IEC 60404-11

Edition 2.0 2021-07

INTERNATIONAL STANDARD

NORME INTERNATIONALE

Magnetic materials –
Part 11: Methods of measurement of the surface insulation resistance of electrical steel strip and sheet

Matériaux magnétiques –
Partie 11: Méthodes de mesurage de la résistance d'isolement superficiel des bandes et tôles en acier électrique

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

COMMISSION ELECTROTECHNIQUE INTERNATIONALE

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FOREWORD

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IEC 60404-11 has been prepared by IEC technical committee 68: Magnetic alloys and steels. It is an International Standard.

This second edition cancels and replaces the first edition published in 1991, Amendment 1:1998 and Amendment 2:2012. This edition constitutes a technical revision.

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

a) Method B has been deleted and the measurement of individual currents through each contact button is enabled by Method A;
b) an improved arrangement of the test apparatus and the voltage stabilizing circuit for Method A, "Arrangement B", is introduced.
c) an alternative layout using two pairs of contact assemblies in opposing position of the test specimen is introduced;

d) the restriction: “The same area of the test specimen shall not be used to test both sides.” has been deleted.

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

CDV	Report on voting
68/665/CDV	68/681/RVC

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/standardsdev/publications.

A list of all parts in the IEC 60404 series, published under the general title *Magnetic materials*, can be found on the IEC 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,
- replaced by a revised edition, or
- amended.

MAGNETIC MATERIALS –

Part 11: Methods of measurement of the surface insulation resistance of electrical steel strip and sheet

1 Scope

This part of IEC 60404 is applicable to electrical steel strip and sheet insulated by coating on one or both sides.

The object of this document is to define the general principles and technical details of the measurement of the surface insulation resistance of electrical steel strip and sheet.

NOTE This test is suitable for manufacturing and quality control in the application of insulation coatings.

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/IEC Guide 98-3, *Uncertainty of measurement – Part 3: Guide to the expression of uncertainty in measurement (GUM:1995)*

3 Terms and definitions

No terms and definitions are listed in this document.

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

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

4 Principle of measurement

The principle of the measurement is based on, and includes, the method originally described by Franklin [1][1] which characterizes one coated surface at a time.

The fundamental arrangement of the test apparatus is shown in Figure 1. Ten metallic contact buttons of fixed area are applied to one coated surface of the test specimen, under specified conditions of voltage and pressure.

The effectiveness of the surface insulation is assessed by the measurement of currents flowing through the 10 contact buttons.

1 Numbers in square brackets refer to the Bibliography.

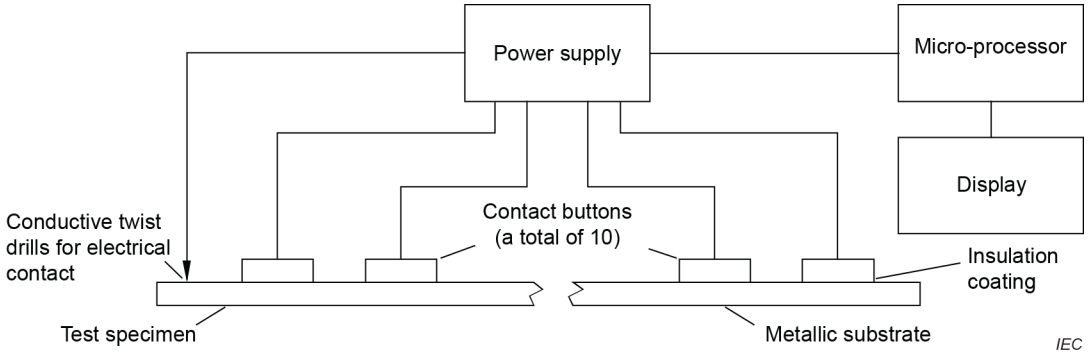
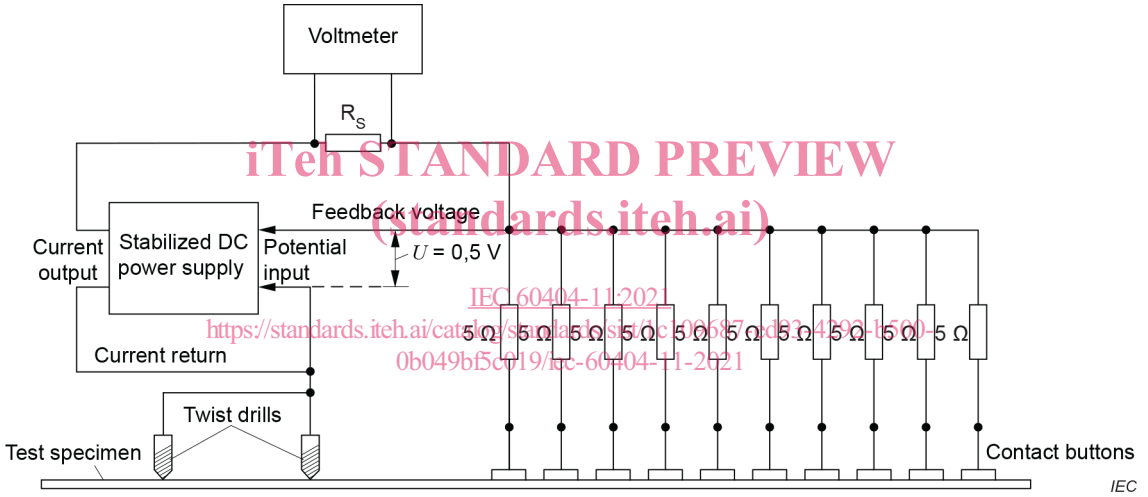


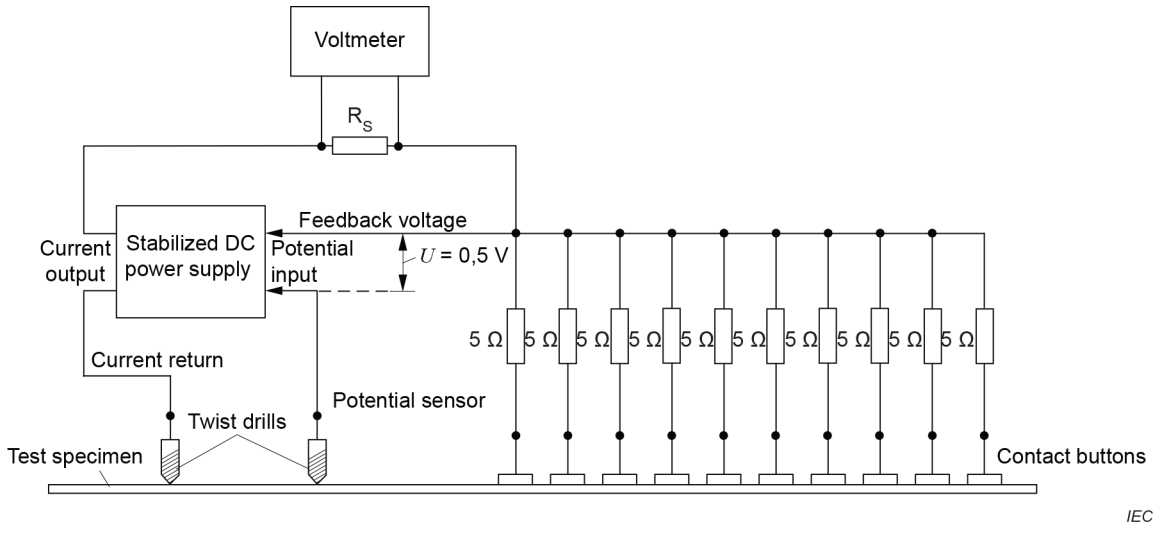
Figure 1 – Fundamental arrangement of the test apparatus (schematic)

A power supply feeds each contact button with a stabilized DC voltage, and the currents through the 10 contact buttons are measured.

The arrangements of the test apparatus and the voltage stabilizing circuit are shown in Figure 2.



a) Arrangement A



b) Arrangement B

Figure 2 – Schematic arrangements of the test apparatus and the voltage stabilizing circuit

Ten contact buttons are applied to one coated surface of the test specimen. 5 Ω resistors of ±1 % precision are connected in series with each contact button as shown in Figure 2. Two conductive twist drills contact electrically with the metallic substrate under the insulation coating.

The voltage between the supply side of the 5 Ω resistors and the twist drills is stabilized at DC 0,5 V with a relative tolerance of ±0,5 % over a current range from 0 A to 1,0 A.

The two twist drills may be placed at each end of the contact buttons and applied to the same side of the test specimen.

In Arrangement A, the two twist drills perform the function of current return contacts with the metallic substrate [see Figure 2 a)].

In Arrangement B, the two twist drills perform different functions [see Figure 2 b)]. One drill provides the current return contact with the metallic substrate. The other drill serves as a potential sensor for the voltage feedback control. This feedback control removes the influence of the contact resistance between the current return drill and the metallic substrate.

NOTE The contribution of the contact resistance on the measurement is significant when measuring a relatively low surface insulation resistance.

Arrangement B is recommended when measuring a relatively low surface insulation resistance.

The total current flowing through the insulation coating between the 10 contact buttons and the metallic substrate in parallel connection is measured (see Figure 2).

The value of the total current shall be determined by measuring the voltage drop across the current sensing resistor R_s connected in series with the current circuit. The current sensing resistor shall not be included within the voltage stabilizing circuit.

The individual contact button currents may be analysed by measuring the individual voltage drops across each 5 Ω resistor.

Because the current path is between the contact buttons and the metallic substrate, this test is not a true measurement of interlaminar resistance, in which the current path is between two metallic substrates of adjacent sheets. However, this test provides a useful index of the quality of the surface insulation resistance.

5 Test specimen

The test specimen shall be a length of strip or a sheet. The width and length of the test specimen shall be greater than the width and length of the contact assembly (see 6.1).

The test specimen shall be representative for the material to be tested. The surfaces shall be clean and free from powder, dust and oil, etc. which may be the result of handling of the test specimen. Measurements shall be performed at room temperature of (23 ± 5) °C.

This measurement is destructive, the surface of the test specimen where the contact assembly touched shall not be used again.

NOTE To obtain a representative result, several test specimens can be taken evenly across the full width of the strip or sheet.

6 Test apparatus

6.1 Contact assembly

The contact assembly consists of 10 vertically mounted contact rods and two twist drills of approximately 3 mm in diameter. These 10 contact rods shall be able to move individually and axially against springs in a mounting block. The contact rods shall press on the surface of the test specimen with the same force. In order to achieve electrical contact with the metallic substrate, the two twist drills shall be rotated when pressed on the test specimen. The twist drills shall pierce the insulation coating but shall not pierce through the test specimen.

The 10 contact rods shall be arranged in one or two rows.

Each rod shall be provided with a contact button of bronze or other equivalent low resistive material with sufficient hardness (for example, stainless steel). The contact buttons shall be electrically insulated from the mounting block.

Each of the 10 contact buttons shall have a contact area of 64,5 mm^2 with a relative tolerance of ±1 %, giving a total area for the 10 buttons of 645 mm^2 with a relative tolerance of ±1 %. Each contact button shall press on the test specimen uniformly over the whole contact area and shall avoid concentrating the force at the edge of the contact button.

NOTE 1 A force concentration at the edge of the contact button can destroy the insulation coating and cause a direct contact between the contact button and the metallic substrate. Therefore, misalignments of the contact buttons can cause an erroneous large current through the contact buttons. Articulated joints which allow the contact buttons to follow the surface of the test specimen improve the contacts by compensating for minor misalignments.

NOTE 2 In case the purchaser and the manufacturer agree to use a different contact button size, e.g. 100 mm^2, for each contact button (e.g. total area of 1 000 mm^2), the measured values differ from the values measured with contact buttons of the standard size of 64,5 mm^2 for each contact button (total area of 645 mm^2).

The test specimen shall be pressed between a baseplate and the contact assembly. Alternatively, the test specimen may be pressed between pairs of contact assemblies (arrangement of the 10 contact buttons each) of the same dimensions in opposing positions provided that the comparability of the results can be demonstrated. This arrangement allows successive measurement of both sides of the test specimen without turning over the test specimen.

6.2 Power supply

The power supply shall be capable of maintaining a stabilized voltage of DC 0,5 V with a relative tolerance of ±0,5 % over a current range from 0 A to 1,0 A.

6.3 Current measurement

The total current flowing through the contact buttons shall be measured with an uncertainty of ±0,5 % or better.

The value of the total current shall be determined by measuring the voltage drop across the current sensing resistor R_s of a low resistance value (e.g. 0,2 Ω) by means of a suitable voltmeter (see Figure 2).

NOTE An ammeter with a low internal resistance value can be used instead of the resistor R_s and the voltmeter.

6.4 Applied force

A pressure of 2 N/mm^2 with a relative tolerance of ±5 % shall be applied to each of the 10 contact buttons pressing on the test specimen. This corresponds to a force of 1 290 N with a relative tolerance of ±5 % for the total contact area of 645 mm^2.

7 Verification

The system shall be verified in four ways:

a) The 10 contact buttons and 2 twist drills shall be applied to a clean and flat copper sheet at the nominal testing pressure. The total current flowing through the 10 contact buttons shall be between 0,97 A and 1,00 A. If this is not the case, the cleanliness of the contact buttons and the contact resistance between the power supply and the copper sheet shall be checked.

b) Standard resistors of 0,1 Ω, 1 Ω, 10 Ω and 100 Ω connected between the twist drills and each contact button in turn may be used in order to show that the stabilization of voltage is adequate and that the required current levels can be achieved.

c) The total force applied to all the 10 contact buttons pressing on the base plate or the 10 contact buttons in opposing positions shall be verified by any suitable means, e.g. load cells, with an uncertainty of ±5 % or better.

d) Pressure measurement sheets, that can indicate applied pressure as colour density variations, shall be pressed between the 10 contact buttons and a flat plate at the nominal testing pressure. In the case of measurements performed with two sets of contact buttons in opposite positions (see 6.1), a plate equipped with pressure measurement sheets on both sides shall be inserted between the pairs of contact assemblies for the purpose of such verification. The 10 marks shall be even and free from signs of force concentration. Carbon paper pressed on white paper by the contact buttons can be used instead of the pressure measurement sheet. Contact buttons giving uneven marks shall be replaced with new ones ensuring even pressure.

8 Measurement procedure

The test specimen shall be positioned between the 10 contact buttons and the baseplate. Alternatively, the test specimen shall be positioned between two sets of 10 contact buttons in opposing positions (see 6.1).

The force of 1 290 N shall be gradually applied to the 10 contact buttons pressing on the test specimen.

The voltage of DC 0,5 V shall be applied across the supply side of the 5 Ω resistors and the twist drills. The total current I_A shall be recorded directly or by a micro-processor (see Figure 1).

If the surface insulation resistance of one coated surface of the test specimen is to be evaluated in the test, the total current I_A shall be taken from 10 separate representative areas, on the same surface of one or several test specimens, and the average value of the total current $\overline{I}_A$ shall be calculated for the 10 values.

If the surface insulation resistance of both coated surfaces of the test specimen is to be evaluated in the test, the total current I_A shall be taken from 5 separate representative areas, each on both surfaces of one or several test specimens, and the average value of the total current $\overline{I}_A$ shall be calculated from the 10 values.

As an alternative, upon agreement between the purchaser and the manufacturer, two sides of the test specimen may be evaluated separately by adding the total currents I_A from the 5 measurements per side separately and calculating the average values of the total current $\overline{I}_A$ of each side separately.

Care shall be taken so that the contact buttons are not placed on any marks of the contact buttons and the drills from previous measurements. It is particularly important to avoid the drill marks from measuring the first side when measuring the opposite side.