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Road vehicles — Automotive cables —

Part 2:
Test methods

Véhicules routiers — Cables automobiles —

Partie 2: Méthodes d'essai

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Contents

Page

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 22, *Road vehicles*, Subcommittee SC 32, *Electrical and electronic components and general system aspects*.

A list of all parts in the ISO 19642 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

This document was prepared following a joint resolution to improve the general structure of the ISO Automotive Electric Cable standards. This new structure adds more clarity and, by defining a new standard family, opens up the standard for future amendments.

Many other standards currently refer to ISO 6722-1, ISO 6722-2 and ISO 14572. So these standards will stay valid at least until the next scheduled systematic review and will be replaced later on by the ISO 19642 series.

For new Automotive Cable Projects customers and suppliers are advised on using the ISO 19642 series.

Road vehicles — Automotive cables —

Part 2:
Test methods

WARNING — The use of this document can involve hazardous materials, operations and equipment. This document does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this document to establish appropriate safety practices and determine the applicability of regulatory limitations prior to use.

1 Scope

This document defines test methods for electrical cables in road vehicles, which are used in other parts of the ISO 19642 series.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 1817, *Rubber, vulcanized or thermoplastic — Determination of the effect of liquids*

ISO 4892-2, *Plastics — Methods of exposure to laboratory light sources — Part 2: Xenon-arc lamps*

ISO 4926, *Road vehicles — Hydraulic braking systems — Non-petroleum-base reference fluids*

ISO 6931-1, *Stainless steels for springs — Part 1: Wire*

ISO 19642-1, *Road vehicles — Automotive cables — Part 1 — Vocabulary and design guidelines*

IEC 60811-201, *Electric and optical fibre cables — Test methods for non-metallic materials — Part 201: General tests — Measurement of insulation thickness*

IEC 60811-403, *Electric and optical fibre cables — Test methods for non-metallic materials — Part 403: Miscellaneous tests — Ozone resistance test on cross-linked compounds*

IEC 60811-501, *Electric and optical fibre cables — Test methods for non-metallic materials — Part 501: Mechanical tests — Tests for determining the mechanical properties of insulating and sheathing compounds*

IEC 62153-4-3, *Metallic communication cable test methods — Part 4-3: Electromagnetic compatibility (EMC) - Surface transfer impedance — Triaxial method*

IEC 62153-4-4, *Metallic communication cable test methods — Part 4-4: Electromagnetic compatibility (EMC) — Shielded screening attenuation, test method for measuring of the screening attenuation as up to and above 3 GHz*

IEC 62153-4-5, *Metallic communication cables test methods — Part 4-5: Electromagnetic compatibility (EMC) — Coupling or screening attenuation — Absorbing clamp method*

SAE RM-66-06, *Motor Vehicle Brake Fluid — High Boiling Compatibility/Reference Fluid*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 19642-1 apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

4 Specifications

4.1 General test conditions

Unless specified otherwise, the device under test (DUT) shall be preconditioned continuously for at least 16 h at a room temperature (RT) of (23 ± 3) °C and a relative humidity (RH) of 45 % to 75 %. Unless specified otherwise, all tests other than “In process” shall be conducted in these conditions.

Where no tolerance is specified, all values shall be considered to be approximate.

When a.c. tests are performed, they shall be at 50 Hz or 60 Hz. Applications at higher frequencies may require additional testing.

Use the temperature tolerances shown in Table 1 unless specified in the individual tests.

Table 1 — Test Temperature Tolerance

Test temperature (t) °C	Temperature tolerance °C
$t \leq 100$	±2
$100 < t \leq 200$	±3
$t > 200$	±4

Unintentional direct contact between different metals shall not occur with any of the test methods, in order to avoid electrochemical effects on the test results.

All tests shall be performed on the same manufactured batch of cable. If, for any reason, a different batch of cable is used for any of the tests, it should be noted accordingly on the test report and test summary.

Unless otherwise specified, each test is to be performed on at least 3 test specimens.

If suppliers and customers agree upon modifications or changes to the methods and requirements, it is required that all the changes and modifications be clearly documented.

4.2 Safety concerns

The precautions as described in the WARNING at the beginning of this document shall be followed.

4.3 Ovens

An oven as described in IEC 60216-4-1 and/or IEC 60216-4-2 Type 1 should be used. The air shall enter the oven in such a way that it flows over the surface of the test specimens and exits the oven. The oven shall have not less than 8 and not more than 20 complete air changes per hour at the specified ageing temperature.

5 Test methods for single core cables

5.1 Dimensional tests

5.1.1 General

Measure with a device accurate to at least 0,01 mm. Other devices may be used. However, in case of dispute, the referee shall be an optical device.

In case of disputed results due to specimen deformation in preparation, a referee method is provided below.

Prepare three test specimens from a cable test specimen 3 m in length. Take these test specimens at 1 m intervals. A test specimen consists of a 20 mm length of cable. Take care not to deform the test specimen. Immerse the test specimens in a casting resin. After hardening, take a section perpendicular to the axis of the test specimen.

5.1.2 Cable outside diameter

5.1.2.1 Purpose

This test is intended to verify that the cable outside diameter is within the required tolerances for intended functional applications.

5.1.2.2 Test specimen

Prepare one test specimen of 3 m in length.

5.1.2.3 Test

The cable outside diameter shall be measured at three separate cross-sections located 1 m apart from each other. A minimum of two readings shall be taken at each cross-section. The specimen should be rotated 90° between readings. The mean of the diameter readings shall determine the cable outside diameter and shall be in accordance with the dimensions tables in the cable documents in the ISO 19642 series for the various cable types. Additionally, no single value, minimum or maximum, may fall outside the range in the dimensions tables in the respective cable documents. For large cables (outside diameter greater than or equal to 18,0 mm), the test method described in IEC 60811-203:2012, 4.2 b, may be used for measuring the outside diameter.

5.1.3 Insulation thickness

5.1.3.1 Purpose

This test is intended to verify that the cable insulation thickness is within the required tolerances to withstand electrical, mechanical and chemical abuse.

5.1.3.2 Test specimens

Prepare three test specimens from a cable test specimen 3 m in length. Take the test specimens at 1 m intervals. Strip the insulation from the cable. A test specimen consists of a thin cross-section of insulation. Take care not to deform the test specimen during the preparation process. If cable marking causes indentation of the insulation, take the first test specimen through this indentation.

5.1.3.3 Test

Use a measuring device which shall not cause deformation.

Place the test specimen under the measuring equipment with the plane of the cut perpendicular to the optical axis. Determine the minimum insulation thickness in accordance with IEC 60811-201.

5.1.4 Conductor diameter

5.1.4.1 Purpose

This test is intended to verify that the cable conductor diameter is within the specified dimensions to fit terminal crimps and mechanical demands.

5.1.4.2 Test specimens

Use the test specimens as specified in 5.1.3.

5.1.4.3 Test

Use a measuring device which shall not cause deformation.

Determine the conductor diameter by measuring the inside diameter of the test specimens and record the maximum inside diameter for each test specimen.

5.1.5 Cross-sectional area (CSA)

5.1.5.1 Purpose

This test is intended to verify that the cable conductor fulfils the specified requirements.

5.1.5.2 Test of cross-sectional area, *A*

In case of dispute, Method 2 (weight method) is the referee method to determine the cross-sectional area, *A*.

— **Method 1:** By using the obtained resistance value, R_{20}, according to 5.2.1, the CSA, *A*, is calculated using the following formula:

$$A = \frac{1\,000 \times (1 + f_b)}{\kappa \times R_{20}}$$

where

- A is the cross-sectional area in mm²;
- R_{20} is the conductor resistance at 20 °C in mΩ/m;
- κ is the conductivity of the used conductor material in Sm/mm²:
  - for copper use a conductivity of 58,0 Sm/mm²;
  - for aluminium use a conductivity of 35,5 Sm/mm²;
  - for aluminium alloy use a conductivity of 33,5 Sm/mm²;
  - for other alloys with different conductivity, values can be used based on agreement between the customer and supplier;
- f_b is bunching loss, depending on strand construction (see ISO 19642-1).

— **Method 2:** Carefully strip the insulation from 1 m ± 5 mm of the cable under test. The conductor is weighed with a scale capable of measurement to 0,5 % accuracy of the measured value. From the result, *A* is calculated using the following formula:

$$A = \frac{W}{\rho}$$

where

A is cross-sectional area in mm^2;

W is the conductor weight in g/m;

ρ is the density of the used conductor material in g/cm^3:

for copper use a density of 8,89 g/cm^3;

for aluminium use a density of 2,70 g/cm^3;

applicable densities shall be used for alloys.

5.1.6 In-process cable outside diameter

5.1.6.1 Purpose

This in-process monitoring is intended to verify that the cable outside diameter is within the required tolerances.

5.1.6.2 Test specimens

The test specimen is 100 % of the cable production; all cable produced is to be monitored.

5.1.6.3 Test

The measurement of diameter shall be performed in the most stable area of the extrusion process.

5.2 Electrical tests

5.2.1 Conductor resistance

5.2.1.1 Purpose

This test is intended to verify that the cable conductor resistance does not exceed the maximum permitted value.

5.2.1.2 Test specimens

Prepare one test specimen of 2 m length, including the length necessary for connections.

5.2.1.3 Preparation of conductor ends

For copper and copper alloy conductors, the ends of the test specimen may be soldered.

For aluminium and aluminium alloy conductors, the oxide film on the aluminium surface shall be removed before carrying out the measurement following one of the two methods mentioned below.

In case of dispute, Method 1 is the reference method.

— **Method 1 for removal of oxide film on the aluminium surface by soldering**

  Remove the insulation from the wire, apply a soldering fluid on the aluminium surface and dip the aluminium wire into the solder bath.

In case of doubt – for example, if the resistance requirements are not met – it is possible that the soldering fluid is not applicable. The following referee soldering fluid shall be used.

The referee soldering fluid consists of the following components:

— Diethanolamine: 45 % to 65 %;

— Fluoroboric acid: 11 % to 13 %;

— Diethylene triamine: 14 % to 17 %.

The solder bath consists of the following components:

— Tin: 80 % to 90 %;

— Zinc: 10 % to 20 %;

— Other metals: 1 %.

— **Method 2 for removal of oxide film on the aluminium surface by pickling**

Remove the insulation and immerse the aluminium conductor in a solution consisting of 3,5 % hydrochloric acid in water for 1 min. Remove the wire from the hydrochloric acid solution, rinse the immersed part with distilled water and dry. Perform the conductor measurement immediately after drying.

5.2.1.4 Test

The current needs to be supplied to the DUT with extra terminals situated outside of the voltage probes (4-wire measurement method). The thickness of the blades for the voltage measurement shall be smaller than 0,5 mm. The distance between the inner edges of the voltage probes shall be 1 000 mm ± 5 mm.

Use a resistance measuring device with an accuracy of ±0,1 % of the measured value and a thermometer with an accuracy of ±0,5 °C.

Measure the ambient room temperature at the time of test. Take care to ensure that connections are secure. Measure the resistance of the test specimen. Correct the measured value using the following formula:

$$R_{20} = \frac{R_T}{L_v \left[1 + \alpha_\rho \left(T - 20\right)\right]}$$

where

R_{20} is the corrected conductor resistance at the reference temperature of 20 °C, expressed in mΩ/m;

R_T is the conductor resistance measured at the conductor temperature in mΩ;

L_v is the distance between the inner edges of the voltage probes, which shall be free from solder and is expressed in m;

T is the ambient room temperature at the time of measurement in °C;

a_ρ in 1/K, is the temperature coefficient for converting the measured resistance to the value at 20 °C.

The temperature coefficient for copper with 100 % conductivity at temperatures at 20 °C is $3{,}93 \times 10^{-3}$ 1/K.

For coated wires or alloys, the correction factor shall be established by agreement between the customer and supplier.

For soft aluminium the temperature coefficient is $4{,}03 \times 10^{-3}$ 1/K.

For other types of aluminium conductor, e.g. alloyed aluminium, CCA, etc, this may be different.

The applied temperature coefficient shall be measured according to 5.2.2 or agreed between customer and supplier and be reported.

5.2.2 Determination of temperature coefficients

5.2.2.1 Purpose

The resistance of a cable under test is determined while its temperature is increased from room temperature up to 50 °C. The resistance is calculated from a measurement of the potential difference across the cable and a measurement of the current passing through the cable. The current is supplied by a constant-current source (a d.c. power supply).

5.2.2.2 Test specimen

Prepare one test specimen according to Table 2, including the length necessary for connections.

Table 2 — Length of cable test specimen

ISO conductor size (a) mm²	Length m
$a < 2{,}5$	10
$2{,}5 \leq a < 10$	5
$a \geq 10$	2

5.2.2.3 Calibration graph

The cable under test is submitted to a temperature range from 20 °C up to 50 °C in a silicone oil bath. At least 80 % of the cable length is submersed in the oil. Alternatively, the test can be performed in a suitable heating chamber.

5.2.2.4 4-point measurement method

Apply a constant current according to Table 3. The current shall not cause warming of the conductor.

Table 3 — Maximum permissible current for resistance measurement

ISO conductor size (a) mm²	Maximum permissible current mA
$a < 0{,}35$	10
$0{,}35 \leq a < 6$	100
$a \geq 6$	1 000

The contact points for voltage measurement shall be below the oil surface in the oil bath to ensure that the part of cable between the voltage measurement points has a uniform temperature.

For the voltage measurement, a gauge with an input impedance greater than 1 MΩ shall be used.

The resistance of the cable is determined at each predefined temperature point by measurement of the current and voltage drop.

5.2.2.5 Procedure

The temperature of the oil bath shall be measured and controlled. The oil bath temperature measurement shall be more accurate than ±0,2 °C. The temperature of the oil bath shall be constant throughout the duration of the bath.

Starting at room temperature less than or equal to 25 °C, the oil is heated up to 30 °C and subsequently in steps of 10 °C up to 60 °C.

After each temperature step, wait until the change in oil temperature is less than ±0,2 °C and the change in the measured resistance value is lower than 0,04 % for 60 s.

Calculate the resistance at each temperature from the measured current, voltage and length between the voltage measurement terminals.

5.2.2.6 Analysis of test results, linear approximation

The determined resistance values, R' in Ω/m, compared to the temperature increase, ΔT (Oil bath temperature T_0 − 20 °C), represents the calibration graph, $R'(\Delta T)$.

The data pairs $R'(\Delta T)$ and ΔT from 30 °C up to and including 60 °C are fitted by linear interpolation to determine the parameters a and b in the following formula:

$$R'\left(\Delta T\right) = a \times \Delta T + b$$

where

$R'(\Delta T)$ is the determined resistance at the increased temperature ΔT;

ΔT is the increased temperature.

For calculation of the resistance temperature coefficient, α_ρ, this formula can be expressed as:

$$R'\left(\Delta T\right) = \alpha_\rho \times R'_{20} \times \Delta T + R'_{20}$$

where

R'_{20} is the electrical resistance per unit length at 20 °C in Ω/m;

α_ρ is the linear temperature coefficient of material specific resistivity in 1/K.

The constants R'_{20} and α_ρ are calculated using the following formulae:

$$R'_{20} = b$$

$$\alpha_\rho = \frac{a}{b}$$

5.2.3 Withstand voltage

5.2.3.1 Purpose

This test is intended to verify that the cable insulation is capable of withstanding the required rated voltage.

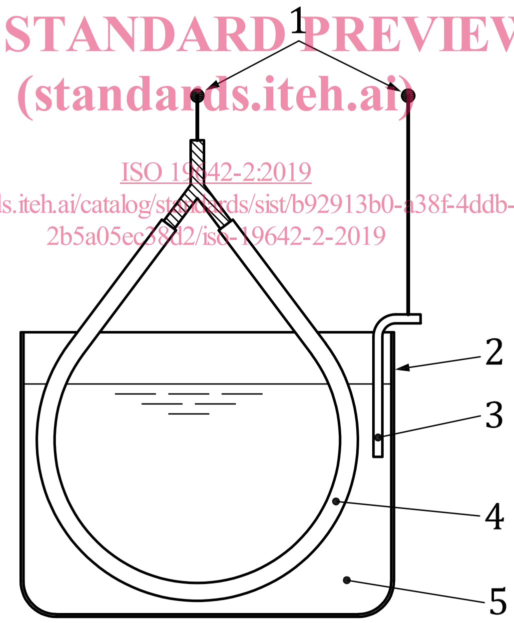
5.2.3.2 Test specimen

Prepare one test specimen of a minimum length of 350 mm. Strip 25 mm of insulation from each end and twist the ends together to form a loop.

5.2.3.3 Test

Partially fill an electrically non-conductive vessel with water salted with 3 % by weight of NaCl with the ends of the test specimen emerging above the bath as shown in Figure 1. Use a 50 Hz or 60 Hz a.c. voltage source.

Immerse the test specimen in the bath as shown in Figure 1 for 4 h and then apply a test voltage of 1 kV (a.c.) for 30 min between the conductor and the bath. Increase the voltage at a rate of 500 V/s until the specified value in the relevant part of the ISO 19642 series is reached, then hold this value for the time specified in the relevant part of the ISO 19642 series. Breakthrough shall not occur. Document "pass" or "fail" in the test report.



Key

1 test voltage (terminals)
2 non-conductive vessel
3 electrode
4 test specimen
5 salt-water bath

Figure 1 — Test apparatus for withstand voltage