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INTERNATIONAL STANDARD

Magnetic materials –
Part 10: Methods of measurement of magnetic properties of electrical steel strip and sheet at medium frequencies

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MAGNETIC MATERIALS –

Part 10: Methods of measurement of magnetic properties of electrical steel strip and sheet at medium frequencies

FOREWORD

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International Standard IEC 60404-10 has been prepared by IEC technical committee 68: Magnetic alloys and steels.

This second edition cancels and replaces the first edition published in 1988. This 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) introduction of formal changes which adapt this standard to other standards of the 60404 series;
c) revision of the problem of the air flux compensation taking account of the condition of the higher frequencies;

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d) revision of the capacitive coupling of mutual inductor windings together with the consideration of the alternative method of numerical air flux compensation.

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

CDV	Report of voting
68/523/CDV	68/556/RVC

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- withdrawn,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 contents of the corrigendum of March 2018 have been included in this copy.

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INTRODUCTION

Besides the fact that the first edition of this part of IEC 60404 is more than 25 years old, the main purpose of this revision is to adapt it to modern measurement and evaluation methods, in particular to introduce the widely spread digital sampling method for the acquisition and evaluation of the measured data.

In addition, the problem of the air flux compensation had to be re-considered under the condition of the elevated frequencies. Capacitive coupling of mutual inductor windings require observance of significant phase shift influence and suggest consideration of the alternative method of numerical air flux compensation. An increase of the frequency range to 20 kHz was discussed by TC 68 since some manufacturers of electrical steel include this range in their catalogues. However, TC 68 decided to keep the frequency range to that defined in IEC 60404-10:1988: 400 Hz to 10 kHz.

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MAGNETIC MATERIALS –

Part 10: Methods of measurement of magnetic properties of electrical steel strip and sheet at medium frequencies

1 Scope

This part of IEC 60404 is applicable to grain-oriented and non-oriented electrical steel strip and sheet for measurements of a.c. magnetic properties in the frequency range 400 Hz to 10 000 Hz.

The object of this document is to define the general principles and the technical details of the measurement of magnetic properties of electrical steel strip and sheet by means of an Epstein frame.

The Epstein frame is applicable to test specimens obtained from electrical steel strips and sheets of any grade. The AC magnetic characteristics are determined for sinusoidal induced voltages, for specified peak values of magnetic polarization and for a specified frequency.

The measurements are to be made at an ambient temperature of (23 ± 5)°C on test specimens which have first been demagnetized.

NOTE Throughout this document the term "magnetic polarization" is used as defined in IEC 60050-221. In some standards of the IEC 60404 series, the term "magnetic flux density" was used.

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 60404-8 (all parts), *Magnetic materials – Part 8: Specifications for individual materials*

IEC 60404-13, *Magnetic materials – Part 13: Methods of measurement of density, resistivity and stacking factor of electrical steel sheet and strip*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60050-221 and IEC 60050-121 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

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4 General principle of a.c. measurements

4.1 General

Clause 4 specifies the general conditions for the determination of a.c.magnetic properties of electrical steel strip and sheet by means of the 25 cm Epstein frame.

4.2 Principle of the 25 cm Epstein frame method

The 25 cm Epstein frame, which comprises a primary winding, a secondary winding and the specimen to be tested as a core, forms an unloaded transformer whose characteristics are measured by the method described in the following subclauses 4.3 to 4.10.

At the higher end of the frequency range, a specially constructed Epstein frame (see Annex A) may be required in which the interwinding capacitances are low, so that the capacitive part of the impedance has a negligible impact on the loss results. The material of the winding formers supporting the windings has a low dielectric loss.

A separate measuring system (for example a commercially available digital bridge capable of measuring resistance, capacitance and inductance) is required to determine the inter-winding capacitance of the Epstein frame.

4.3 Test specimen

The strips to be tested are assembled in a square, having double-overlapped corner joints (see Figure 1) thus forming four limbs of equal length and equal cross-sectional area.

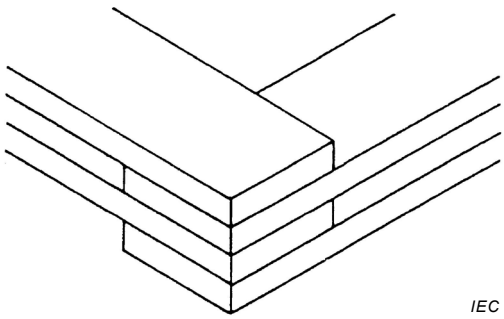

Figure 1 – Double-lapped joints

The strips shall be sampled in accordance with the appropriate product standard in the IEC 60404-8 series.

They shall be cut by a method which will produce substantially burr-free edges and, if so specified, heat treated in accordance with the corresponding product standard. They shall have the following dimensions:

– width b = 30 mm ± 0,2 mm;

– length 280 mm ≤ l ≤ 320 mm.

The length of the strips shall be equal within a tolerance of ± 0,5 mm.

When the strips are cut parallel or normal to the direction of rolling, the edge of the parent sheet shall be taken as the reference direction.

The following tolerances shall apply for the angle between the specified and actual direction of cutting:

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