SLOVENSKI STANDARD

SIST EN 10332:2003

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Magnetni materiali – Trajnomagnetni (trdomagnetni) materiali – Metode za merjenje magnetnih lastnosti

Magnetic materials - Permanent magnet (magnetically hard) materials - Methods of measurement of magnetic properties

Magnetische Werkstoffe - Dauermagnet- (hartmagnetische) Werkstoffe - Verfahren zur Messung der magnetischen Eigenschaften

Matériaux magnétiques - Matériaux pour aimants permanents (magnétiquement durs) - Méthodes de mesure des propriétés magnétiques

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Magnetic materials - Permanent magnet (magnetically hard) materials - Methods of measurement of magnetic properties

Matériaux magnétiques - Matériaux pour aimants permanents (magnétiquement durs) - Méthodes de mesure des propriétés magnétiques

Magnetische Werkstoffe - Dauermagnet- (hartmagnetische) Werkstoffe - Verfahren zur Messung der magnetischen Eigenschaften

This European Standard was approved by CEN on 7 February 2003.

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This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the Management Centre has the same status as the official versions.

CEN members are the national standards bodies of Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Luxembourg, Malta, Netherlands, Norway, Portugal, Slovakia, Spain, Sweden, Switzerland and United Kingdom.

EUROPEAN COMMITTEE FOR STANDARDIZATION
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Foreword

This document (EN 10332:2003) has been prepared by Technical Committee ECISS/TC 24, "Electrical steel sheet and strip qualities - Qualities dimensions, tolerances and specific tests", the secretariat of which is held by DIN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by November 2003, and conflicting national standards shall be withdrawn at the latest by November 2003.

This document is equivalent to IEC 60404-5.

Annex A is normative.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Luxembourg, Malta, Netherlands, Norway, Portugal, Slovakia, Spain, Sweden, Switzerland and the United Kingdom.

1 Scope

This European standard specifies the method of measurement of the magnetic flux density, magnetic polarization and the magnetic field strength and also the determination of the demagnetization curve and recoil line of permanent magnet materials, such as those specified in IEC 60404-8-1, the properties of which are presumed homogeneous throughout their volume.

The performance of a magnetic system is not only dependent on the properties of the permanent magnet material but also on the dimensions of the system, the air-gap and other elements of the magnetic circuit. The methods described in this standard refer to the measurement on the magnetic properties in a closed magnetic circuit simulating a ring.

2 Normative references

This European Standard incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text, and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European Standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies (including amendments).

IEC 60050-121:1998, *International Electrotechnical Vocabulary – Part 121: Electromagnetism.*

IEC 60050-151:2001, *International Electrotechnical Vocabulary – Part 151: Electrical and magnetic devices.*

IEC 60050-221:1990, *International Electrotechnical Vocabulary) – Chapter 221: Magnetic materials and components*.

3 Terms and definitions

For the purposes of this European Standard, the terms and definitions given in IEC 60050-121:1998, IEC 60050-151:2001 and IEC 60050-221:1990 apply.

For permanent magnet materials this standard deals with both the coercivity H_{cB} (the coercivity related to the magnetic flux density) and the intrinsic coercivity H_{cJ} (the coercivity related to the magnetic polarization).

The measurements specified in this standard are for both the magnetic flux density, B, and the magnetic polarization, J, as a function of the magnetic field strength, H. These quantities are related by the following equation :

$$B = \mu_0 H + J \qquad (1)$$

where

B is the magnetic flux density, in teslas ;

μ_0 is the magnetic constant = $4\pi\ 10^{-7}$, in henry per metre ;

H is the magnetic field strength, in amperes per metre ;

J is the magnetic polarization, in teslas.

Using this relationship H_{cJ} values can be obtained from the $B(H)$ hysteresis loop and H_{cB} values can be obtained from the $J(H)$. The point at which the modulus of the product BH has a maximum value is called the working point for $(BH)_{max}$ (see Figure 2).

4 Electromagnet and conditions for magnetization

4.1 General

The measurements are carried out in a closed magnetic circuit consisting of an electromagnet made of soft magnetic material and the test specimen. The construction of the yokes shall be symmetrical ; at least one of the poles shall be movable to minimize the air-gap between the test specimen and the pole pieces (see Figure 1). The end faces of both pole pieces shall be ground as nearly as possible parallel to each other and as nearly as possible perpendicular to the pole axis to minimize the air-gap (see Figure A.1).

NOTE For certain measurements, the yoke and the poles can be laminated to decrease eddy currents. The coercivity of the material should normally be not more than 100 A/m.

To obtain a sufficiently uniform magnetizing field in the space occupied by the test specimen, the following conditions shall be fulfilled simultaneously :

4.2 Geometrical conditions

$$d_1 \geq d_2 + 1{,}2\, l' \quad (2)$$

$$d_1 \geq 2{,}0\, l' \quad (3)$$

where

d_1 is the diameter of a circular pole piece or the dimension of the smallest side of a rectangular pole piece, in millimetres ;

l' is the distance between the pole pieces, in millimetres ;

d_2 is the maximum diameter of the cylindrical volume with a homogeneous field, in millimetres.

With reference to the magnetic field strength at the centre of the air-gap, condition (2) ensures that the maximum field decrease at a radial distance of $d_2/2$ and condition (3) ensures that the maximum field increase along the axis of the electromagnet at the pole faces is 1 %.

4.3 Electromagnetic conditions

During the measurement of the demagnetization curve, the flux density in the pole pieces shall be kept substantially lower than the saturation magnetic polarization so that the pole faces shall be brought as near as possible to be equipotential. In practice, the magnetic flux density shall be less than 1 T in iron and less than 1,2 T in iron alloy containing 35 % to 50 % cobalt.

The yoke is excited by magnetizing coils which are arranged symmetrically as near as possible to the test specimen (see Figure 1). The axis of the test specimen shall be coincident with the axis of the magnetizing coils.

Before measurement, the test specimen shall be magnetized in a magnetic field H_{max} intended to bring the test specimen close to saturation (see the following note). The determination of the demagnetization curve shall then be made in a magnetic field in the direction opposite to that used for the initial magnetization.

If it is not possible to magnetize the test specimen to near saturation within the yoke (for instance if the conditions in the following note cannot be met) the test specimen shall be magnetized outside the electromagnet in a superconducting coil or pulse magnetizer.

NOTE Where the product standard or the manufacturer does not specify the value of the magnetizing field strength H_{max}, it is recommended that before the measurement of the demagnetization curve, the test specimen should be magnetized to saturation. The test specimen is considered to be saturated if the following relationships hold for two values of magnetic field strength H_1 and H_2 :

$$P_2 \leq P_1 \, e^{0,024\,54 \ln (H_2 / H_1)} \quad (4)$$

or

$$P_2 \leq P_1 \, 10^{0,024\,54 \log (H_2 / H_1)} \quad (5)$$

and $H_2 \geq 1{,}2\, H_1$ (6)

where

P_2 is the maximum attainable value of $(BH)_{max}$, in joules per cubic metre, or of coercivity H_{cB} in amperes per metre ;

P_1 is the lower value of $(BH)_{max}$, in joules per cubic metre, or of coercivity H_{cB} in amperes per metre ;

H_2 is the magnetic field strength corresponding to P_2, in amperes per metre ;

H_1 is the magnetic field strength corresponding to P_1, in amperes per metre.

In the special case of H_2/H_1 = 1,5, relationships (4) et (5) become $P_2 \leq 1{,}01\, P_1$.

In any cases, the magnetization process shall not cause the test specimen to be heated excessively.

5 Test specimen

The test specimen shall have a simple shape (for example a right cylinder or parallelepiped). The length l of the test specimen shall be not less than 5 mm and its other dimensions shall be a minimum of 5 mm and shall be such that the test specimen and the sensing devices shall be within the diameter d_2 as defined in clause 3.

The end faces of the test specimen shall be made as nearly as possible parallel to each other and perpendicular to the test specimen axis to reduce the air-gap (see Annex A).

The cross-sectional area of the test specimen shall be as uniform as possible throughout its length ; any variation shall be less than 1 % of its minimum cross-sectional area. The mean cross-sectional area shall be determined to within 1 %.

The test specimen shall be marked with the direction of magnetization.

6 Determination of the magnetic flux density

The changes in magnetic flux density in the test specimen are determined by integrating the voltages induced in a search coil.

The search coil shall be wound as closely as possible to the test specimen and symmetrical with respect to the pole faces. The leads shall be tightly twisted to avoid errors caused by voltages induced in loops in the leads.

The total error of measuring the magnetic flux density shall be not greater than ± 2 %.

The variation of the apparent magnetic flux density ΔB_{ap}, uncorrected for air flux, between the two instants t_1 and t_2 is given by :

$$\Delta B_{ap} = B_2 - B_1 = \frac{1}{AN} \int_{t_1}^{t_2} U \, dt \quad (7)$$

where

B_2 is the magnetic flux density at the instant t_2, in teslas ;

B_1 is the magnetic flux density at the instant t_1, in teslas ;

A is the cross-sectional area of the test specimen, in square metres ;

N is the number of turns on the search coil ;

$\int_{t_1}^{t_2} U \, dt$ is the integrated induced voltage, in webers, for the time interval of integration ($t_2 - t_1$), in seconds.

This change in the apparent magnetic flux density ΔB_{ap} shall be corrected to take into account the air flux included in the search coil. Thus, the change in magnetic flux density ΔB in the test specimen is given by :

$$\Delta B = \Delta B_{ap} - \mu_0 \, \Delta H \, \frac{(A_t - A)}{A} \tag{8}$$

where

μ_o is the magnetic constant = $4\pi \, 10^{-7}$ in henry per metre ;

ΔH is the change in the measured magnetic field strength, in amperes per metre ;

A_t is the average cross-sectional area of the search coil, in square metres.

7 Determination of the magnetic polarization

The changes in magnetic polarization in the test specimen are determined by integrating the induced voltages at the terminals of a 2-search-coil device where the test specimen is contained in only one of these coils. If each of the individual coils has the same product of cross-sectional area and the number of turns, and if both are connected electrically in opposition, the change of magnetic polarization ΔJ in the test specimen is given by :

$$\Delta J = J_2 - J_1 = \frac{1}{AN} \int_{t_1}^{t_2} U \, dt \tag{9}$$

where

J_2 is the magnetic polarization at the instant t_2, in teslas ;

J_1 is the magnetic polarization at the instant t_1, in teslas ;

A is the cross-sectional area of the test specimen, in square metres ;

N is the number of turns on the search coil ;

$\int_{t_1}^{t_2} U \, dt$ is the integrated induced voltage, in webers, for the time interval of integration ($t_2 - t_1$) in seconds.

Thus, the output of coil 1 compensates for the output of coil 2 except for J within the test specimen.

Because no individual air flux correction is needed, test specimens having a range of cross-sectional areas may be measured with the same two-search-coil device.

The two-search-coil device shall lie totally within the homogeneous field defined by conditions (2) and (3) (see 4.2).

The total measuring error shall not be greater than ± 2 %.