SURFACE VEHICLE RECOMMENDED PRACTICE

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Recommended Testing Methods for Physical Protection of Wiring Harnesses

RATIONALE

This Recommended Practice is being revised to clarify the definitions of sample, specimen and bundle; to clarify how to prepare specimens for certain tests; to add second procedures for noise suppression and abrasion resistance testing; to add a dielectric test; to remove performance class information for abrasion resistance; and to state the preferred colors for coverings applied to high-voltage and medium-voltage wiring.

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1. SCOPE

This SAE Recommended Practice describes the recommended methods for testing flexible harness coverings for use on ground vehicle electrical distribution systems. This Recommended Practice shall apply to all tapes, extruded tube and textile tube.

1.1 Application

This document shall be applied for coverings used on wiring assemblies. The Customer's Engineering Group must approve material based on the functional application performance requirements to assure proper validation of covering materials.

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 SAE Publications

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

SAE ARP1536A Abrasion Test Procedure for Chafe Guard

SAE J311 Fluid for Passenger Car Type Automatic Transmissions

SAE J369 Flammability of Polymeric Interior Materials - Horizontal Test Method

SAE J1128 Low Voltage Primary Cable

SAE J1756 Determination of the Fogging Characteristics of Interior Automotive Materials

SAE J2302 Thermal Effectiveness of Sleeve Insulation

SAE J2495 Thermal Containment Efficiency of Sleeve Materials

2.1.2 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 D 471 Standard Test Method for Rubber Property - Effect of Liquids

ASTM D 3032 Standard Test Methods for Hookup Wire Insulation, Section 22 - Dynamic Cut Through

ASTM D 4157 Test Method for Abrasion Resistance of Textile Fabrics

ASTM D 5423 Forced-Convection Laboratory Ovens for Evaluation of Electrical Insulation

ASTM F 1306 Test Method for Slow Rate Penetration Resistance of Flexible Barrier Films

2.1.3 ISO Publications

Available from American National Standards Institute, 25 West 43rd Street, New York, NY 10036-8002, Tel: 212-642-4900, www.ansi.org.

ISO 3795 Road Vehicles, and Tractors and Machinery for Agriculture and Forestry - Determination of Burning Behavior of Interior Materials

ISO 6722-1 Road Vehicles - 60 V and 600 V Single-Core Cables - Dimensions, Test Methods and Requirements

Applicable Quality Standards (e.g., QS 9000, ISO/TS16949, etc.)

2.1.4 Other Publications

LV312 Protection Systems for Wiring Harness Components in Motor Vehicles : Adhesive Tapes

3. GLOSSARY

3.1 FUNCTIONALITY

Performs to design intent.

3.2 DEGRADATION

Loss of functionality due to physical changes such as cracks, tears, melting or other forms of reduction in material strength, composition or integrity.

3.3 EXTERIOR APPLICATION

Applications outside the passenger compartment

3.4 INTERIOR APPLICATION

Applications inside the passenger compartment.

3.5 RECOMMENDED PRACTICES

Suggested test method that does not include specification limits.

3.6 TAPE

A continuous strip of cloth, fabric, metal, paper or plastic material with or without adhesive.

3.7 EXTRUDED TUBE

Tubes, plain or profiled, including convoluted tubings, that are extruded from elastomers, metals, plastics, or combination of materials.

3.8 TEXTILE TUBE

Tubes that are made with textile materials.

3.9 SPECIMEN

The combination of one or more coverings applied to a wire bundle, where the coverings and wires are specified by the customer. In some instances, the coverings may be applied to a mandrel.

3.10 SAMPLE

The coverings being tested using the methods in this Recommended Practice. The combination of samples applied to a wire bundle form a specimen.

3.11 BUNDLE

Short for “wire bundle”; consists of a grouping of wires prepared in accordance with section 7.2. When samples of one or more coverings are applied to a wire bundle, the combination becomes a specimen.

4. QUALITY REQUIREMENTS

4.1 Product Quality Assurance

Product Quality Assurance must follow the requirements and be in compliance with the applicable Quality Standard.

5. CLASSIFICATION (TEMPERATURE IDENTIFICATION)

Temperature requirement is by class as noted in Table 1. It is the responsibility of the customer to determine the "Class" to be used for any application. Temperature ratings are to be considered the minimum service temperature required.

It is the responsibility of the supplier to properly designate the service temperature of their product and provide the necessary data to the performance criteria in this specification when submitting to the customer for approval. Verification of any and all of the data submitted by the supplier is at the discretion of the customer.

Table 1 - Temperature classifications

Class	Temperature (°C)
Class A	–40 to 85
Class B	–40 to 100
Class C	–40 to 125
Class D	–40 to 150
Class E	–40 to 175
Class F	–40 to 200
Class G	–40 to 225
Class H	–40 to 250

6. TESTING METHODS

The recommended test methods are found in Table 2.

Table 2 - Testing methods and their applicability to covering categories and classes

Test	Category			Applicable Class and/or Application	Test Method
	Tape	Extruded Tube	Textile Tube		
Heat Aging	X	X	X	All	7.3
Temperature/Humidity	X	X	X	All	7.4
Flammability	X	X	X	All	7.5
Low Temperature Flexibility	X	X	X	All	7.6
Automotive Fluids Resistance	X	X	X	For Exterior Applications Only	7.7
Fogging	X	X	X	For Interior Applications Only	7.8
Component Compatibility	X	X	X	Customer Designated	7.9
Noise Suppression	X	X	X	Customer Designated	7.10
Abrasion Resistance	X	X	X	Customer Designated	7.11
Puncture/Pinch	X	X		Customer Designated	7.12
Cut Through	X	X	X	Customer Designated	7.13
Impact		X		Customer Designated	7.14
Thermal Insulation	X	X	X	Customer Designated	7.15

7. TESTS PROCEDURES

7.1 Sampling

If it is not specified, the sample size must be five. The suggested dimension of the sample is 10 mm minimum, however, if the manufacturer is supplying sizes other than 10 mm, the customer may request other sample sizes. Selection must be representative of the current production for each test and test results should be reported. Precondition/equilibrate dry samples to 23 °C ± 5 °C and 50% ± 5% relative humidity for a minimum of 24 h prior to testing unless otherwise noted.

7.2 Sample/Specimen Preparation

7.2.1 Tape

Assemble a bundle of wire 300 mm or greater (300 to 450 mm recommended) in length of an appropriate number and size to approximate a diameter of 10 mm as designated by customer. Wire sizes and insulation types will be specified by the customer. If specified, cover the bundle with a piece of 10 mm diameter convoluted tubing of the same length as the bundle. Note that for the Heat Aging and Temperature/Humidity Cycling tests, the appropriate wire type and tubing with the same operation temperature as the tape in question must be used; for other tests, it may be appropriate to use wire types and/or tubing with different operation temperatures. Wrap the tape to be tested around the bundle with a 50% overlap.

7.2.2 Extruded Tube

Assemble a bundle of wire 300 mm or greater (300 to 450 mm recommended) in length of wire of an appropriate number and size to approximate a diameter of 10 mm or as specified by customer; in the absence of such specification, assemble the bundle so that its diameter is 80% of the diameter of the tubing to be tested. Wire sizes and insulation types will be specified by the customer. Cover the bundle with a piece of extruded tube of the same length as the bundle. Note that for the Heat Aging and Temperature/Humidity Cycling tests, the appropriate wire type with the same continuous operating temperature must be used with the extruded tube being tested as specified by the customer or test method; for other tests, it may be appropriate to use wire types with different operation temperatures.

7.2.3 Textile Tube

Assemble a bundle of wire 300 mm or greater (300 to 450 mm recommended) in length of an appropriate number and size to approximate a diameter of 10 mm or as specified by customer; in the absence of such specification, assemble the bundle so that its diameter is 80% of the diameter of the tubing to be tested. Wire sizes and insulation types will be specified by the customer. Cover the bundle with a piece of textile tube of the same length as the bundle. Note that for the Heat Aging and Temperature/Humidity Cycling tests, the appropriate wire type with the same continuous operating temperature must be used with the textile tube being tested as specified by the customer or test method; for other tests, it may be appropriate to use wire types with different operation temperatures.

7.3 Heat Aging

7.3.1 The material shall withstand temperature according to class noted in Table 3, and tested according to the procedure described in 7.3.2.

7.3.2 Place 30 pieces of 450 mm long test specimens of each sample in a forced air convection oven (Type II as specified in ASTM D 5423, with air exchange rate of 100 to 200 per hour) at the sample maximum class temperature (refer to Table 3) for the duration of time interval.

Table 3 - Test temperature for heat aging and temperature/humidity cycling

Class	Temperature (°C)
Class A	85 ± 2
Class B	100 ± 2
Class C	125 ± 3
Class D	150 ± 3
Class E	175 ± 3
Class F	200 ± 3
Class G	225 ± 4
Class H	250 ± 4

7.3.3 At 500, 1000, 1500, 2000, 2500, and 3000 h intervals, remove five pieces of test specimens of each sample from the oven and condition them at 23 °C ± 5 °C and 50% ± 5% relative humidity for at least 4 h.

7.3.4 Wrap each of the conditioned test specimens around a mandrel with a diameter equal to four times the nominal ID of the test specimen at a uniform rate of one turn per 10 s. After 1500 h of heat aging and at 500-h intervals to 3000 h, bend the specimens around a mandrel with a diameter equal to ten times the nominal ID of the test specimen at a uniform rate of one turn per 10 s. Visually inspect the sample on each specimen for any sign of degradation. Record and report any change in appearance and signs of degradation (e.g., cracks, melting, fading, etc.). Perform any quantitative measurements (e.g., length of any cracks or flagging sections, etc.) as requested by the customer.

7.4 Temperature/Humidity Cycling

7.4.1 Place test specimens in an environmental chamber and set the cycling sequence as following for three cycles. Refer to SAE J1128 for complete description.

Table 4 - Cycling sequence for temperature/humidity cycling test

Step	Condition	Duration	Total Time
1	Increase Temperature from 23 °C ± 5 °C & 50% ± 5% RH to –40 °C	30 min	0:30
2	Hold Temperature at –40 °C ± 2 °C	1 h	1:30
3	Increase Temperature from –40 °C ± 2 °C to 80 °C ± 2 °C & 95% ± 5% RH	30 min	2:00
4	Hold Temperature at 80 °C ± 2 °C & 95% ± 5% RH	4 h	6:00
5	Change Temperature from 80 °C ± 2 °C & 95% ± 5% RH to the Class Temperature(1)	30 min	6:30
6	Hold at Class Temperature(1)	1 h	7:30
7	Change Temperature from the Class Temperature[1] to 23 ° ± 5 °C & 50% ± 5% RH	30 min	8:00

1. Refers to Table 3.

7.4.2 Wrap each of the conditioned test specimens around a mandrel with a diameter equal to four times the nominal ID of the test specimen at a uniform rate of one turn per 10 s. Visually inspect the sample on each specimen for any sign of degradation. Record and report any change in appearance and signs of degradation (e.g., cracks, melting, fading, etc.). Perform any quantitative measurements (e.g., length of any cracks or flagging sections, etc.) as requested by the customer.

7.5 Flammability

7.5.1 Horizontal

Conduct horizontal burn test, calculate and record burn rate of each test specimen following the guidelines as established in SAE J369 (ISO 3795). Record and report as required by the customer.

7.5.2 Vertical

Conduct vertical burn test, calculate and record burn rate of each test specimen following the procedure specified in standard UL94 section 8, "20 mm Vertical Burning Test." Record and report as required by the customer.

7.6 Low Temperature Flexibility

7.6.1 Assemble test specimens according to section 7.2. Condition test specimens in a –40 °C ± 2 °C cold chamber for 4 h. If the product being tested is composed of PVC, then condition the specimens at -25 °C ± 2 °C.

7.6.2 While still in the chamber, and within 5 minutes after opening the chamber for access to the specimens, wrap the test specimens around a mandrel with a diameter equal to four times the nominal ID of the test specimen at a uniform rate of one turn per 10 s.

7.6.3 Visually inspect the sample on each specimen for any sign of degradation. Record and report any change in appearance and signs of degradation (e.g., cracks, melting, fading, etc.). Perform any quantitative measurements (e.g., length of any cracks or flagging sections, etc.) as requested by the customer.

7.7 Fluids Resistance

7.7.1 Prepare three specimens for each test fluid.

7.7.2 Immerse each set of test specimens in each test fluid specified in Table 5 for 5 min. Take precautions to ensure that at least 10 mm from each end of the sample is not exposed to the fluid. For exposures to engine coolant, engine oil, power steering and transmission fluids, ensure that fluid and samples are aged at the specified temperature for 5 minutes. For exposures to diesel fuel, gasohol and gasoline, ensure that fluid is saturated by a non-immersion technique until dripping occurs.

7.7.2.1 Solutions are determined as % by volume.

7.7.2.2 See SAE J1128 (Table C) for reference standard sources as denoted in Table 5.

Table 5 - Fluids to be used for fluids compatibility test

Fluid Name	Reference Standard [Table Note 1]	Test Temperature (°C)
Engine Oil	ASTM D 471, IRM-902	50 ± 3
Gasoline	ASTM D 471, Ref. Fuel C	23 ± 5
Gasohol	10% Ethanol + 90% ASTM D 471, Ref. Fuel C	23 ± 5
Diesel Fuel	90 % ASTM D 471, IRM-903 + 10% p-xylene	23 ± 5
Power Steering	ASTM D 471, IRM-903	50 ± 3
Auto Trans	Dexron III, SAE J311; Dexron VI	50 ± 3
Engine Coolant	50% distilled Water + 50% Ethylene Glycol	50 ± 3
Battery Acid	H2SO4, Specific Gravity = 1.260 ± 0.005	23 ± 5
Brake Fluid	SAE RM-66-04	23 ± 5
Diesel Emission Fluid	ISO 22241	23 ± 5

Table Note 1: Fluid availability may change over time.

7.7.3 Remove each specimen from test fluid and allow it to drain for 20 min. Let samples condition 23 °C ± 5 °C for 72 h.

7.7.4 Visually inspect the sample on each specimen for any sign of degradation after 1, 24, 48, and 72 h. After 72 h, wrap each specimen a complete 360 degrees around a mandrel with a diameter equal to four times the nominal ID of the test specimen at a uniform rate of one turn per 10 s. Record and report any change in appearance, signs of degradation or loss of flexibility. Perform any quantitative measurements (e.g., length of any cracks or flagging sections, etc.) as requested by the customer.

7.8 Fogging

7.8.1 Conduct the Fogging Test according to SAE J1756 using either the Photometric Method or the Gravimetric Method per agreement between customer and the supplier.

7.8.2 The test duration is to be specified by the customer.

7.8.3 Report Fog Number when using the Photometric Method; and Fog Mass when using the Gravimetric Method or as required by the customer.

7.9 Component Compatibility

7.9.1 Assemble components and test as specified by customer.

7.9.2 Test to be performed at rated temperature as required by Class specified (refer to Table 3) with no loss of functionality observed.

7.10 Noise Suppression

7.10.1 Noise Suppression is a comparative test and its requirements are to be established by the customer. It is recommended that testing be conducted with a reference standard of known or acceptable noise suppression performance level. There are two procedures given for measuring noise suppression; their order does not signify a preference. The use of either one, or of any other procedure, is to be agreed upon between the supplier and customer.

7.10.2 Prepare samples according to 7.2 except use a solid steel mandrel rather than a wire bundle. The mandrel is not to be covered with convolute or any other covering prior to applying the covering being tested.

7.10.3 Option 1

Test to be performed similarly to that prescribed in LV312-1 section 5.5.5, "Geräuschdämpfung " ["Acoustic Insulation"]. Note that this procedure specifies a single layer of tape covering; if specified by the customer, perform with a 50% overlap (if tape).

7.10.3.1 Test Apparatus

7.10.3.1.1 Insulating Cabinet

Provides a 30 dB attenuation of the laboratory ambient noise.

7.10.3.1.2 Excitation Equipment

A steel bar 8 mm in diameter is dropped onto an aluminum plate 350 mm x 190 mm (thickness 0.3 mm) from a height of 20 mm, exerting a force of 0.16 N. The detailed test setup is documented in Figure 1 and Figure 2.

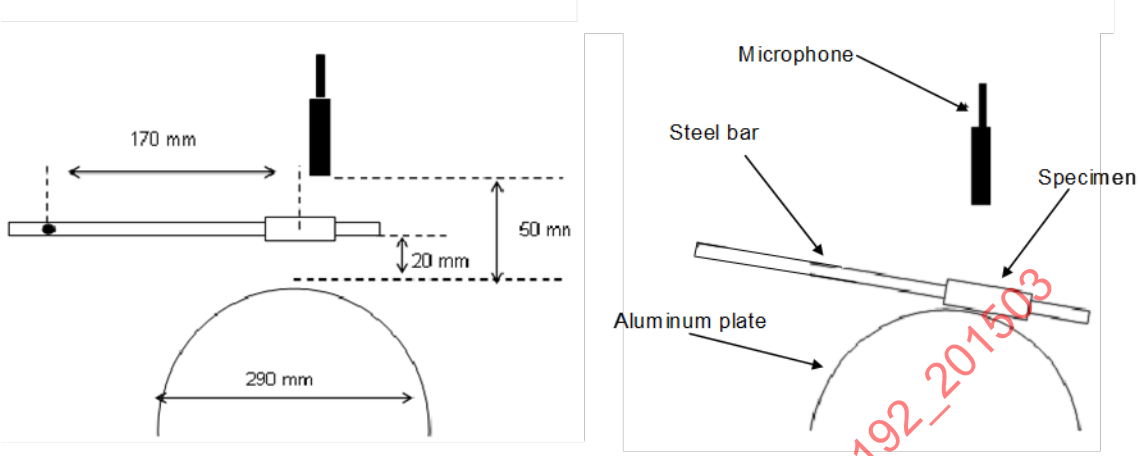

Figure 1 - Test setup

Figure 2 - Picture of test setup

7.10.3.2 Noise Measurement

The noise is measured by a microphone positioned 50mm over the impact location. The noise is measured in the form of the sound pressure level (*L*sp) with frequency evaluation A and time evaluation S. Unless otherwise specified, a single layer of the covering is applied to the steel bar in the area of the impact location over a length of 5 cm in longitudinal direction. Measured is the difference between the noise of the bar that is covered with the covering and the uncovered bar. The measuring unit is dB(A). The measurement is performed ten times at the same location of the specimen. If a trend towards lower silencing values can be discerned, for example by compressing the specimen, this shall be noted in the test report.

Record and report results.

7.10.4 Option 2: Test Apparatus

7.10.4.1 Insulating Cabinet

Provides a 30 dB attenuation of the laboratory ambient noise.

7.10.4.2 Excitation Equipment

The excitation of test equipment is created by a signal generator and amplified. The power amplifier runs a vibrator. The axle of the vibrator goes through a hole inside the cabinet and is fixed to the equipment.

7.10.4.3 Noise Measurement

The microphone is inside the cabinet and connected to an integrating sonometer outside the cabinet. The microphone (Solo (Black Edition or SLM), or equivalent) is fixed at 150 mm from the noisy contact of the steel mandrel and steel plate.

7.10.5 Test Set-Up

7.10.5.1 Rattling Test Set-Up

See Figure 3.

7.10.5.2 Rubbing Test Set-Up

See Figure 4.

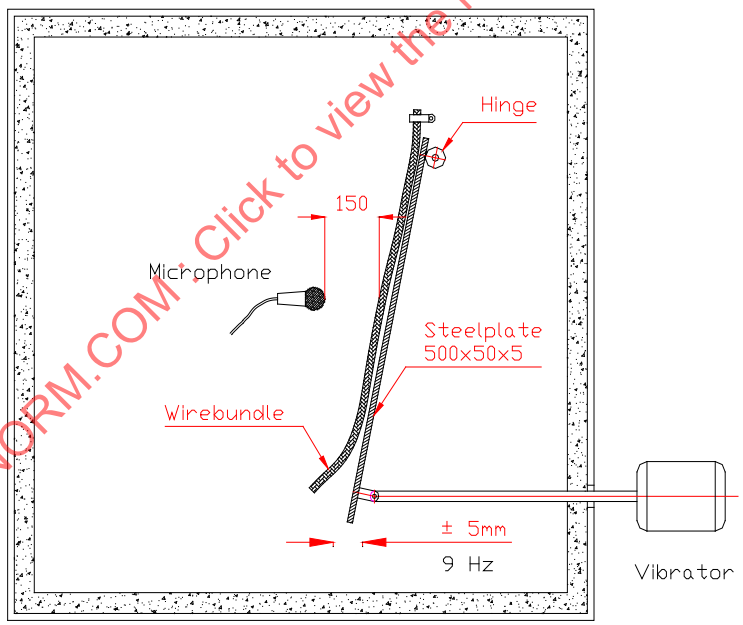

Figure 3 - Rattling test set-up

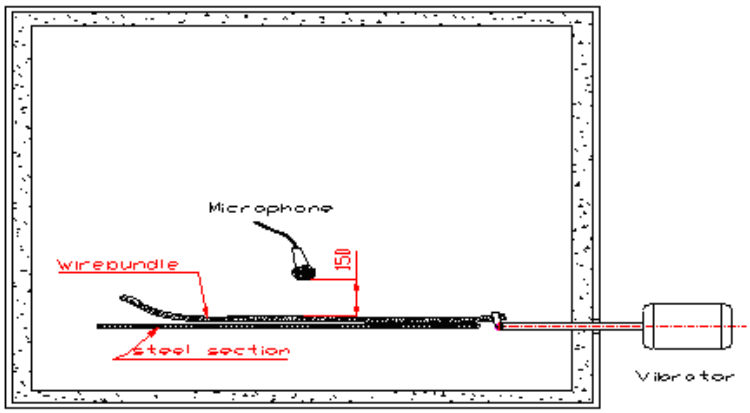

Figure 4 - Rubbing test set-up

7.10.6 Test Procedure

7.10.6.1 Run the test on the steel panel without the steel mandrel following the Rattling or Rubbing Test set-up illustration. This provides the background noise (A) inside the cabinet.

7.10.6.2 Affix steel mandrel without harness covering along the steel plate and run the test again. The noise level (B) is measured.

7.10.6.3 Affix steel mandrel with harness covering material on the steel plate and run the test. The noise level (C) is measured.

7.10.6.4 Noise Attenuation in dB is the difference between the noise level B and the noise level C. Record Noise Attenuation Level.

7.11 Abrasion Resistance

7.11.1 Abrasion resistance is a comparative test and its requirements are to be established by the customer. It is recommended that testing be conducted with a reference standard of known or acceptable abrasion resistance performance level. Two test options are given; their order does not signify a preference.

7.11.2 Option 1: Test samples to the scrape abrasion test procedure from ISO 6722-1 and LV312. Samples and specimens are to be prepared according to those procedures, except that coverings other than tape may be used. The recommended modifications to the procedure are as follows:

- Diameter of needle: 0.45 ± 0.01 mm
- Test specimen: one layer of covering applied to steel rod with diameter of 10 ± 1 mm. A different diameter rod may be agreed upon between customer and supplier.
- The scrape test is performed on the center of the covering
- Final number of double strokes (cycles) is determined by the mean value of 10 individual measurements

7.11.3 Option 2: Test eight 250 mm long samples for each harness covering following the SAE ARP1536A for tubing and sleeving materials. Modify the SAE ARP1536A Abrasion Tester by replacing the hose with a stainless steel mandrel and/or replacing the 1134-g (2.5-lb) weight with 2268-g (5-lb) weight. Control the weight to within ±2 g, and identify the diameter of the mandrel being used. Classification of wear classes for covering based on this test is left to the end user.

Record the number of cycles to failure of the sample on each test specimen. Average the test results of six test specimens by excluding the highest and the lowest values. Report the relative performance of the sample of interest as x times of the Reference Sample.