

INTERNATIONAL STANDARD

REDLINE VERSION

**Winding wires - Test methods -
Part 5: Electrical properties**

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

**Winding wires - Test methods -
Part 5: Electrical properties**

FOREWORD

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This redline version of the official IEC Standard allows the user to identify the changes made to the previous edition IEC 60851-5:2008+AMD1:2011+AMD2:2019 CSV. A vertical bar appears in the margin wherever a change has been made. Additions are in green text, deletions are in strikethrough red text.

IEC 60851-5 has been prepared by IEC technical committee 55: Winding wires. It is an International Standard.

This fifth edition cancels and replaces the fourth edition published in 2008, Amendment 1:2011 and Amendment 2:2019. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

- a) Subclauses 5.3.1 and 5.3.2 modified to expand the conductor size range for the loads applied during cylinder method testing for dielectric breakdown voltage of enameled wires and for fully insulated wires.
- b) Addition of subclause 6.5 for inline continuity testing of rectangular wire (under consideration).

The text of this International Standard is based on the following documents:

Draft	Report on voting
55/2089/FDIS	55/2117/RVD

Full information on the voting for its approval can be found in the report on voting indicated in the above table.

The language used for the development of this International Standard is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/publications.

A list of all the parts in the IEC 60851 series, under the general title *Winding wires - Test methods*, can be found on the website.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under webstore.iec.ch in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn, or
- revised.

INTRODUCTION

This part of IEC 60851 forms an element of a series of standards which deals with insulated wires used for windings in electrical equipment. The series has three groups describing:

- a) winding wires – test methods (IEC 60851);
- b) specifications for particular types of winding wires (IEC 60317);
- c) packaging of winding wires (IEC 60264).

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1 Scope

This part of IEC 60851 specifies the following tests:

- Test 5: Electrical resistance;
- Test 13: Breakdown voltage;
- Test 14: Continuity of insulation;
- Test 19: Dielectric dissipation factor;
- Test 23: Pin hole.

For definitions and general notes on methods of test ~~and the complete series of methods of test for winding wires, see IEC 60851-1~~, Clause 3 of IEC 60851-1:2021 applies.

This part of IEC 60851 also specifies methods for determining the dissipation factor of enamelled winding wire, provided in Annex A.

2 Normative references

~~The following referenced documents are indispensable for the application 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.~~

~~IEC 60851-1, Winding wires — Test methods — Part 1: General~~

There are no normative references in this document.

3 Terms and definitions

No terms and definitions are listed in this document.

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

- IEC Electropedia: available at <https://www.electropedia.org/>
- ISO Online browsing platform: available at <https://www.iso.org/obp>

4 Test 5: Electrical resistance

Electrical resistance is the DC resistance at 20 °C of 1 m of wire.

The method used shall provide a precision of 0,5 %.

For bunched wires a length of up to 10 m shall be used and the ends shall be soldered before the measurement. When measuring the resistance to check for an excessive number of broken wires, a length of 10 m of bunched wire shall be used.

If the resistance R_t is measured at a temperature t other than 20 °C, the resistance R_{20} at 20 °C shall be calculated by means of the following formula:

$$R_{20} = \frac{R_t}{1 + \alpha (t - 20)}$$

where

t is the actual temperature in degrees Celsius during the measurement;

α is the temperature coefficient in K⁻¹.

In the temperature range from 15 °C to 25 °C, the temperature coefficient to be used shall be:

- for copper: $\alpha_{20} = 3,96 \times 10^{-3} \text{ K}^{-1}$;
- for aluminium: $\alpha_{20} = 4,07 \times 10^{-3} \text{ K}^{-1}$.

One test shall be made. The electrical resistance measurement shall be reported.

5 Test 13: Breakdown voltage

5.1 Principle

The test voltage shall be an AC voltage of 50 Hz or 60 Hz nominal frequency. The test voltage shall be applied at zero and increased at a uniform rate in accordance with Table 1.

Table 1 – Rates of test voltage increase

Breakdown voltage V		Rate of increase V/s
Over	Up to and including	
–	500	20
500	2 500	100
2 500	–	500

An overview of breakdown voltage specimen preparations specified in 5.3 to 5.7 is provided in 5.8.

5.2 Equipment

The following equipment shall be used:

- test transformer with a rated power of at least 500 VA providing an AC voltage of an undistorted sine waveform under test conditions, with a peak factor being within the limits of $\sqrt{2} \pm 5\%$ (1,34 to 1,48) and with a capacity to supply a current of 5 mA with a maximum voltage drop of 2 %;
- fault detection circuit, which operates at a current of 5 mA or more;
- arrangement to provide a uniform rise of the test voltage at the specified rate;
- oven with forced air circulation;
- polished metal cylinder, 25 mm $\pm$ 1 mm in diameter, mounted with its axis horizontal (see Figure 1) and electrically connected to one terminal of the test voltage supply;
- twisting device in accordance with Figure 2, that allows to twist two pieces of wire for a length of 125 mm;

- strips of metal foil, 6 mm in width and pressure sensitive tape, 12 mm in width;
- container with metal shot of stainless steel or nickel-plated iron. The diameter of the shot shall not exceed 2 mm. The shot shall be cleaned periodically by suitable means;
- metal mandrel, 50 mm $\pm$ 2 mm in diameter;
- metal mandrel, 25 mm $\pm$ 1 mm in diameter;
- metal mandrel, 80 mm $\pm$ 3 mm in diameter.

5.3 Enamelled round wire

5.3.1 Grade 1 to grade 3 with a nominal diameter up to and including ~~0,100~~ 0,500 mm

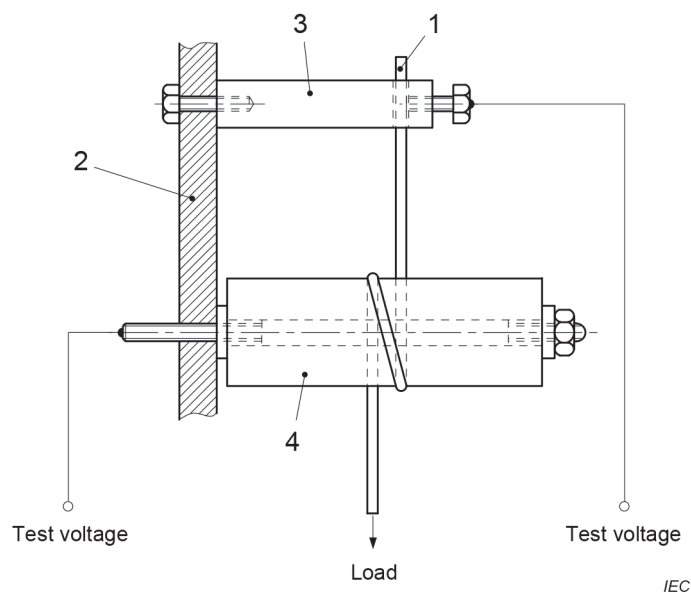
The test is carried out on a cylinder with a diameter of 25 mm $\pm$ 1 mm. A straight piece of wire with the insulation removed at one end shall be connected to the upper terminal as shown in Figure 1 and wound once around the cylinder. A load as specified in Table 2 shall be applied to the lower end of the wire to keep the specimen in close contact with the cylinder.

The test voltage shall be applied in accordance with 5.1 between the conductor of the wire and the cylinder. The test shall be carried out at room temperature.

Five specimens shall be tested. The five single values shall be reported.

Table 2 – Loads applied to enamelled wire

Nominal conductor diameter mm		Load N
Over	Up to and including	
–	0,018	0,013
0,018	0,020	0,015
0,020	0,022	0,020
0,022	0,025	0,025
0,025	0,028	0,030
0,028	0,032	0,040
0,032	0,036	0,050
0,036	0,040	0,060
0,040	0,045	0,080
0,045	0,050	0,100
0,050	0,056	0,120
0,056	0,063	0,150
0,063	0,071	0,200
0,071	0,080	0,250
0,080	0,090	0,300
0,090	0,100	0,400
0,100	0,160	0,600
0,160	0,250	0,850
0,250	0,355	1,700
0,355	0,500	3,400

**Key**

- 1 specimen
- 2 insulating material
- 3 upper terminal
- 4 cylinder

Figure 1 – Arrangement of cylinder and specimen for the breakdown voltage test

5.3.2 Grade of FIW 3 to FIW 9 with a nominal conductor diameter up to and including 1,600 mm

The test is carried out on a cylinder with a diameter as set out in Table 3.

A straight piece of wire with the insulation removed at one end shall be connected to the upper terminal as shown in Figure 1 and wound once around the cylinder. A load as specified in Table 3 shall be applied to the lower end of the wire to keep the specimen in close contact with the cylinder.

The test voltage shall be applied in accordance with 5.1 between the conductor of the wire and the cylinder. The test shall be carried out at room temperature. Five specimens shall be tested. The five single values shall be reported.

Table 3 – Loads and diameters of test cylinders applied to wire

Nominal diameter		Load	Diameter of test cylinder
mm			
Over	Up to and including	N	mm
-	0,040	0,080	25 ± 1
0,040	0,045	0,100	25 ± 1
0,045	0,050	0,130	25 ± 1
0,050	0,056	0,160	25 ± 1
0,056	0,063	0,200	25 ± 1
0,063	0,071	0,260	25 ± 1
0,071	0,080	0,330	25 ± 1
0,080	0,090	0,400	25 ± 1
0,090	0,100	0,500	25 ± 1
0,100	0,160	0,600	25 ± 1
0,160	0,250	0,850	25 ± 1
0,250	0,355	1,700	25 ± 1
0,355	0,500	3,400	25 ± 1
0,500	0,710	7,000	50 ± 2
0,710	1,060	13,500	50 ± 2
1,060	1,400	27,000	80 ± 3
1,400	1,600	54,000	80 ± 3

5.4 Enamelled round wire with a nominal conductor diameter over 0,100 mm up to and including 2,500 mm, grade 1 to grade 3

5.4.1 Test at room temperature

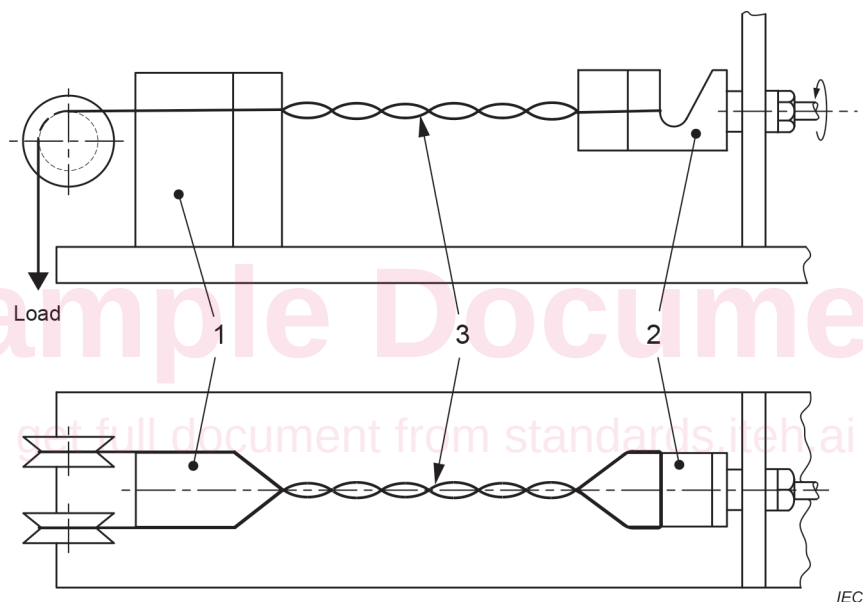
A straight piece of wire, approximately 400 mm in length, with the insulation removed at both ends, shall be twisted back on itself for a distance of (125 ± 5) mm on the twisting device as shown in Figure 2. The ends of the wire shall be joined, and the load applied with the number of twists, as given in Table 4. The loop at the end of the twisted section shall be cut at two places to provide a maximum spacing between the cut ends. Any bending to ensure adequate separation between the two wire ends shall avoid sharp bends or damage to the coating.

The test voltage shall be applied in accordance with 5.1 between the conductors of the wires.

Five specimens shall be tested. The five single values shall be reported.

Table 4 – Loads applied to the wire and number of twists

Nominal conductor diameter mm		Load N	Number of twists
Over	Up to and including		
0,100	0,250	0,85	33
0,250	0,355	1,70	23
0,355	0,500	3,40	16
0,500	0,710	7,00	12
0,710	1,060	13,50	8
1,060	1,400	27,00	6
1,400	2,000	54,00	4
2,000	2,500	108,00	3

**Key**

- 1 spacer
- 2 rotary hook
- 3 specimen

Figure 2 – Device for twisting the specimen for breakdown voltage test**5.4.2 Test at elevated temperature**

A specimen prepared in accordance with 5.4.1 shall be placed in the oven preheated to the specified test temperature ± 3 °C. The test voltage shall be applied in accordance with 5.1 between the conductors of the wires in not less than 15 min after placing the specimen in the oven. The test shall be completed within 30 min.

Five specimens shall be tested. The five single values shall be reported.

5.5 Round wire with a nominal conductor diameter over 2,500 mm

5.5.1 Test at room temperature

A straight piece of wire of sufficient length, with the insulation removed at one end, shall be bent around a mandrel as shown in Figure 3.

The diameter of the mandrel shall be $50 \text{ mm} \pm 2 \text{ mm}$.

The specimen shall be placed in the container and shall be surrounded by shot at least 5 mm between the specimen and the inner walls of the container. The ends of the specimen shall be sufficiently long to avoid flashover.

The shot shall be poured gently into a container until the specimen is covered by shot at a depth of 90 mm. The metal shot shall be not more than 2 mm in diameter; balls of stainless steel, nickel or nickel-plated iron have been found suitable. The shot shall be cleaned periodically with a suitable solvent (for example, 1,1,1-trichloroethane).

The test voltage shall be applied in accordance with 5.1, between the conductor and the shot.

NOTE—By agreement between the purchaser and the supplier, the test may be carried out with the specimen under oil. Oil should be in accordance with IEC 60296 or as agreed upon between customer and supplier.

Five specimens shall be tested. The five single values shall be reported.

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Five specimens shall be tested. The five single values shall be reported.