SLOVENSKI STANDARD
SIST EN 60404-4:2002

01-september-2002

Magnetic materials - Part 4: Methods of measurement of d.c. magnetic properties of iron and steel (IEC 60404-4:1995)

Magnetic materials -- Part 4: Methods of measurement of d.c. magnetic properties of magnetically soft materials

Magnetische Werkstoffe -- Teil 4: Verfahren zur Messung der magnetischen Eigenschaften von weichmagnetischen Werkstoffen im Gleichfeld

Matériaux magnétiques -- Partie 4: Méthodes de mesure en courant continu des propriétés magnétiques des matériaux magnétiquement doux

Ta slovenski standard je istoveten z: **EN 60404-4:1997**

ICS:

17.220.20	Merjenje električnih in magnetnih veličin	Measurement of electrical and magnetic quantities
29.030	Magnetni materiali	Magnetic materials

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EN 60404-4

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Descriptors: Magnetic materials, iron and steel, magnetic properties, methods of measurement of d.c., ring method, permeameter method, calibration

English version

Magnetic materials
Part 4: Methods of measurement of d.c. magnetic properties of iron and steel
(IEC 404-4:1995)

Matériaux magnétiques
Partie 4: Méthodes de mesure en courant continu des propriétés magnétiques du fer et de l'acier
(CEI 404-4:1995)

Magnetische Werkstoffe
Teil 4: Verfahren zur Messung der magnetischen Eigenschaften von Eisen und Stahl im Gleichfeld
(IEC 404-4:1995)

This European Standard was approved by CENELEC on 1996-12-09. CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Central Secretariat or to any CENELEC member.

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 CENELEC member into its own language and notified to the Central Secretariat has the same status as the official versions.

CENELEC members are the national electrotechnical committees of Austria, Belgium, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and United Kingdom.

CENELEC

European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

Central Secretariat: rue de Stassart 35, B - 1050 Brussels

Ref. No. EN 60404-4:1997 E

Foreword

The text of the International Standard IEC 404-4:1995, prepared by IEC TC 68, Magnetic alloys and steels, was submitted to the formal vote and was approved by CENELEC as EN 60404-4 on 1996-12-09 without any modification.

The following dates were fixed:

- latest date by which the EN has to be implemented at national level by publication of an identical national standard or by endorsement (dop) 1997-12-01
- latest date by which the national standards conflicting with the EN have to be withdrawn (dow) 1997-12-01

Annexes designated "normative" are part of the body of the standard.
Annexes designated "informative" are given for information only.
In this standard, annexes A and ZA are normative and annexes B and C are informative.
Annex ZA has been added by CENELEC.

Endorsement notice

The text of the International Standard IEC 404-4:1995 was approved by CENELEC as a European Standard without any modification.

Annex ZA (normative)

Normative references to international publications with their corresponding European publications

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).

NOTE: When an international publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

Publication	Year	Title	EN/HD	Year
IEC 404-7	1982	Magnetic materials Part 7: Method of measurement of the coercivity of magnetic materials in an open magnetic circuit	-	-
IEC 404-8-2	1985	Part 8: Specifications for individual materials Section 2: Specification for cold-rolled magnetic alloyed steel strip delivered in the semi-processed state	-	-
IEC 404-8-3	1985	Section 3: Specification for cold-rolled magnetic non-alloyed steel strip delivered in the semi-processed state	-	-
IEC 404-8-4	1986	Section 4: Specification for cold-rolled non-oriented magnetic steel sheet and strip	-	-
IEC 404-8-6	1986	Section 6: Soft magnetic metallic materials	-	-
A1	1992		-	-
IEC 404-8-7	1988	Section 7: Specification for grain-oriented magnetic steel sheet and strip	-	-
A1	1991		-	-
IEC 404-8-8	1991	Section 8: Specification for thin magnetic steel strip for use at medium frequencies	-	-

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Matériaux magnétiques –

Partie 4:
Méthodes de mesure en courant continu des propriétés magnétiques du fer et de l'acier

Magnetic materials –

Part 4:
Methods of measurement of d.c. magnetic properties of iron and steel

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CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

MAGNETIC MATERIALS –

Part 4: Methods of measurement of d.c. magnetic properties of iron and steel

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.

2) The formal decisions or agreements of the IEC on technical matters, prepared by technical committees on which all the National Committees having a special interest therein are represented, express, as nearly as possible, an international consensus of opinion on the subjects dealt with.

3) They have the form of recommendations for international use published in the form of standards, technical reports or guides and they are accepted by the National Committees in that sense.

4) In order to promote international unification, IEC National Committees undertake to apply IEC International Standards transparently to the maximum extent possible in their national and regional standards. Any divergence between the IEC Standard and the corresponding national or regional standard shall be clearly indicated in the latter.

International Standard IEC 404-4 has been prepared by IEC technical committee 68: Magnetic alloys and steels.

This second edition cancels and replaces the first edition published in 1982 and constitutes a technical revision.

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

DIS	Report on voting
68(CO)95	68/117/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 forms an integral part of this standard.

Annexes B and C are for information only.

MAGNETIC MATERIALS –

Part 4: Methods of measurement of d.c. magnetic properties of iron and steel

1 Scope and object

This part of IEC 404 specifies the methods of measuring the d.c. magnetic properties of iron and steel in a closed magnetic circuit using either the ring or the permeameter methods.

Two methods are used:

a) the ring method, particularly for magnetic field strengths of up to 10 kA/m;

b) the permeameter method for magnetic field strengths in the range 1 kA/m to 200 kA/m.

NOTE – The measurement of coercivity in an open magnetic circuit is specified in IEC 404-7.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of IEC 404. 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 404 are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

IEC 404-7: 1982, *Magnetic materials – Part 7: Method of measurement of the coercivity of magnetic materials in an open magnetic circuit*

IEC 404-8-2: 1985, *Magnetic materials – Part 8: Specifications for individual materials – Section Two: Specification for cold-rolled magnetic alloyed steel strip delivered in the semi-processed state*

IEC 404-8-3: 1985, *Magnetic materials – Part 8: Specifications for individual materials – Section Three: Specification for cold-rolled magnetic non-alloyed steel strip delivered in the semi-processed state*

IEC 404-8-4: 1986, *Magnetic materials – Part 8: Specifications for individual materials – Section Four: Specification for cold-rolled non-oriented magnetic steel sheet and strip*

IEC 404-8-6: 1986, *Magnetic materials – Part 8: Specifications for individual materials – Section Six: Soft magnetic metallic materials*
Amendment 1 (1992)

IEC 404-8-7: 1988, *Magnetic materials – Part 8: Specifications for individual materials – Section Seven: Specification for grain-oriented magnetic steel sheet and strip*
Amendment 1 (1991)

IEC 404-8-8: 1991, *Magnetic materials – Part 8: Specifications for individual materials – Section 8: Specification for thin magnetic steel strip for use at medium frequencies*

3 Determination of the magnetic characteristics by the ring method

3.1 *Object*

This clause describes the ring method used to obtain the normal magnetization curve and the hysteresis loop.

3.2 *General*

This method is used particularly for magnetic field strengths of up to 10 kA/m. However, if care is taken to avoid heating the test specimen, this method may be used at higher magnetic field strengths.

3.3 *Effect of temperature on the measurements*

Care shall be taken to avoid unduly heating the test specimen. The measurements shall be made at an ambient temperature of (23 ± 5) °C. The temperature of the test specimen shall not exceed 50 °C which shall be monitored by means of a temperature sensor.

For materials which are particularly temperature sensitive, product standards may define lower or higher test specimen temperatures.

3.4 *Test specimen*

The test specimen is a homogeneous unwelded ring of rectangular or circular cross-section. The cross-sectional area of the ring is determined by the product dimensions, uniformity of magnetic properties, instrumentation sensitivity and space required for the test windings. Usually the cross-sectional area is in the range of 100 mm² to 500 mm².

Care shall be taken in the preparation of the test specimen to avoid work hardening or heating of the material which might affect the magnetic characteristics. The test specimen can be prepared by turning and finished by light grinding with sufficient coolant to prevent heating the material. The edges of the rings shall be deburred.

To reduce the effect of the radial variation of the magnetic field strength, the following relationship shall apply:

$$D \leq 1{,}1\ d \qquad (1)$$

where

D is the outside diameter of test specimen, in metres;

d is the inside diameter of test specimen, in metres.

The dimensions of the test specimen shall be determined by measuring the outside and inside diameters of the ring together with the height or diameter using a suitable micrometer or vernier gauge. The mean cross-sectional area shall be calculated with an uncertainty of ±0,5 % or better.

The mean magnetic path length of the test specimen shall also be calculated with an uncertainty of ±0,5 % or better from the relationship:

$$l = \pi \frac{D + d}{2} \qquad (2)$$

where

l is the mean magnetic path length of test specimen, in metres.

3.5 *Windings*

Before winding, a connection shall be made to the core in order to check subsequently the insulation of the windings, a temperature sensor shall be attached to the test specimen and then the ring shall be overlaid with a thin layer of insulating material.

Firstly, a secondary winding of insulated copper wire shall be wound evenly round the core. The dimensions of the secondary winding shall be determined and the mean cross-sectional area, A_c, of the secondary winding shall be calculated.

A magnetizing winding of wire capable of carrying the maximum magnetizing current and of a sufficient number of turns to produce the maximum required magnetic field strength shall be evenly wound in one or more layers on the core. The magnetizing winding can consist of:

a) a large number of turns of a single conductor applied closely and uniformly round the whole ring, or

b) a smaller number of turns of a multicore cable applied closely and uniformly round the whole ring, the ends of the conductor in the individual cores being interconnected to give the effect of one multilayer winding, or

c) an arrangement of rigid, or part rigid and part flexible, conductors which can be opened to admit the ring (carrying the secondary winding and insulation) and then closed to form a uniformly wound toroid round the ring.

If necessary, the wound ring is immersed in an oil bath or subjected to an air blast in order to cool it.

NOTE – If the above arrangements are used with a uniformly distributed secondary winding, an error, which may be present in any ring test, is liable to be magnified and to become of considerable importance. This error arises because, in winding a ring specimen toroidally, an effective circular turn of diameter equal to the mean diameter of the ring is produced.

The flux between the effective mutually inductive circular turns of the magnetizing winding and secondary winding, associated with flux parallel to the axis of the ring, is added to, or subtracted from the circumferential flux. When a multiconductor cable is used for the magnetizing winding, the number of turns in the primary of the supplementary mutual inductance is increased in proportion to the number of cores, and the error from this source, particularly at high field-strengths where the permeability of the test specimen is reduced, may amount to several per cent. To eliminate this error a turn should be wound back on the secondary winding along the mean circumference of the ring, or, preferably, the magnetizing cable should be wound in pairs of layers, alternate layers being wound clockwise and anti-clockwise around the ring.

3.6 *Methods of measurement by the ring method*

3.6.1 *Magnetic field strength*

The magnetizing current shall be measured with an uncertainty of ±0,5 % or better. The magnetic field strength shall be calculated from the following relationship:

$$H = \frac{N_1 I}{l} \qquad (3)$$

where

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

N_1 is the number of turns of magnetizing winding of the ring;

l is the mean magnetic path length, in metres;

I is the magnetizing current, in amperes.

3.6.2 *Magnetic flux density*

The secondary winding N_2 (B coil) shall be connected to a flux integrator (electronic integrator, ballistic galvanometer or fluxmeter) the calibration of which shall be established in accordance with one of the procedures given in annex B with an uncertainty of ±1 % or better.

The changes of the magnetic flux density shall be calculated from the following relationship:

$$\Delta B = \frac{K_B \alpha_B}{N_2 A} \qquad (4)$$

where

ΔB is the measured change of the magnetic flux density, in teslas;

K_B is the flux integrator calibration constant, in volts seconds;

α_B is the reading of the flux integrator;

N_2 is the number of turns on the secondary winding of the ring;

A is the cross-sectional area of the ring, in square metres.

For direct reading of the ΔB, the flux integrator may be adjusted so that $K_B/(N_2 A)$ becomes a power of 10.

Provided that the secondary winding is wound closely on the test specimen, the air flux included in the secondary winding over the range of magnetic field strength 0 to 4 kA/m will be insignificant and no correction need be applied. At higher values of magnetic field strength, an air flux correction shall be applied in accordance with equation (8).

3.6.3 *Connection of apparatus*

The apparatus is connected as shown in figure 1.

A source of direct current E (stabilized d.c. supply with a ripple content of less than 0,1 %, or a battery) is connected through a current-measuring device A and a reversing switch S_1 to the magnetizing winding N_1 on the ring specimen. If a bipolar current source is used,