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TECHNICAL REPORT

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Determination of magnetic loss under magnetic polarization waveforms including higher harmonic components – Measurement, modelling and calculation methods

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

DETERMINATION OF MAGNETIC LOSS UNDER MAGNETIC POLARIZATION WAVEFORMS INCLUDING HIGHER HARMONIC COMPONENTS – MEASUREMENT, MODELLING AND CALCULATION METHODS

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IEC/TR 62383, which is a technical report, has been prepared by IEC technical committee 68: Magnetic alloys and steels.

The text of this technical report is based on the following documents:

Enquiry draft	Report on voting
68/309/DTR	68/315/RVC

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

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The committee has decided that the contents of this publication will remain unchanged until the maintenance result 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

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- withdrawn,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

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

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INTRODUCTION

The specific total loss has to be measured for the design of electrical machines and classification of electrical steel sheets. During the last 20 years, electrical engineers have determined the magnetic induction waveforms of electrical machines [1] to [4][1)], and calculated the magnetic power loss under non-sinusoidal waveform of magnetic polarization [5] to [13]. They designed electrical machines using numeric calculation (FEM, BEM) and high speed computers, including non-linear and hysteresis properties of magnetic materials.

Under standard measurement conditions, the specific total loss of electrical steel is to be measured only under the condition of sinusoidal waveform of the magnetic polarization. However, the actual magnetic polarization waveforms of the electric machine are almost always not sinusoidal because of the material behaviour (anisotropy, non-linear B-H performance in high polarization regions such as the stator tooth of electrical machines), because of PWM modulated voltage for variable speed motors and because of the layout of the magnetic circuit and the winding scheme (tooth harmonics).

Specific total loss values obtained by the standard method are not really applicable to an actual electrical machine design because the specific total loss of ferromagnetic material cannot be predicted easily due to non-linear and hysteresis effects, but these higher harmonic polarizations bring about a large increase in magnetic loss.

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1) The figures in square brackets refer to the Bibliography.

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DETERMINATION OF MAGNETIC LOSS UNDER MAGNETIC POLARIZATION WAVEFORMS INCLUDING HIGHER HARMONIC COMPONENTS – MEASUREMENT, MODELLING AND CALCULATION METHODS

1 Scope

Nowadays, by computer aided testing (CAT), a.c. magnetic properties of electrical steel sheets can be measured under various measuring conditions automatically. For example, the magnetic loss in the presence of higher harmonic frequency components of magnetic polarization can be measured using the arbitrary waveform synthesizer, digitiser and computer.

The present standard methods (IEC 60404-2, IEC 60404-3 and IEC 60404-10) for the determination of specific total loss are restricted to the sinusoidal waveform of magnetic polarization, and these standards are still important for the characterization of core materials. However, actual waveforms of magnetic polarization in the electrical machines and transformers always include higher harmonic polarizations, and nowadays electrical machines can be designed using numerical methods including higher harmonics. But for these conditions, there is still no standard testing method.

This technical report reviews methods for measurement of the magnetic loss of soft magnetic materials under the condition of magnetic polarization which includes higher harmonic components.

2 Normative references

The following referenced documents are indispensable for the application 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 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 60404-3:1992, *Magnetic materials − Part 3: Methods of measurement of the magnetic properties of magnetic sheet and strip by means of a single sheet tester*

IEC 60404-6, *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*

IEC 60404-10, *Magnetic materials − Part 8: Specifications for individual materials – Section 10: Specification for magnetic materials (iron and steel) for use in relays*