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INTERNATIONAL STANDARD

NORME INTERNATIONALE

AMENDMENT 1
AMENDEMENT 1

Magnetic materials –
Part 15: Methods for the determination of the relative magnetic permeability of feebly magnetic materials

Matériaux magnétiques –
Partie 15: Méthodes de détermination de la perméabilité magnétique relative des matériaux faiblement magnétiques

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FOREWORD

This amendment has been prepared by IEC technical committee 68: Magnetic alloys and steels.

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

CDV	Report on voting
68/531/CDV	68/544/RVC

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

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

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

4.2 Principle

Replace the first sentence of the first paragraph with the following:

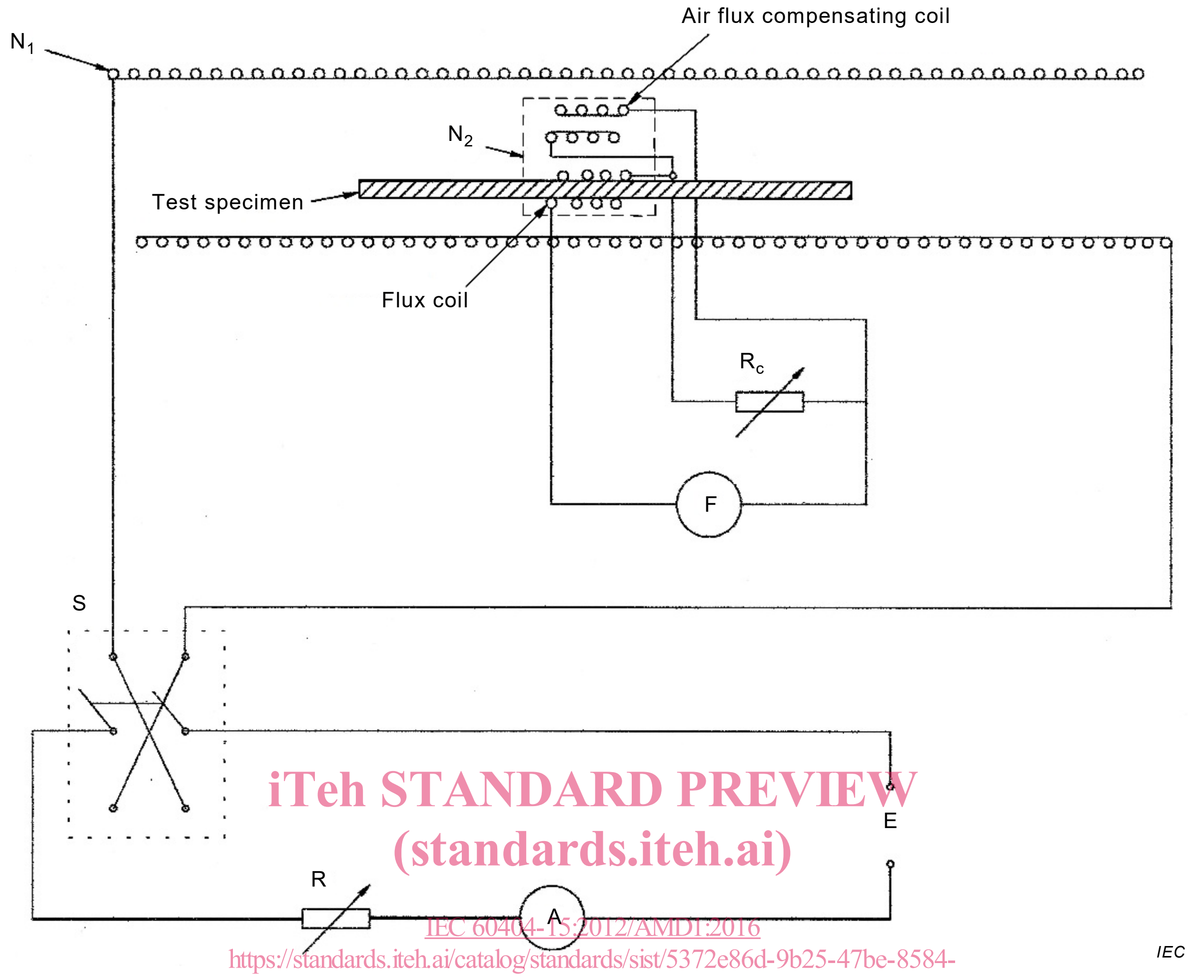
The relative magnetic permeability of a feebly magnetic test specimen is determined from the magnetic polarization J and the corresponding magnetic field strength H measured using the circuit shown in Figure 1 or Figure 5, using

Figure 1 – Circuit diagram for the solenoid method

Replace the existing title of Figure 1 with the following:

Figure 1 – Circuit diagram for the solenoid method with withdrawal of test specimen

Add a new Figure 5 with title and key, after Figure 1 and the note located below it, as follows:



Key

A Current measuring device or ammeter

E d.c. power supply

F Flux integrator

N_1 Solenoid

N_2 Compensated search coil

R Variable resistor (controlling magnetizing current)

R_c Variable resistor (to adjust the output of the air flux compensating coil)

S Switch for reversing the current in the solenoid

Figure 5 – Circuit diagram for the solenoid method with reversing of magnetizing current

Replace the existing Subclause 4.3.2 with the following:

4.3.2 *Search coil for the solenoid method with withdrawal of test specimen*. For the solenoid method with withdrawal of test specimen, the search coil shall be wound on a nonmagnetic, non-conducting former. Typically, for test specimens up to 30 mm in diameter, the internal diameter of the aperture in the search coil is 32 mm to allow test specimens to be freely inserted and withdrawn. The length of the winding shall be 40 mm; end cheeks of between 75 mm and 80 mm diameter shall be fitted to the former. The winding can be, for example, 10 000 turns of 0,2 mm diameter insulated wire with interleaving as necessary.

NOTE The winding can be tapped at intervals to facilitate the adjustment of the sensitivity of the measuring system when determining the relative magnetic permeability of test specimens in the higher part of the permeability range.

Insert, after 4.3.2, a new Subclause 4.3.7:

4.3.7 *Search coil for the solenoid method with reversing of magnetizing current*. For the solenoid method with reversing of magnetizing current, the flux coil and the air flux compensating coil shall each be wound on a non-magnetic, non-conducting former. The cross section area of the flux coil shall be no more than ten times that of the test specimen and there must be a sufficient number of turns for adequate resolution (typically >1 000 turns). The flux coil should be no longer than 20 % of the test specimen length.

The flux coil and the air flux compensating coil are connected in series opposition to form a compensated search coil. The length and effective area-turns of the flux coil and the air flux compensating coil shall be nearly equal, with the area-turns of the air flux compensating coil slightly larger than those of the flux coil so the compensating signal can be attenuated with a variable resistor (R_c in Figure 5) to match the signal from the empty flux coil.

The air flux compensating coil shall be located a sufficient distance from the flux coil such that there is no significant coupling to the magnetic flux of the test specimen. Coupling will change the effectiveness of the compensation when a sample is present, and can cause significant measurement error.

The signal from the air flux compensating coil shall be adjusted to exactly cancel the signal from the empty flux coil. With no sample present, apply the highest magnetizing current to be used in the test, reset the flux integrator, reverse the magnetizing current, and adjust the variable resistor R_c to obtain the minimum output from the compensated coil set N_2. Repeat as necessary until the output is as low as can be adjusted.

Replace the first paragraph (including Equation (2) and its key) of the existing Subclause 4.3.3 with the following:

4.3.3 *Moment detection coil.* For much shorter solid right cylinders with a length to diameter ratio of 1:1, a moment detection coil with a homogeneous sensitivity over the volume of the test specimen shall be used for measuring the magnetic dipole moment of the cylinder (see Figure 2). The magnetic polarization is calculated from

$$J = \frac{j}{V} \tag{2}$$

where

J is the magnetic polarization (in T);

j is the magnetic dipole moment (in Wbm);

V is the volume of the test specimen (in m^3)

Replace the first sentence of the existing Subclause 4.5.1 with the following:

4.5.1 *Cross-sectional area of test specimen.* The cross-section area of the test specimen shall be established from a number of measurements of each dimension.

Replace the first sentence of the existing Subclause 4.5.2 with the following:

4.5.2 *Calibration of flux integrator.* The calibration of the flux integrator shall be established with an uncertainty of ± 0,5 % or better.

Replace the first sentence of the existing Subclause 4.5.3 with the following:

4.5.3 *Demagnetization of test specimen.* The test specimen shall be demagnetized immediately prior to the measurement from a magnetic field strength of not less than 20 kA/m by the slow reversal of a gradually reducing direct current or a gradually reducing alternating current (for the frequency, see next paragraph), provided the magnetic field produced by the latter can completely penetrate the test specimen.

Delete the last five paragraphs and the note of the existing Subclause 4.5.3 (from "The magnetic polarization shall be measured" *to* "avoid signal contributions from electrostatic charges").

Add the following new Subclauses 4.5.4, 4.5.5, 4.5.6 and 4.5.7:

4.5.4 *Measurement of magnetic polarization with withdrawal of the test specimen.* The magnetic polarization shall be measured by inserting the demagnetized test specimen into the search coil or moment detection coil, adjust the magnetizing current to the required value taking care not to overshoot, zero the flux integrator, withdraw the test specimen and record the integrator reading. Care shall be taken to withdraw the test specimen from the search coil or moment detection coil to a position where it no longer has an influence on the search coil or moment detection coil, as indicated by the integrator reading.

The weight of the specimen can change the direction of the search coil axis used in the solenoid method by a small amount during the withdrawal of the specimen, which leads to an additional induced voltage in the search coil. Therefore the search coil should be fixed very rigidly or mechanically decoupled from the movement of the specimen.

Electrostatic charging of the search coil or moment coil during the withdrawal of the specimen can disturb the flux measurements and should be prevented. A copper shielding might be effective to avoid signal contributions from electrostatic charges.

Small fluctuations of the magnetizing current or of the ambient magnetic field can induce large instabilities in the measured flux. To avoid this, a compensation coil can be used.

4.5.5 *Measurement of magnetic polarization with reversing of magnetizing current.* The magnetic polarization shall be measured by inserting the demagnetized test specimen into the center of the compensated search coil, adjust the magnetizing current to the required positive value taking care not to overshoot, zero the flux integrator, reverse the magnetizing current to the same amplitude as the positive value taking care not to overshoot, and record the integrator reading. The reading represents two times the magnetic polarization due to the current reversal.

NOTE The use of an air flux compensating coil and compensating resistor allows the air flux enclosed by the flux coil to be cancelled out so that magnetic polarization can be measured directly (see 4.3.7).

4.5.6 *Averaging over the two sample directions.* For the solenoid method, the complete measurement procedure shall be performed two times, once with one end of the test specimen inserted into the search coil and again with the other end inserted into the search coil. Either the two integrator readings shall be averaged or used separately, depending on the customer's requirement.

4.5.7 *Repeatability.* The procedure is repeated as necessary to determine the measurement repeatability.

Replace the first two paragraphs of Subclause 4.6 and the key of Equation (4) with the following:

For the solenoid method with withdrawal of test specimen, the magnetic polarization shall be calculated using Equation (4):

$$J = \frac{\Phi_{IR}}{NA_S} \quad (4)$$

For the solenoid method with reversing of magnetizing current, the magnetic polarization shall be calculated using Equation (7):

$$J = \frac{\Phi_{IR}}{2NA_S} \quad (7)$$

where

J is the magnetic polarization (in T);

Φ_{IR} is the flux integrator reading corrected in accordance with the integrator calibration (in Wb);

A_s is the cross sectional area of the test specimen (in m^2);

N is the number of turns of the search coil.

Add a new line to the key for Equation (5) after the word "Where":

j is the magnetic dipole moment (in Wbm);

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