

INTERNATIONAL STANDARD

NORME INTERNATIONALE



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

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 100 kHz, sur des éprouvettes en forme de tore



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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 consolidated version of the official IEC Standard and its amendment has been prepared for user convenience.

IEC 60404-6 edition 3.1 contains the third edition (2018-05) [documents 68/595/FDIS and 68/600/RVD], its corrigendum 1 (2018-11) and its amendment 1 (2021-07) [documents 68/669/CDV and 68/684/RVC].

In this Redline version, a vertical line in the margin shows where the technical content is modified by amendment 1. Additions are in green text, deletions are in strikethrough red text. A separate Final version with all changes accepted is available in this publication.

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

This third edition constitutes a technical revision.

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

- a) 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;
- b) limitation of the frequency range up to 100 kHz;
- c) deletion of Clause 7 of the second edition that specified the measurement of magnetic properties using a digital impedance bridge;
- d) 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;
- e) addition of an informative annex on the technical details of the digital sampling technique for the determination of magnetic properties.

This document 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 the base publication and its amendment will remain unchanged until the stability date indicated on the IEC web site under "<http://webstore.iec.ch>" in the data related to the specific publication. At this date, the publication will be

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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 is made in accordance with the ring method of IEC 60404-4. The determinations of the magnetic characteristics of magnetically soft components are made in accordance with IEC 62044-3.

NOTE IEC 62044-3:2000 specifies methods for the measurement of AC magnetic characteristics of magnetically soft components in the frequency range up to 10 MHz.

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

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

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

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

IEC 60404-4, *Magnetic materials – Part 4: Methods of measurement of d.c. magnetic properties of iron and steel*

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 (GUM:1995)*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60050-121 and IEC 60050-221 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. 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 no greater than 1,4 and preferably less than 1,25 to achieve a sufficiently homogenous magnetization of the test specimen.

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).