

# **SLOVENSKI STANDARD**

## **oSIST prEN 60404-6:2017**

**01-julij-2017**

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**Magnetni materiali - 6. del: Metode merjenja magnetnih lastnosti mehkomagnetnih kovinskih in praškastih materialov s frekvencami v območju 20 Hz do 200 kHz z uporabo obročastih vzorcev**

Magnetic materials - Part 6: Methods of measurement of the magnetic properties of magnetically soft metallic and powder materials at frequencies in the range 20 Hz to 200 kHz by the use of ring specimens

Magnetische Werkstoffe - Teil 6: Verfahren zur Messung der magnetischen Eigenschaften weichmagnetischer und pulverförmiger Werkstoffe bei Frequenzen im Bereich 20 Hz bis 200 kHz mit Hilfe von Ringproben

Matériaux magnétiques - Partie 6: Méthodes de mesure des propriétés magnétiques des matériaux métalliques et des matériaux en poudre, magnétiquement doux, aux fréquences comprises entre 20 Hz et 200 kHz, sur des éprouvettes en forme de tore

**Ta slovenski standard je istoveten z: prEN 60404-6:2017**

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29.030	Magnetni materiali	Magnetic materials

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## COMMITTEE DRAFT FOR VOTE (CDV)

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SECRETARIAT:

Germany

SECRETARY:

Mr Johannes D. Sievert

OF INTEREST TO THE FOLLOWING COMMITTEES:

TC 51

PROPOSED HORIZONTAL STANDARD:



Other TC/SCs are requested to indicate their interest, if any, in this CDV to the secretary.

FUNCTIONS CONCERNED:

☐ EMC☐ ENVIRONMENT☒ QUALITY ASSURANCE☐ SAFETY☒ SUBMITTED FOR CENELEC PARALLEL VOTING☐ NOT SUBMITTED FOR CENELEC PARALLEL VOTING**Attention IEC-CENELEC parallel voting**

The attention of IEC National Committees, members of CENELEC, is drawn to the fact that this Committee Draft for Vote (CDV) is submitted for parallel voting.

The CENELEC members are invited to vote through the CENELEC online voting system.

This document is still under study and subject to change. It should not be used for reference purposes.

Recipients of this document are invited to submit, with their comments, notification of any relevant patent rights of which they are aware and to provide supporting documentation.

TITLE:

**Magnetic materials - Part 6: Methods of measurement of the magnetic properties of magnetically soft metallic and powder materials at frequencies in the range 20 Hz to 100 kHz by the use of ring specimens**

NOTE FROM TC/SC OFFICERS:

This new edition of 60404-6 includes the following technical changes with respect to the previous edition:

- adaption to modern measurement and evaluation methods, in particular the digital sampling method;
- limitation of the frequency range up to 100 kHz;
- deletion of the measurement of magnetic properties using a digital impedance bridge;
- addition of an informative Annex on the technical details of the digital sampling technique.

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# INTERNATIONAL ELECTROTECHNICAL COMMISSION

## MAGNETIC MATERIALS –

### **Part 6: Methods of measurement of the magnetic properties of magnetically soft metallic and powder materials at frequencies in the range 20 Hz to 100 kHz by the use of ring specimens**

#### FOREWORD

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This international Standard 60404-6 has been prepared by IEC technical committee 68: Magnetic alloys and steels.

This third edition cancels and replaces the second published in 2003. This edition constitutes a technical revision.

- a) This edition includes the following significant technical changes with respect to the previous edition:
- b) adaption to modern measurement and evaluation methods, in particular the introduction of the widely spread digital sampling method for the acquisition and evaluation of the measured data;
- c) limitation of the frequency range up to 100 kHz;
- d) deletion of Clause 7 of the second edition that specifies the measurement of magnetic properties using a digital impedance bridge;

- e) addition of a new Clause 7 on the measurement of the specific total loss by the wattmeter method including an example of the application of the digital sampling method;
- f) addition of an informative Annex on the technical details of the digital sampling technique for the determination of magnetic properties.

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

FDIS	68
68/XX/FDIS	68/XX/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.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

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 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.

A bilingual version of this publication may be issued at a later date.

The National Committees are requested to note that for this publication the stability date is 2021.

THIS TEXT IS INCLUDED FOR THE INFORMATION OF THE NATIONAL COMMITTEES AND WILL BE DELETED AT THE PUBLICATION STAGE.

## MAGNETIC MATERIALS –

### Part 6: Methods of measurement of the magnetic properties of magnetically soft metallic and powder materials at frequencies in the range 20 Hz to 100 kHz by the use of ring specimens

#### 1 Scope

This part of IEC 60404 specifies methods for the measurement of AC magnetic properties of soft magnetic materials, other than electrical steels and soft ferrites, in the frequency range 20 Hz to 100 kHz. The materials covered by this part of IEC 60404 include those speciality alloys listed in IEC 60404-8-6, amorphous and nano-crystalline soft magnetic materials, pressed and sintered and metal injection moulded parts such as are listed in IEC 60404-8-9, cast parts and magnetically soft composite materials.

The object of this part is to define the general principles and the technical details of the measurement of the magnetic properties of magnetically soft materials by means of ring methods. For materials supplied in powder form, a ring test specimen is formed by the appropriate pressing method for that material.

The measurement of the DC magnetic properties of soft magnetic materials shall be made in accordance with the ring method of IEC 60404-4. The determinations of the magnetic characteristics of magnetically soft components shall be made in accordance with IEC 62044-3.

NOTE IEC 62044-3 specifies methods for the measurement of AC magnetic characteristics of magnetically soft components in the frequency range up to 10 MHz.

Normally, the measurements shall be made at an ambient temperature of  $(23 \pm 5)^\circ\text{C}$  on test specimens which have firstly been magnetized, then demagnetized. Measurements can be made over other temperature ranges by agreement between supplier and purchaser.

#### 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.

IEC 60050 (all parts), *International Electrotechnical Vocabulary*

IEC 60404-2, *Magnetic materials – Part 2: Methods of measurement of the magnetic properties of electrical steel strip and sheet by means of an Epstein frame*

IEC 60404-4, *Magnetic materials – Part 4: Methods of measurement of DC magnetic properties of magnetically soft materials*

IEC 60404-8-6, *Magnetic materials – Part 8-6: Specifications for individual materials – Soft magnetic metallic materials*

IEC 60404-8-9, *Magnetic materials – Part 8: Specifications for individual materials – Section 9: Standard specification for sintered soft magnetic materials*

IEC 62044-3, *Cores made of soft magnetic materials – Measuring methods – Part 3: Magnetic properties at high excitation level*

ISO/IEC Guide 98-3, *Uncertainty of measurement – Part 3: Guide to the expression of uncertainty in measurement*

### 3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases 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 General principles of measurement

### 4.1 Principle of the ring method

The measurements are made on a closed magnetic circuit in the form of a ring test specimen wound with two windings.

### 4.2 Test specimen

The test specimen shall be in the form of a ring of rectangular cross-section which may be formed by

- a) winding thin strip or wire to produce a clock-spring wound toroidal core; or
- b) a stack of punched, laser cut, wire cut or photochemically etched ring laminations; or
- c) pressing and sintering of powders, metal injection moulding, 3D printing or casting.

In the case of powder materials, the production of a ring test specimen by metal injection moulding or by pressing (with heating if applicable) shall be carried out in accordance with the material manufacturer's recommendations to achieve the optimum magnetic performance of the powder material.

For all types of test specimen, burrs and sharp edges should be removed prior to heat treatment. In the case of high permeability material, it is preferable to enclose the test specimen in a two-part non-magnetic annular case. The case dimensions shall be such that it closely fits without introducing stress into the material of the test specimen.

The ring shall have dimensions such that the ratio of the outer to inner diameter shall be not greater than 1,4 and preferably less than 1,25 to achieve a sufficiently homogenous magnetization of the specimen. This is necessary to determine the material properties from a ring geometry.

For solid and pressed powder materials, the dimensions of the test specimen, that is the outer and inner diameters and the height of the ring, shall be measured with suitable calibrated instruments. The respective dimensions shall be measured at several locations on a test specimen and averaged. The cross-sectional area of the test specimen shall be calculated from Formula (1).

$$A = \frac{(D - d)}{2} h \quad (1)$$

where

- $A$  is the cross-sectional area of the test specimen, in square metres;
- $D$  is the outer diameter of the test specimen, in metres;
- $d$  is the inner diameter of the test specimen, in metres;
- $h$  is the height of the test specimen, in metres.

For a stack of laminations or a toroidal wound core, the cross-sectional area of the test specimen shall be calculated from the mass, density and the values of the inner and outer diameter of the ring. The mass and diameters shall be measured with suitable calibrated instruments. The density shall be the conventional density for the material supplied by the manufacturer. The cross-sectional area shall be calculated from Formula (2).

$$A = \frac{2m}{\rho\pi(D+d)} \quad (2)$$

where

$m$  is the mass of the test specimen, in kilograms;

$\rho$  is the density of the material, in kilograms per cubic metre.

For the calculation of the magnetic field strength, the mean magnetic path length of the test specimen determined from Formula (3) is used.

$$l_m = \pi \frac{(D+d)}{2} \quad (3)$$

where

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

NOTE For measurements of magnetically soft components, an effective core cross-sectional area and an effective magnetic path length are used (described in IEC 62044-3). The difference in results between material measurements and component measurements is larger when the ratio of the outer to inner diameter is larger.

If the specific total loss is to be determined, then the mass of the test specimen shall be measured with a suitable calibrated balance.

### 4.3 Windings

The test specimen shall be wound with a magnetizing winding and a secondary winding (see Annex A).

The numbers of turns depend upon the measuring equipment and method being used. The secondary winding shall be wound as closely as possible to the test specimen to minimize the effect of air flux included in the winding. All windings shall be wound uniformly over the whole length of the test specimen.

For measurements at frequencies above power frequencies, care shall be taken to avoid complications related to capacitance and other effects. These are introduced and discussed in Annex A.

Care shall be taken to ensure that the wire insulation is not damaged during the winding process causing a short circuit to the test specimen. An electrical check shall be made with a suitable AC insulation resistance measuring device to ensure that there is no direct connection between the winding and the test specimen.

## 5 Temperature measurements

When the temperature of the surface of the test specimen is required, it shall be measured by affixing a calibrated non-magnetic thermocouple (for example a type T thermocouple) to the test specimen. Where the test specimen is enclosed in an annular case, a small hole shall be made in the case, taking care not to damage the material of the test specimen, and the thermocouple fixed in contact with the test specimen. If this is not possible, the thermocouple shall be affixed to the case and this procedure shall be reported in the test report. The thermocouple shall be connected to a suitable calibrated voltmeter in order to measure its output voltage which can be related to the corresponding temperature through the calibration tables for the thermocouple.

Where the temperature of the test specimen is found to vary with time after magnetization, the measurements of the magnetic properties shall be carried out either when an agreed temperature is reached or after a time agreed between the purchaser and supplier. If measurements are to be made at elevated temperatures, these may be carried out with the test specimen placed in a suitable oven to produce the required temperature.

NOTE A second smaller time-dependent magnetic relaxation effect can also affect the magnetic properties. For the types of materials covered by this document, the effect is usually masked by temperature changes. However, if such magnetic relaxation effects become apparent, then the test specimen can be allowed to dwell at the prescribed magnetic flux density or magnetic field strength for an agreed period of time before making the final measurements.

## 6 Measurement of the relative amplitude permeability and the AC magnetization curve

### 6.1 General

The measurements are made using the ring method at frequencies normally from 20 Hz to 100 kHz, the upper frequency being limited by the performance of the instrumentation.

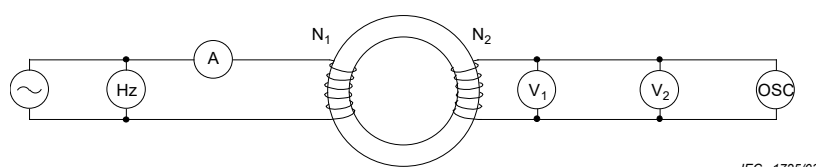
NOTE Where suitable calibrated instruments exist and careful winding to reduce interwinding capacitance has been performed, this upper limit can be extended to 1 MHz (See Annex A).

### 6.2 Apparatus and connections

The apparatus shall be connected as shown in Figure 1.

NOTE 1 Figure 3 can be used for the measurement of the relative amplitude permeability and the magnetization curve using the digital sampling technique.

NOTE 2 For the application of digital sampling technique, see Annex B.



IEC 1725/03

#### Key

- ~ power supply (usually an oscillator and a power amplifier)
- A true r.m.s. or peak reading ammeter, or a true r.m.s. or peak reading voltmeter and a non-inductive precision resistor to measure the magnetizing current
- Hz frequency meter
- N<sub>1</sub> magnetizing winding
- N<sub>2</sub> secondary winding
- Osc oscilloscope
- V<sub>1</sub> average type voltmeter
- V<sub>2</sub> r.m.s. voltmeter

**Figure 1 – Circuit of the measurement apparatus**

When conducting sinusoidal current measurements, a non-inductive precision resistor should be connected in series with the magnetizing winding to guarantee that the magnetizing circuit resistance is at least ten times greater than the impedance of the test specimen.

The source of alternating current shall have a variation of voltage and frequency at its output individually not exceeding  $\pm 0,2\%$  of the adjusted value during the measurement. It shall be connected to a true r.m.s. or peak reading voltmeter and a non-inductive precision resistor, in series with the magnetizing winding on the test specimen, to measure the magnetizing current.

The secondary circuit comprises a secondary winding connected to two voltmeters in parallel. One voltmeter measures the true r.m.s. value, the other measures the average rectified value but is sometimes scaled in values 1,111 times the rectified value.

The waveform of the secondary voltage should be checked with an oscilloscope to ensure that only the fundamental component is present.

### 6.3 Waveform of secondary voltage or magnetizing current

In order to obtain comparable measurements, it shall be agreed prior to the measurements that either the waveform of the secondary voltage or the waveform of the magnetizing current shall be maintained sinusoidal with a form factor of 1,111 with a relative tolerance of  $\pm 1\%$ . In the latter case, a non-inductive precision resistor connected in series with the magnetizing circuit is required.