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Magnetic materials

Part 11: Method of test for the determination of surface insulation resistance of magnetic sheet and strip

National foreword

This British Standard is the UK implementation of EN 60404-11:2013. It is identical to IEC 60404-11:1991, incorporating amendments 1:1998 and 2:2012. It supersedes BS EN 10282:2001 which is withdrawn.

The start and finish of text introduced or altered by amendment is indicated in the text by tags. Tags indicating changes to ISO text carry the number of the ISO amendment. For example, text altered by ISO amendment 1 is indicated by A1 A1.

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Magnetic materials - Part 11: Method of test for the determination of surface insulation resistance of magnetic sheet and strip

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Matériaux magnétiques - Partie 11: Méthode d'essai pour la détermination de la résistance d'isolement superficiel des tôles et feuillards magnétiques (CEI 60404-11:1991 + A1:1998 + A2:2012)

Magnetische Werkstoffe - Teil 11: Messverfahren für die Bestimmung des Oberflächenisolationswiderstandes von Elektroblech und –band (IEC 60404-11:1991 + A1:1998 + A2:2012)

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Foreword

This document (EN 60404-11:2013) consists of the text of IEC 60404-11:1991 + A1:1998 + A2:2012 prepared by IEC TC 68 "Magnetic alloys and steels".

The following dates are fixed:

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This document supersedes EN 10282:2001.

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MAGNETIC MATERIALS –

Part 11: Method of test for the determination of surface insulation resistance of magnetic sheet and strip

1 Scope and field of application

This International Standard is intended to define a measurement method for the determination of the characteristics of surface insulation resistance of magnetic sheet and strip.

This method is applicable to magnetic sheet and strip insulated on one or both surfaces and is suitable for manufacturing control in the application of insulation coatings.

2 Principle of measurement

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

The arrangement of the apparatus is shown in figure 1. Ten metallic contacts of fixed area are applied to one coated surface of the sheet, under specified conditions of voltage and pressure.

The effectiveness of the surface insulation is assessed by the measurement of the currents through the 10 contacts.

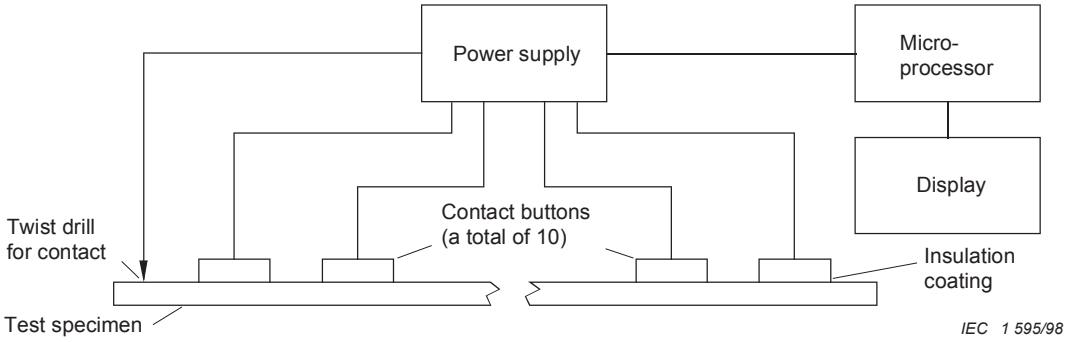

Figure 1 – Arrangement of apparatus for the measurement of surface insulation resistance

* Franklin, R.F., "Measurement and control of interlaminar resistance of laminated magnetic cores", *ASTM Bulletin,* no. 144, January 1947, p. 57.

Each contact button is individually fed from a d.c. power supply in one of the two ways which constitute the two modes of measurement used in this standard, namely:

a) *Mode A* The voltage between the supply side of the 5 Ω ± 1 % resistors (see figure 2) and the drill contacts is stabilized at 500 mV ± 0,5 % over a current range of 0 to 1 A. [A1] The two twist drills perform the function of current return contacts with the substrate. [A1]

b) *Mode B* The voltage between each contact button and the drill contacts is stabilized at 250 mV ± 0,5 % over a current range from 0 to 2,5 A for the analysis of individual electrode currents.

[A1] The two twist drills perform different functions. One drill provides the current return contact with the substrate. The other drill serves as a potential sensor for the voltage feedback control. This method removes the influence of the variable contact resistance between the current return drill and the substrate. [A1]

The voltage across subsidiary current sensing resistors of low-value, connected in series with each electrode, but not included within the stabilized voltage, serves to indicate the value of the current, as shown in [A1] figures 2 and 3 [A1].

Because the current path is between the contacts and the metallic substrate, this is not a true measurement of interlaminar resistance. However, this test provides a useful indication of surface insulation quality.

3 Test specimen

Each test specimen shall be formed from a single sheet or length of strip. The width and length of the test specimen shall be respectively greater than the width and length of the contact assembly described in clause 4. [A1] This measurement is destructive; the test specimen can only be used once. [A1]

To obtain a representative result, test specimens shall be taken from the full sheet width.

4 Apparatus

4.1 Contact assembly

The test specimen is pressed between a plate and the contact assembly. The contact assembly consists of 10 vertically-mounted metallic rods which move axially against springs in a mounting block. These 10 contact rods are normally arranged in two rows. However, for convenience these 10 contacts can be arranged in one row. Each rod shall be provided with a contact button of bronze or other suitable material (for example, stainless steel) and shall be electrically insulated from the mounting frame.

[A2] NOTE Articulation of contact buttons improves contact by compensating for minor misalignments. [A2]

Each of the 10 contact buttons shall have a contact area of 64,5 mm² ± 1 %, giving a total area for the 10 buttons of 645 mm² ± 1 %.

Electrical contact with the substrate of the test specimen shall be achieved by means of two spring-loaded twist drills of about 3 mm diameter which pierce the insulation coating.

〈A2〉 4.2 Power supply

Mode A: A d.c. power supply capable of maintaining a stabilized voltage of 500 mV across the electrodes at a current of 0,1 A per electrode (1,0 A total) shall be used.

Mode B: A d.c power supply capable of maintaining a stabilized voltage of 250 mV at a current of 2,5 A for an individual electrode shall be used. A single supply and a current-sensing resistor, Rs, can be used and switched to each contact button in turn, or a 10-outlet system can be used with each electrode fed simultaneously and independently. 〈A2〉

4.3 Current measurement

The current flowing through the contact buttons shall be measured with an uncertainty of ± 2% or better. This can be achieved by inserting a low value (e.g. 0,2 Ω) resistor in the supply to the contact buttons, at a point outside the connection to the stabilizing circuit, and measuring the voltage drop across the low value resistor by means of a suitable voltmeter.

〈A1〉 The electrical arrangements of the stabilizing circuit and current measurement system are shown in figures 2 and 3 for modes A and B respectively. 〈A1〉

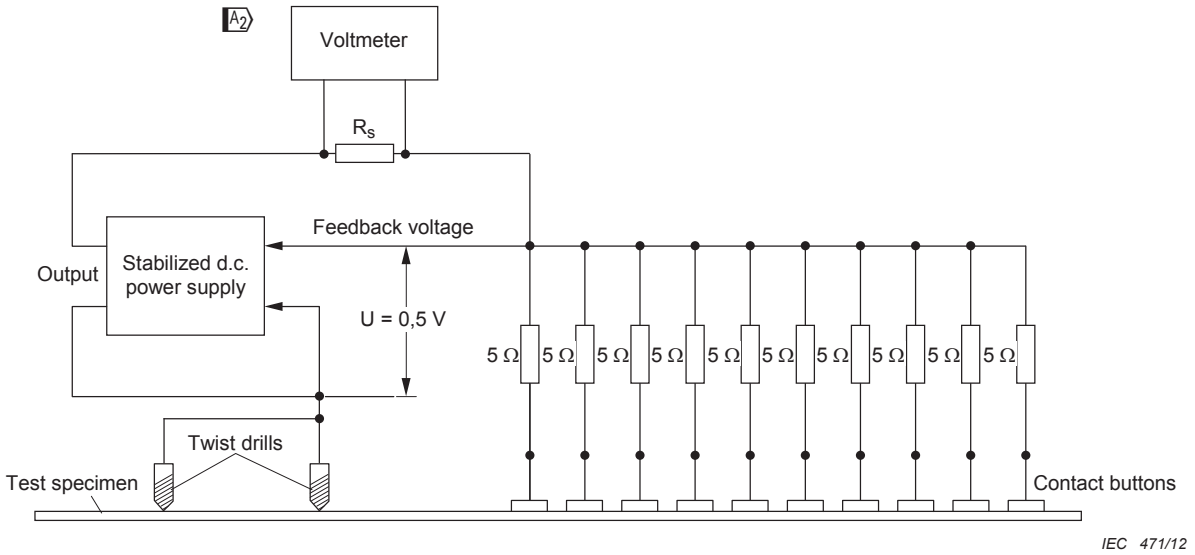

Figure 2 – Arrangement of stabilizing circuit: mode A

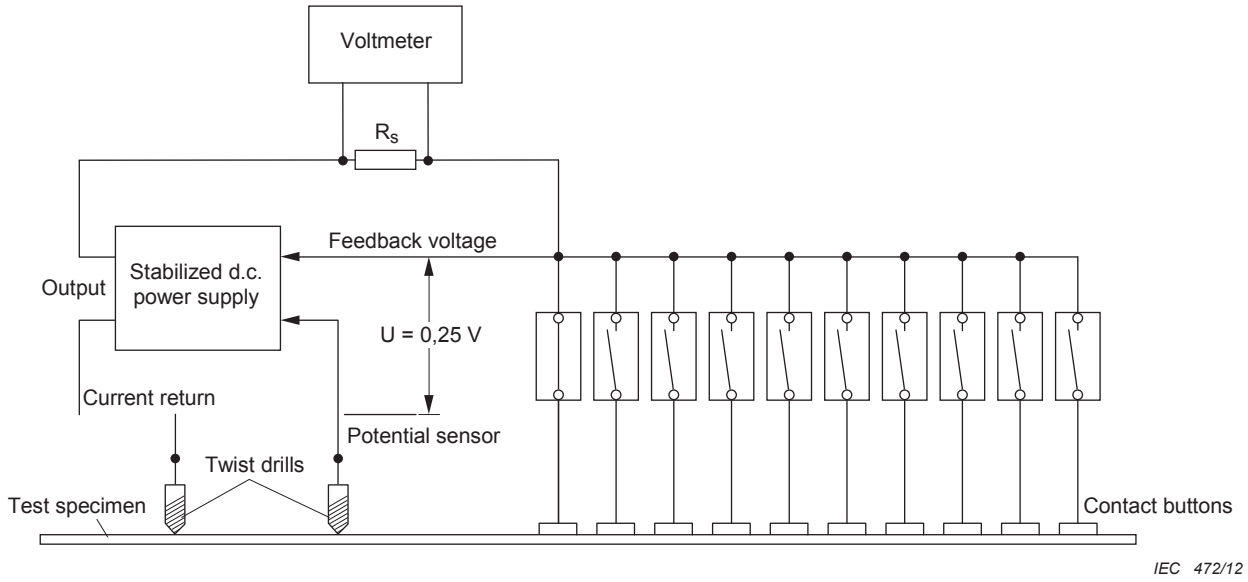

Figure 3 – Arrangement of stabilizing circuit: mode B ⟨A2⟩

⟨A1⟩ 4.4 Determination of applied force ⟨A1⟩

The total force applied by all of the contacts pressing on the test specimen shall be ⟨A1⟩ determined ⟨A1⟩ by any suitable means with an uncertainty of ±5 % or better.

5 Calibration

The calibration of the system shall be checked in three ways:

a) The electrodes and drills shall be applied to a clean copper sheet at nominal testing pressure. [A2] The total current passing through the 10 electrodes shall be 1,0 A ± 3 % for mode A. [A2] For mode B the electrode to drill voltage shall be less than 25 mV with a current of 2,5 A flowing. If this is not the case, the electrodes shall be checked for cleanliness and the twist drills checked for sharpness and contact resistance.

b) Carbon paper pressed onto white paper by the electrodes at nominal testing pressure shall give a set of even smudges free from signs of force concentration. [A2] Pressure measurement sheets that could indicate applied pressure as colour density variations can be used instead of the carbon paper and white paper. [A2]

c) Standard resistors of 0,1 Ω, 1 Ω, 10 Ω and 100 Ω connected between the drills and each electrode in turn shall be used to show that the stabilization is adequate and that the required current levels can be achieved.

6 Measuring procedure

The test specimen shall be positioned between the baseplate and the 10 contact buttons and a force of 1 290 N ± 5 % shall be gradually applied. This corresponds to a pressure of 2 N/mm² for the total contact area of 645 mm².

[A2] The stabilized d.c. voltage shall be gradually applied to the electrodes and the total current for mode A, or each electrode current for mode B, shall be recorded individually or by computer. [A2]

If the insulation quality of a single surface is to be evaluated in the test, 10 readings shall be taken using the 10 contact buttons on 10 separate representative areas of the sheet or on 10 test specimens.

If the insulation quality of both surfaces is to be jointly evaluated in the test then five applications of the contact buttons shall be made to each surface on five separate representative areas or test specimens. The same area of the test specimen shall not be used to test both sides.

7 Evaluation of surface insulation resistance

The recorded currents shall be used to calculate reported values of insulation resistance in the following ways:

a) For Mode A, the coefficient of surface insulation resistance shall be determined by inserting the 10 values of the current flowing through the 10 electrodes in parallel (either all from one surface or five from each of the two coated surfaces) in the following formula:

$$C = A\left[\frac{U}{\frac{1}{10}\sum_{1}^{10} I_A} - \frac{R}{10}\right] = 645\left[\frac{0{,}5}{\frac{1}{10}\sum_{1}^{10} I_A} - 0{,}5\right] \qquad (1)$$

where

[A2] C is the coefficient of surface insulation resistance, in $\Omega \cdot mm^2$/side [A2]

A is the total area of the 10 contact buttons, in mm²

U is the voltage applied to the contacts and 5 Ω resistors, in V

R is the resistance in series with each contact, equal to 5 Ω

I_A is the measured total electrode current (10 values), in A

[A1] NOTE If five measurements are taken from each surface, the value C is the coefficient of the surface insulation resistance of one surface, which represents the mean of the two surfaces of the product. [A1]

b) For Mode B, the surface insulation resistance shall be calculated from each of the 100 values of electrode current using the formula:

$$R = 0{,}25 / I_B \qquad (2)$$

where

R is the surface insulation resistance, in Ω

I_B is the individual electrode current, in A

The 100 resistance values shall be arranged in ascending order of magnitude. The results shall be expressed as marker values R_{16} and R_{50} where R_{16} is the 16th value and R_{50} is the 50th value.

NOTE For the purposes of building engineering insight into the applicability of results, the values $\sum_{1}^{10} I_A$ and $\sum_{1}^{10} I_B$ may be noted and included in the test report.

The processing of data is conveniently carried out by a microprocessor controlling the test system. Such a microprocessor may also be used to measure the resistance between the two insulation piercing drills to verify that the substrate has been well contacted.

[A1] The feedback system used in mode B allows a contact resistance, between the current return drill and the substrate, of up to about 1,5 Ω. The feedback system should be capable of maintaining a supply voltage, between the electrodes and the substrate, of 250 mV under these conditions. [A1]

8 Test report

The test report shall include:

a) the nature of the coating and whether the coating is applied to one or both surfaces of the steel;

b) for Mode A, the value of the coefficient of the surface insulation resistance for either a single insulated surface, or for the sheet as a whole if the two surfaces are insulated;

c) for Mode B, the values of surface insulation resistance equal to the two marker values R_{50} and R_{16} [A2] in Ω [A2];

d) the number of this standard.

The test report may also include:

e) the value of $\sum_{1}^{10} I_A$;

f) the value of $\sum_{1}^{100} I_B$.

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