of the connector. Measure the exact length (200 mm minimum) of a suitable specimen at room temperature. Place the specimen horizontally into a full draft, circulating-air oven maintained at the temperature specified in Figure 1 for a period of 15 minutes. Remove the specimen, cool to room temperature, and measure the length again. Maximum shrinkage shall not exceed the values shown in Figure 1. In addition, there shall be no evidence of cracks, fractures, or other defects in the surface of the specimen.

4.8 Resistance to Flame Propagation

For this test, a Bunsen or Tirrill gas burner having a barrel diameter of approximately 9.0 mm shall be employed. With the barrel vertical and the burner well away from the specimen, the height of the flame is to be adjusted to approximately 100 mm. The blue inner cone is to be approximately 50 mm high and the temperature at its tip is to be a minimum of 900 °C as measured using a chromel-alumel thermocouple. Suspend an approximate 500 mm specimen in a draft-free chamber and expose it to the tip of the inner cone of the flame, as shown in A.5 in Appendix A, for the period of time specified in Figure 1. Any combustion of the specimen must extinguish itself within the time specified in Figure 1 following the removal of the flame. See note below for exception.

NOTE: The Class C test results are to be used for information only and not a pass/fail test requirement, unless agreed upon between cable manufacturer and user. If agreed upon, use test criteria as shown in Figure 1 for Classes D, E, or F.

4.9 Low Temperature Test

Affix one end of an approximate 400 mm specimen to a 25 mm rotatable mandrel and attach a 4.5 kg mass to the free end. Subject the specimen, in a vertical position (i.e., with the mass freely hanging), to the temperature specified in Figure 1 for a period of 4 hours. Without removing the sample from the freezing chamber, wind it a minimum of three turns onto the rotatable mandrel at a speed of one turn/second. There shall be no evidence of cracks, fractures, or other defects.

NOTE: If the test device is precooled, a freezing time of 2 hours is sufficient.

4.10 Mechanical Strength Test

An approximate 1200 mm specimen shall be suspended as defined by A.6 in Appendix A and subjected to the following force for a period of 5 minutes:

5 mm cable - 180 N
7 mm cable - 250 N
7 mm high energy cable - 250 N
8 mm cable - 250 N

4.10.1 Resistive Cable

For resistive cables, measure the resistance prior to the test on the full length of the specimen and again after the test on a 250 mm straight portion of the specimen that was under stress. The change in the resistance per unit length shall not exceed the value shown in Figure 1.

4.10.2 Reactive Cable

For reactive cables, verify with approximately 12 VDC that there is no discontinuity in a 250 mm straight portion of the specimen that was under stress.

4.11 Stripping of Insulation

Where cables are required to be stripped, it shall be possible to remove at least 20 mm of insulation from the conductor cleanly and without difficulty. Specific stripping force values, when required, shall be agreed on between the manufacturer and the user.

4.12 Resistance to Oil

Measure the diameter of an approximate 400 mm specimen and then immerse for 48 hours in ASTM No. 1 oil at a temperature of 90 °C ± 2 °C with the cable ends emerging approximately 50 mm above the surface of the oil. (The oil shall be stirred during the test.) Remove the specimen, wipe off the excess oil, and cool to room temperature. The maximum change in diameter shall not exceed 15% nor decrease more than 5% for all Classes except C, see NOTE below. Subject the specimen to winding test as specified in A.4 in Appendix A. On completion of the windings, there shall be no evidence of cracks, fractures, or other defects.

NOTE: The Class C test criteria for change in diameter shall be a maximum not to exceed 20% nor decrease more than 5%.

4.13 Resistance to Fuel

Measure the diameter of an approximate 400 mm specimen and then immerse in ASTM fuel C at room temperature for 30 minutes with cable ends emerging approximately 100 mm above the surface of the fuel. Remove the sample and allow to dry for approximately 30 minutes. The maximum change in diameter shall not exceed 15% nor decrease more than 5%. Subject the specimen to winding test as specified in A.4 in Appendix A.

On completion of the windings, there shall be no evidence of cracks, fractures, or other defects.

4.14 Accelerated Life Test

Subject an approximate 1200 mm specimen to winding test as specified in A.4 in Appendix A, and then as specified in A.2. The specimen, while secured to the mandrel, shall then be subjected to each of the five tests outlined in the sequence listed. Test voltages shall be 15 kV (rms) for 5 mm and 7 mm cable and 20 kV (rms) for 7 mm high energy and 8 mm cable. The test voltage shall be applied for 30 minutes while the mandrel is contained within a close-fitting, nonmagnetic metallic sleeve, which may have flared ends. Conditioning prior to the application of the test potential shall be conducted with the sleeve in position.

NOTE: The applied potential is to be increased from near zero at an essentially uniform rate not to exceed 500 V/s. The sequence of the high temperature resistance test and low temperature resistance test may be reversed.

When immersed in liquids, the cable ends shall emerge approximately 100 mm above the surface of the liquid. There shall be no breakdown of the test specimen at any point in the sequential testing procedure.

4.14.1 Resistance to Salt Water

Place the test specimen in a full draft, circulating-air oven maintained at 90 °C ± 2 °C for 4 hours and then immediately immerse in a salt solution (3% m/m of NaCl in water) and maintain at 50 °C ± 2 °C for 16 hours. Remove the specimen from the solution, drain for 30 minutes at room temperature, and then apply the specified voltage.

4.14.2 Resistance to Oil

Place the test specimen in a full draft, circulating-air oven maintained at 90 °C ± 2 °C for 4 hours and then immediately immerse in ASTM No. 1 oil and maintain at 90 °C ± 2 °C for 16 hours. Remove the specimen from the oil, drain for 30 minutes at room temperature, and then apply the specified voltage.

4.14.3 Resistance to Fuel

Immerse the test specimen in ASTM fuel C at room temperature for 30 minutes. Remove the specimen from the fuel, drain for 4 hours with or without the sleeve, and then apply the specified voltage with the metallic sleeve in place.

4.14.4 High Temperature Resistance

Place the test specimen in a full draft, circulating-air oven maintained at the temperature shown in Figure 1 for a period of 48 hours. Remove the specimen from the oven, cool to room temperature, and then apply the specified voltage.

4.14.5 Low Temperature Resistance

Remove the nonmagnetic metallic sleeve. Unwind the test specimen from the mandrel, leaving one end secured, and attach a 4.5 kg mass to the other end. With the mass fully supported by the test specimen, the entire arrangement shall be subjected to the temperature specified in Figure 1 for a period of 4 hours. Without removing the specimen from the freezing chamber, wind it onto the mandrel for five complete turns at the rate of one turn in 5 seconds. Remove the sample from the freezing chamber, allow it to return to room temperature, remove weight and resecure free end, then replace the nonmagnetic metallic sleeve in place, and apply the specified voltage.

NOTE: If the test device is precooled, a freezing time of 2 hours is sufficient.

5. NOTES

5.1 Revision Indicator

A change bar (I) located in the left margin is for the convenience of the user in locating areas where technical revisions, not editorial changes, have been made to the previous issue of this document. An (R) symbol to the left of the document title indicates a complete revision of the document, including technical revisions. Change bars and (R) are not used in original publications, nor in documents that contain editorial changes only.

PREPARED BY THE SAE HIGH VOLTAGE IGNITION CABLE TASK FORCE
AND THE SAE IGNITION STANDARDS COMMITTEE

APPENDIX A

A.1 TEST APPARATUS FOR HIGH POTENTIAL TEST (SEE 4.2)

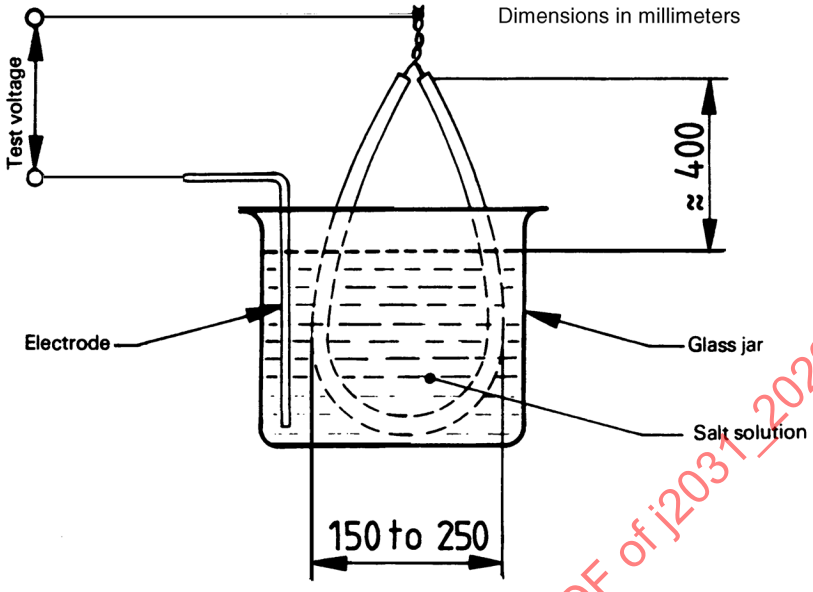

Figure A1 - Test apparatus for high potential test

A.2 TEST APPARATUS FOR CORONA RESISTANCE TEST (SEE 4.4)

Winding of the cable: Attach to one end of the cable specimen a mass of 2.5 kg. Fix the free end of the specimen to a mandrel so that the mass can hang freely. Rotate the mandrel against the force exerted by the mass so that the cable specimen is wound up in five complete turns at a pitch of approximately 19 mm. During winding, the specimen shall not be forced against the natural torsion. Then fix the ends of the cable, remove the mass, and push a closely fitting sleeve over the specimen.

The sleeve and the mandrel shall be of nonmagnetic metal. The sleeve may have flared ends.

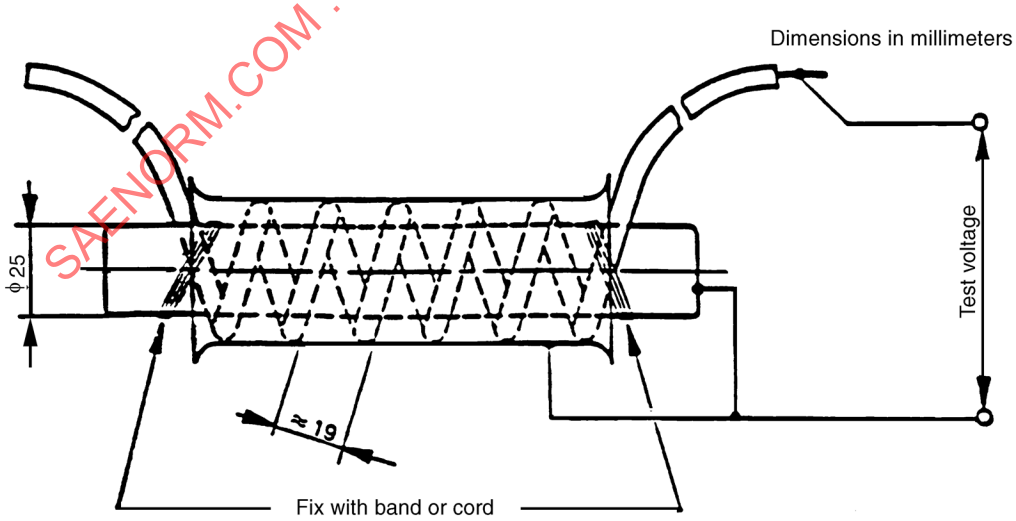

Figure A2 - Test apparatus for corona resistance test