SLOVENSKI STANDARD
oSIST prEN IEC 62044-3:2023

01-marec-2023

Jedra iz mehkomagnetnih materialov - Merilne metode - 3. del: Magnetne lastnosti pri močnem vzbujanju

Cores made of soft magnetic materials - Measuring methods - Part 3: Magnetic properties at high excitation level

Kerne aus weichmagnetischen Materialien - Messverfahren - Teil 3: Messungen der magnetischen Eigenschaften im Leistungsapplikationsbereich

Noyaux en matériaux magnétiques doux - Méthodes de mesure - Partie 3: Propriétés magnétiques à niveau élevé d'excitation

Ta slovenski standard je istoveten z: **prEN IEC 62044-3:2023**

ICS:

17.220.20	Merjenje električnih in magnetnih veličin	Measurement of electrical and magnetic quantities
29.100.10	Magnetne komponente	Magnetic components

oSIST prEN IEC 62044-3:2023 **en**

51/1426/CDV

COMMITTEE DRAFT FOR VOTE (CDV)

PROJECT NUMBER: **IEC 62044-3 ED2**	
DATE OF CIRCULATION: **2023-01-13**	CLOSING DATE FOR VOTING: **2023-04-07**
SUPERSEDES DOCUMENTS: **51/1411/CD, 51/1421/CC**	

IEC TC 51 : MAGNETIC COMPONENTS, FERRITE AND MAGNETIC POWDER MATERIALS	
SECRETARIAT: Japan	SECRETARY: Mr Takeshi Abe
OF INTEREST TO THE FOLLOWING COMMITTEES:	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:

Cores made of soft magnetic materials - Measuring methods - Part 3: Magnetic properties at high excitation level

PROPOSED STABILITY DATE: 2028

NOTE FROM TC/SC OFFICERS:

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

CORES MADE OF SOFT MAGNETIC MATERIALS – MEASURING METHODS –

Part 3: Magnetic properties at high excitation level

FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as “IEC Publication(s)”). 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. 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 IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
6) All users should ensure that they have the latest edition of this publication.
7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

IEC 62044-3 has been prepared by IEC technical committee 51: Magnetic components, ferrite and magnetic powder materials. It is an International Standard.

This second edition cancels and replaces the first edition published in 2000. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

a) addition of Annex F and Annex G.

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

FDIS	Report on voting
51/xxxx/FDIS	51/xxxx/RVD

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

The language used for the development of this International Standard is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at https://www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at https://www.iec.ch/standardsdev/publications.

IEC 62044, presented under the general title *Cores made of soft magnetic materials – Measuring methods,* will include the following parts:

Part 1: Generic specification

Part 2: Magnetic properties at low excitation level

Part 3: Magnetic properties at high excitation level

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

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

CORES MADE OF SOFT MAGNETIC MATERIALS – MEASURING METHODS –

Part 3: Magnetic properties at high excitation level

1 Scope

This part of IEC 62044 specifies measuring methods for power loss and amplitude permeability of magnetic cores forming the closed magnetic circuits intended for use at high excitation levels in inductors, chokes, transformers and similar devices for power electronics applications.

The methods given in this document can cover the measurement of magnetic properties for frequencies ranging practically from d.c. to 10 MHz, and even possibly higher, for the calorimetric and reflection methods. The applicability of the individual methods to specific frequency ranges is dependent on the level of accuracy that is to be obtained.

The methods in this standard are basically the most suitable for sine-wave excitations. Other periodic waveforms can also be used; however, adequate accuracy can only be obtained if the measuring circuitry and instruments used are able to handle and process the amplitudes and phases of the signals involved within the frequency spectrum corresponding to the given magnetic flux density and field strength waveforms with only slightly degraded accuracy.

NOTE It can be necessary for some magnetically soft metallic materials to follow specific general principles, customary for these materials, related to the preparation of specimens and prescribed calculations. These principles are formulated in IEC 60404-8-6.

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 60205, *Calculation of the effective parameters of magnetic piece parts*

IEC 60401-3:2015, *Ferrite materials – Guide on the format of data appearing in manufacturers' catalogues of transformer and inductor cores*

IEC 61332:2016, *Soft ferrite material classification*

IEC 62044-1:2002, *Cores made of soft magnetic materials - Measuring methods - Part 1: Generic specification*

3 Terms, definitions and symbols

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 https://www.electropedia.org/
– ISO Online browsing platform: available at https://www.iso.org/obp

3.1 Definitions

3.1.1
(effective) amplitude permeability
amplitude permeability: μ_a, effective amplitude permeability: μ_{ea}

magnetic permeability obtained from the peak value of the effective magnetic flux density, $\hat{B}_e$, and the peak value of the effective magnetic field strength, $\hat{H}_e$, at the stated value of either, when the magnetic flux density and magnetic field vary periodically with time and with an average of zero, and the material is initially in a specified neutralized state

Note 1 to entry: This definition differs from that of IEC 60050 [221-03-07].

Note 2 to entry: Two amplitude permeabilities are in common use, namely:

– that in which the peak values apply to the actual waveforms of the magnetic flux density and field strength,

– that in which the peak values apply to the fundamental components of waveforms of the magnetic flux density and the field

Note 3 to entry: The magnetic flux density and the field strength and, consequently, the amplitude permeability may even be quasi-static quantities, provided the core is cyclically magnetized and no excursion of the B-H curve appears.

3.1.2
maximum (effective) amplitude permeability
$\mu_{ea\ max}$

maximum value of the (effective) amplitude permeability when the amplitude of excitation ($\hat{B}_e$ or $\hat{H}_e$) is varied

3.1.3
excitation
either magnetic flux density or field strength for which the waveform and amplitude both remain within the specified tolerance

Note 1 to entry: When the magnetic flux density (field strength) mode of excitation is chosen, the resultant waveform of field strength (magnetic flux density) may be distorted with respect to the excitation waveform due to the non-linear behaviour of the magnetic material.

3.1.4
high excitation level
excitation at which the permeability depends on excitation amplitude (particularly at low frequencies) and/or at which the power loss results in a noticeable temperature rise (particularly at high frequencies)

3.1.5
exciting winding
winding of measuring coil to which the exciting voltage is applied or through which the exciting current is flowing

3.1.6
voltage sensing winding
unloaded winding of a measuring coil across which the electromotive force induced by the excitation may be determined

3.1.7
measuring winding
winding, usually secondary, loaded or unloaded, which can be used for measurement apart from the exciting and/or voltage sensing winding

3.1.8
power loss
power absorbed by the core

3.2 Symbols

All the formulae in this standard use basic SI units. When multiples or sub-multiples are used, the appropriate power of 10 shall be introduced.

A_e effective cross-sectional area of the core
$\hat{B}_e$ peak value of the effective magnetic flux density in the core
f frequency
$\hat{H}_e$ peak value of the effective magnetic field strength in the core
l_e effective magnetic path length of the core
L inductance
i instantaneous value of the current
I current
N number of turns of winding of the measuring coil
P power loss in the core
Q_c quality factor of the core for a given frequency
R resistance
t time
T temperature
u instantaneous value of the voltage
U voltage
V_e effective volume of the core
δ relative error, deviation, etc.
Δ absolute error, deviation, etc.
μ_{ea} (effective) amplitude permeability
μ_0 magnetic constant : approximately $4\pi \times 10^{-7}$ H/m
π the number 3,14159...
φ phase shift
ω angular frequency = $2\pi f$

NOTE 1 Additional subscript, upper script, etc. gives a more specific meaning to the given symbol.

NOTE 2 Symbols which are used sporadically are defined in the place where they appear in the text.

NOTE 3 Effective parameters, such as effective magnetic path length, l_e, effective cross-sectional area, A_e, and effective volume of the core, V_e, are calculated in accordance with IEC 60205.

NOTE 4 In the further text of this standard, the terms magnetic flux density and field strength stand for the shortened terms magnetic flux density and magnetic field strength.

4 General precautions for measurements at high excitation level

4.1 General statements

4.1.1 Relation to practice

The measuring conditions, methods and procedures shall be chosen in such a way that the measured results are suitable for predicting the performance of the core under practical circumstances. This does not imply that all these stipulations, especially those related to the excitation waveforms, have to correspond to terms encountered in practice.

4.1.2 Core effective parameters and material properties

Since the core is in general of non-uniform cross-section and generally has non-uniformly distributed windings along the core path, the measurement does not yield the amplitude permeability and the power loss of the material, but the effective values of these parameters appropriate to the effective magnetic flux density $\hat{B}_e$ and the effective field strength $\hat{H}_e$ in the core.

For the measurement of the amplitude permeability and the power loss of the material, the core shall have a ring or toroidal shape in which the ratio of outer to inner diameter should not be greater than 1,4 and should have windings distributed uniformly, close to the core, of inductive coupling coefficient practically equal to unity.

4.1.3 Reproducibility of the magnetic state

To obliterate various remanence and time effects in the core material, the measurement shall be made at a well-defined and reproducible magnetic state.

Any measurement under specified excitation, unless otherwise stated, is to be made at the time $t_m = t_c + \Delta t$ after the magnetic conditioning start; t_c is the time period within which the magnetic conditioning is completed and, whereupon, the specified excitation is set; Δt is the time period during which the core is kept stable under the excitation being set.

4.2 Measuring coil

4.2.1 General

Normally, a measuring coil will be used, but in principle any coaxial line, cavity or other suitable device providing the necessary interaction between the magnetic material and the electromagnetic signal, may also be used.

For measurement on toroid using coils, the turns of the measuring coil shall be distributed in such a way as to keep both the stray capacitance and the stray field as low as necessary for sufficiently accurate measurement.

For measurements on cores which assemble around a coil, the shape of the measuring coil shall correspond to that of the coils used for normal application of the core and its influence on the variation of the inductance to be measured shall be negligible.

Unless otherwise specified, the test coil complete with coil former or encapsulation, or both, shall be positioned coaxial to the limb which it embraces, and the side of the coil at which the start of the winding is located shall be lightly pressed into contact with the core at one end of this limb as follows:

- for a symmetrical core, the coil assembly shall contact the core at either one end or the other;

- for a core that is symmetrical except for an air-gap, the coil assembly shall make end contact to that half of the core that contains the least proportion of the air-gap.

One of the coil faces shall be marked so as to define its orientation. The coil shall be kept in the defined position during the whole measurement in order to obtain the maximum reproducibility of the measurement.

4.2.2 Number of turns

The number of turns shall be specified for each winding in relation to the measuring conditions, the equipment used and the accuracy to be obtained. The windings shall be wound as close to the core as possible, to make the coupling (magnetic flux linkage) coefficients between the measuring coil windings and the core and between the windings of measuring coil, as close to 100 % as possible.

The resistance, self-capacitance and inter-winding capacitance of windings should be as low as possible to make the related errors negligible.

In the case of ring or toroidal cores, the turns shall be distributed evenly around the core circumference.

The connectors, primarily of exciting winding, should consist of insulated strands, if this is necessary for measurements at high frequencies.

When winding a sharp-edge core, care should be taken to ensure that the wire insulation is not ruptured and, in the case of stranded wire, strands are not broken.

4.2.3 Single winding and double winding

The use of a single winding both for excitation and voltage sensing is recommended if

– the coupling between the exciting winding and the voltage sensing winding is so reduced that it results in a non-negligible error in the determination of the measuring magnetic flux density B in the core;
– the inter-winding capacitance is too high;
– there is no measuring circuitry contra-indication against the direct connection of the exciting winding to input(s) of measuring instruments.

NOTE 1 When single winding is used, it is recommended that its resistance be made as low as possible to make the winding ohmic power loss negligible compared to the power loss in the core.

The use of separate exciting and voltage sensing windings (double winding) is recommended if, for whatever reason, the exciting winding should be galvanically separated from the voltage and the current measuring instruments, for example, to avoid a floating or d.c. connection to their inputs.

NOTE 2 When the exciting and voltage sensing windings are used, it is critical to make their magnetic coupling coefficient as close to 100 % as possible.

NOTE 3 The voltage needed for calculation of the magnetic flux density in the core is typically measured across a voltage sensing winding that is separate from the current-carrying (exciting) winding. When measuring core losses, ohmic losses in the voltage sensing winding do not affect the calculation, but ohmic losses in the current-carrying (exciting) winding must be excluded from the core loss calculation.

NOTE 4 The use of two windings is recommended at more than 200 kHz.