NORME INTERNATIONALE
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CEI
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Deuxième édition
Second edition
1996-10

Fils de bobinage – Méthodes d'essai –

Partie 6: Propriétés thermiques

Winding wires – Test methods –

Part 6: Thermal properties

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

WINDING WIRES – TEST METHODS –

Part 6: Thermal properties

FOREWORD

1) The IEC (International Electrotechnical Commission) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of the IEC is to promote international cooperation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, the IEC publishes International Standards. Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. The IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
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International Standard IEC 851-6 has been prepared by IEC technical committee 55: Winding wires.

This second edition cancels and replaces the first edition published in 1985 and constitutes a technical revision.

The text of this standard is based on the following documents:

FDIS	Report on voting
55/475A/FDIS	55/516/RVD

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

Annex A is for information only.

INTRODUCTION

This part of IEC 851 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) methods of test (IEC 851);

b) specifications (IEC 317);

c) packaging (IEC 264).

WINDING WIRES – TEST METHODS –

Part 6: Thermal properties

1 Scope

This part of IEC 851 specifies the following tests:

- Test 9: Heat shock;
- Test 10: Cut-through;
- Test 15: Temperature index;
- Test 12: Loss of mass.

For definitions, general notes on methods of test and the complete series of methods of test for winding wires see IEC 851-1.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of IEC 851. At the time of publication, the editions indicated were valid. All normative documents are subject to revision, and parties to agreements based on this part of IEC 851 are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. Members of the IEC and ISO maintain registers of currently valid International Standards.

IEC 172: 1987, *Test procedure for the determination of the temperature index of enamelled winding wires*

IEC 851-1: 1996, *Winding wires – Test methods – Part 1: General*

IEC 851-3: 1996, *Winding wires – Test methods – Part 3: Mechanical properties*

IEC 851-5: 1996, *Winding wires – Test methods – Part 5: Electrical properties*

3 Test 9: Heat shock (applicable to enamelled and tape wrapped wire)

Heat shock is the potential of the wire to withstand temperature exposure after the wire has been stretched and/or wound or bent around a mandrel.

3.1 *Specimen*

3.1.1 *Round wire*

A specimen shall be prepared in accordance with:

- 5.1.1 of IEC 851-3 for enamelled wires with a nominal conductor diameter up to and including 1,600 mm;

– 5.2 of IEC 851-3 for enamelled wires with a nominal conductor diameter over 1,600 mm;

– 5.1.1 of IEC 851-3 for tape wrapped wires with a nominal conductor diameter up to and including 1,600 mm;

– 5.5.4 of IEC 851-3 for tape wrapped wires with a nominal conductor diameter over 1,600 mm.

3.1.2 *Rectangular wire*

A specimen shall be prepared in accordance with 5.1.2 of IEC 851-3, bent however, only flatwise (on the thickness).

3.2 *Procedure*

The specimen is placed into an oven with forced air circulation for a period of 30 min and at a temperature ±5 °C specified in the relevant standard. After removal from the oven, the specimen shall be allowed to cool to room temperature and shall then be examined for cracks under a magnification according to table 1.

Table 1 – Magnification

Wire dimension	Magnification
Round wire of nominal conductor diameter up to and including 0,040 mm	10 to 15 times
Round wire of nominal conductor diameter over 0,040 mm up to and including 0,500 mm	6 to 10 times
Round wire of nominal conductor diameter over 0,500 mm	0 to 6 times
Rectangular wire	6 to 10 times

3.3 *Result*

Three specimens shall be tested in the case of round wire and two specimens shall be tested in the case of rectangular wire. Any crack detected shall be reported.

4 **Test 10: Cut-through** (applicable to enamelled round wire with a nominal conductor diameter over 0,100 mm up to and including 1,600 mm and tape wrapped round wire)

Cut-through is expressed as the temperature at which a short circuit occurs between two pieces of wire crossing each other at right angles with a specified load applied to the crossing point.

NOTE – In many cases, the cut-through temperature indicates decomposition of the insulation.

4.1 *Equipment*

The following equipment shall be used:

– metal block of brass or aluminium provided with means for electrical heating and temperature measurement and control, with two slots for inserting two wire pieces, which cross each other at right angles with the crossing point in the centre of the block, and with a ceramic piston to apply a load on the crossing point, as shown in figure 1;

– transformer of at least 100 VA providing an alternating test voltage of (100 ± 10) V, connected to an overcurrent device operating at a current of (5 ± 1) mA, and to a resistor limiting the current to 50 mA maximum.

4.2 *Procedure*

Two straight pieces of wire shall be inserted into the metal block crossing each other at right angles, with the metal block pre-heated at the temperature specified in the relevant standard. The temperature shall be measured as close as possible to the crossing point and shall not vary by more than ±3 °C from the specified value. The crossing point shall lie centrally under the piston. In the case of wire of a nominal conductor diameter of less than 0,200 mm, two straight pieces of wire shall be placed in parallel, side by side, and a third piece shall be placed at right angles across the first two with the crossing points arranged symmetrically to the axis of the piston.

After a heating period as given in table 2, a load as given in table 3 shall be applied by means of the piston. Immediately thereafter, the test voltage shall be applied between the lower and upper pieces of wire. In the case where two lower pieces are used, they shall be connected. The load and the test voltage shall be applied for 2 min.

Three tests shall be made. Any failure shall be reported.

Table 2 – Heating period

Nominal conductor diameter mm		Time from inserting until loading
Over	Up to and including	min
–	1,000	1
1,000	1,600	2

Table 3 – Loads applied to the crossing point

Nominal conductor diameter mm		Load
Over	Up to and including	N
0,100	0,125	1,25
0,125	0,315	2,20
0,315	0,500	4,50
0,500	0,800	9,00
0,800	1,250	18,00
1,250	1,600	36,00

5 Test 15: Temperature index

5.1 *Enamelled wire*

5.1.1 *Round wire*

The temperature index shall be determined in accordance with IEC 172.

5.1.2 *Rectangular wire*

As IEC 172 makes no provision for testing rectangular wire, the test shall be made on round wire with a nominal conductor diameter preferably of 1,000 mm and of grade 2, using coating of the same formulation as that applied to the rectangular wire, unless otherwise agreed between purchaser and supplier.

5.2 *Tape wrapped wire*

Method of test under consideration.

6 Test 21: Loss of mass (applicable to enamelled round wire)

Loss of mass refers to the wire coating and indicates the degree of curing.

6.1 *Specimen*

A piece of wire providing not less than 0,5 g of coating shall be cleaned by adequate means without affecting the coating. The specimen shall be heated for 1 h at (130 ± 3) °C in an oven with forced air circulation. After removal from the oven, the specimen shall be placed in a desiccator and allowed to cool to room temperature for at least 30 min. The specimen shall then be weighed to 0,1 mg (M_1).

6.2 *Procedure*

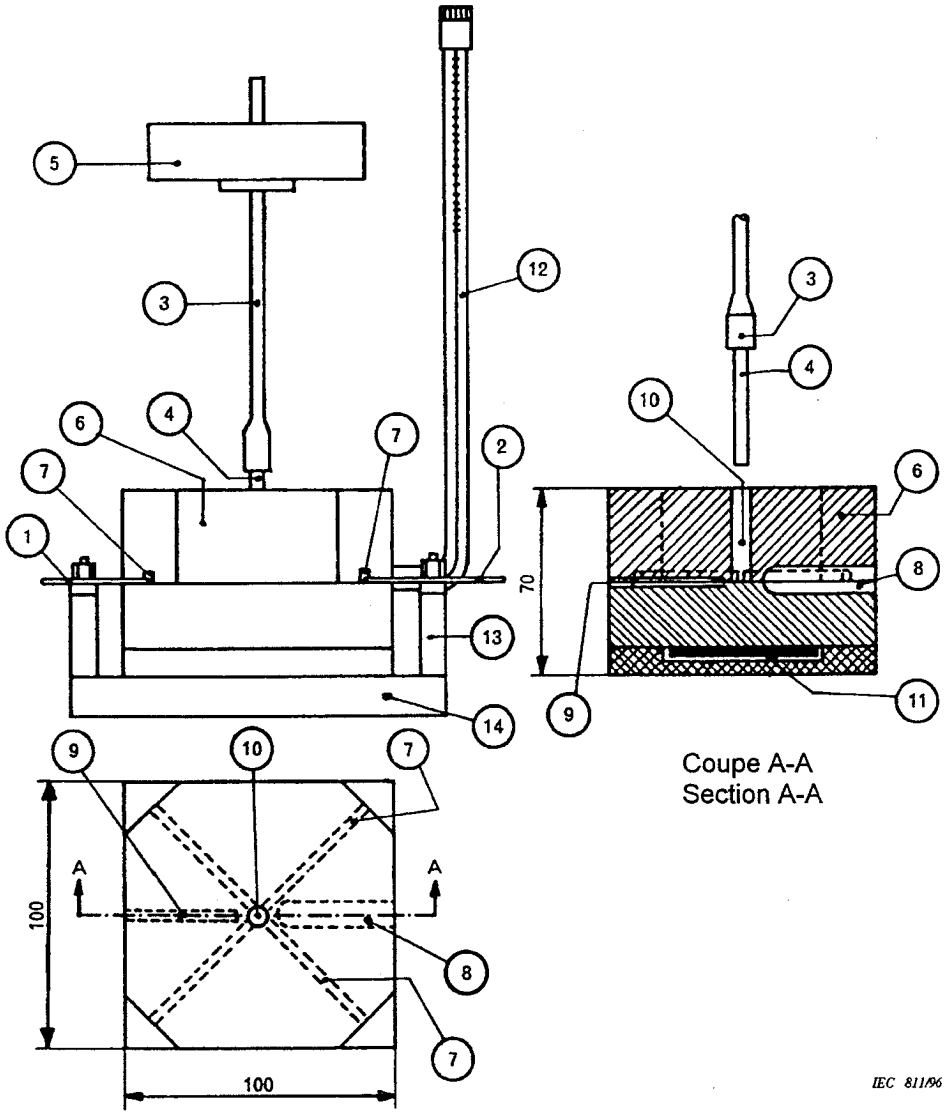
A crucible shall be conditioned for 2 h at (150 ± 3) °C. The crucible containing the specimen shall then be placed in an oven with forced air circulation for 2 h at a temperature that varies by not more than ±3 °C from the value specified in the relevant standard. After removal from the oven, the specimen shall be placed in a desiccator and allowed to cool to room temperature for at least 30 min. The specimen shall than be weighed to 0,1 mg (M_2).

The coating shall be removed by suitable chemical means not affecting the conductor, and the bare conductor shall be dried for (15 ± 1) min at (150 ± 3) °C, placed in a desiccator and allowed to cool to room temperature for at least 30 min. The bare conductor shall then be weighed to 0,1 mg (M_3).

The loss of mass shall be determined according to the following equation:

$$\Delta M = \frac{M_1 - M_2}{M_1 - M_3} \times 100\ \%$$

Two tests shall be made. The two single values shall be reported.



1 = éprouvette
specimen

2 = éprouvette
specimen

3 = piston
piston

4 = piston en céramique
ceramic piston

5 = charge
load

6 = bloc métallique (cuivre ou laiton)
metal block (copper or brass)

7 = fentes pour l'introduction des éprouvettes
slots for insertion of the specimens

8 = trou pour l'introduction de l'appareil de régulation de la température
hole for insertion of the temperature controling device

9 = trou pour l'introduction du thermocouple
hole for insertion of the thermocouple

10 = trou pour l'introduction du piston chargé
hole for insertion of the loaded piston

11 = élément de chauffage électrique
electrical heating element

12 = appareil de régulation de la température
temperature controlling device

13 = bornes isolées pour connexion des éprouvettes de fil
insulated terminals for connection of the wire specimens

14 = socle isolé
insulated base plate

Dimensions en millimètres *Dimensions in millimetres*

Figure 1 – Appareil à compression pour essai de thermoplasticité
Compression device for the cut-through test

Annex A
(informative)

High temperature failure test
(applicable to enamelled round wire)

High-temperature failure is expressed by the time to failure of a specimen, which is connected to a test voltage while exposed to elevated temperature.

NOTE – This test is intended to indicate the performance of wire at temperatures up to 450 °C where overload conditions under voltage stress may be encountered. It is not possible to use this test for conditions which produce failures in seconds or in a few minutes because this test requires a minimum time-to-failure of 15 min. Where such short-time failure properties are needed, other tests are required.

A.1 Equipment

The following equipment is used:

– oven with or without forced air circulation providing a maximum service temperature of 450 °C. The temperature should not vary from the set temperature by more than ±5 °C. The design of the oven ensures that the specimen reaches the set temperature ±1 % within 3 min. The oven is equipped with appropriate terminals to apply the test voltage in accordance with table A.1.

– transformer of at least 100 VA providing an alternating test voltage of 50 Hz or 60 Hz according to table A.1, connected to an overcurrent device operating at a current of (10 ± 5) mA. To avoid over-voltage surges, a capacitor of 1 µF to 2 µF is connected in parallel with the secondary terminals of the transformer. The overcurrent device indicates failure and disconnects a corresponding timer.

Table A.1 – Test voltage

Increase in diameter due to the insulation mm		Test voltage (a.c.)
Over	Up to and including	V
0,024	0,035	65
0,035	0,050	85
0,050	0,070	115
0,070	0,090	165
0,090	0,130	200

A.2 Specimen

A specimen is prepared in accordance with 4.4 of IEC 851-5. Experience has shown that wire with a nominal conductor diameter of about 1 mm and of grade 2 has been found convenient to handle and to test.

A.3 Procedure

The specimen is connected to the terminals and placed in the oven preheated to the temperature selected for the test. The test voltage is immediately applied and the timer started.

Five specimens are tested. The times to failure are reported. A time to failure below 15 min is disregarded.