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INTERNATIONAL STANDARD

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Magnetic materials –
Part 17: Methods of measurement of the magnetostriction characteristics of grain-oriented electrical steel strip and sheet by means of a single sheet tester and an optical sensor

Matériaux magnétiques –
Partie 17: Méthodes de mesure des caractéristiques de magnétostriction des bandes et tôles magnétiques en acier à grains orientés au moyen d'un essai sur tôle unique et d'un capteur optique



IEC 60404-17:2021-11(en-fr)

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MAGNETIC MATERIALS –

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The text of this International Standard is based on the following documents:

Draft	Report on voting
68/685/CDV	68/692/RVC

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 www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/standardsdev/publications.

A list of all parts in the IEC 60404 series, published under the general title *Magnetic materials*, can be found on the IEC website.

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INTRODUCTION

This document provides standard methods to measure the magnetostriction characteristics of grain-oriented electrical steel strip and sheet under an applied AC magnetic field at 50 Hz or 60 Hz. The technical details are specified after intense considerations among magnetostriction experts, so that a satisfactory reproducibility of the measurement can be expected. The measurement requires detections of tiny vibrations of the test specimen at a resolution of 0,01 µm or better. In order to meet this challenging condition, not only the magnetic aspects, but also mechanical aspects of the test apparatus, e.g. the influence of friction, Maxwell forces, resonance and external vibrations, had to be specified.

The methods to determine magnetostriction characteristics of the butterfly loop, the peak-to-peak and zero-to-peak values of magnetostriction strain are specified in this document. Subsidiary characteristics of the velocity levels and the acceleration levels are described in Annex E.

The technical report IEC TR 62581:2010 [1][1] reviewed the methods of measurement of the magnetostriction characteristics of grain-oriented electrical steel by means of a single sheet tester. Various methods have been used for the measurement of the change in length of the various test specimens. However, for methods using sensors in contact with the test specimen, it is difficult to avoid measurement offsets associated with the contact methods. Moreover, the methods require special skills to be used in order to carry out the measurements. Therefore, this document provides methods using an optical sensor, namely a laser Doppler vibrometer, which fulfils the requirements of non-contact, high resolution and high reproducibility of measurements.

It is well known that mechanical stress in grain-oriented electrical steel has a strong influence on magnetostriction [1]. Grain-oriented electrical steel has a particular behaviour with regards to its sensitivity to compressive stress along the rolling direction compared to other kinds of electrical steels. It depends on the degree of grain-orientation of the material and the level of tensile stress in the material applied by surface coatings. Methods of measurement under an externally applied compressive stress are described in Annex B.

International round robin comparisons of the magnetostriction measurements have been carried out repeatedly by reducing the range of methods [2], [3], [4]. The reproducibility of the measurement was characterized by a relative standard deviation of more than 20 % when various methods were allowed. It became less than 2 % when test apparatuses following the principles described in this document were used for the assessment of grain-oriented electrical steel sheets cut along the rolling direction under the condition of a peak magnetic polarization of 1,7 T and a magnetizing frequency of 50 Hz.

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[1] Numbers in square bracket refer to the Bibliography.

MAGNETIC MATERIALS –

Part 17: Methods of measurement of the magnetostriction characteristics of grain-oriented electrical steel strip and sheet by means of a single sheet tester and an optical sensor

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1 Scope

This part of IEC 60404 is applicable to grain-oriented electrical steel strip and sheet specified in IEC 60404-8-7 for the measurement of magnetostriction characteristics under an applied AC magnetic field at 50 Hz or 60 Hz.

This document defines the general principles and technical details of the measurement of magnetostriction characteristics of grain-oriented electrical steel strip and sheet by means of a single sheet tester and an optical sensor.

NOTE 1 The accelerometer method [5] is also an established method for the measurement of magnetostriction. However, it is more suited to the measurement of magnetostriction under an externally applied tensile or compressive stress, not zero stress, because it places a weight on the test specimen to prevent a deformation of the test specimen. Since this document includes the measurement at zero stress, the optical sensor method is provided as the optimum method.

This document is applicable to the measurement of:

– the butterfly loop;

– the peak-to-peak value $\lambda_{p\text{-}p}$;

– the zero-to-peak value $\lambda_{0\text{-}p}$.

The magnetostriction characteristics are determined for a sinusoidal induced secondary voltage, for a specified peak value of the magnetic polarization and at a specified magnetizing frequency.

NOTE 2 Throughout this document the term “magnetic polarization” is used as described in IEC 60050-121:1998, 121-11-54. In some standards of the IEC 60404 series, the term “magnetic flux density” is 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 60050-103, *International Electrotechnical Vocabulary – Part 103: Mathematics – Functions* (available at www.electropedia.org)

IEC 60050-121, *International Electrotechnical Vocabulary – Part 121: Electromagnetism* (available at www.electropedia.org)

IEC 60050-221, *International Electrotechnical Vocabulary – Chapter 221: Magnetic materials and components* (available at www.electropedia.org)

IEC 60050-801, *International Electrotechnical Vocabulary – Chapter 801: Acoustics and electroacoustics* (available at www.electropedia.org)

IEC 60404-8-7, *Magnetic materials – Part 8-7: Specifications for individual materials – Cold-rolled grain-oriented electrical steel strip and sheet delivered in the fully-processed state*

IEC 61672-1:2013, *Electroacoustics – Sound level meters – Part 1: Specifications*

3 Terms and definitions

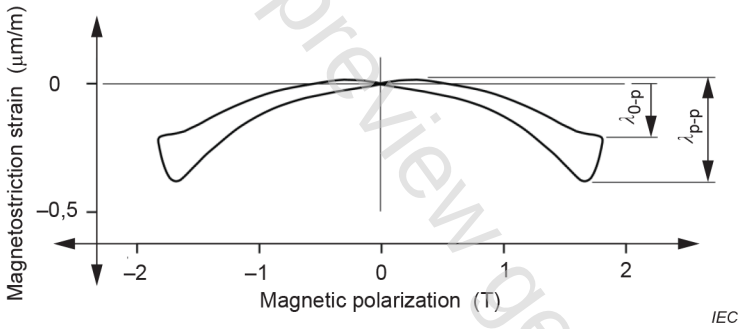
For the purposes of this document, the terms and definitions given in IEC 60050-103, IEC 60050-121, IEC 60050-221, IEC 60050-801, IEC 61672-1 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- ISO Online browsing platform: available at http://www.iso.org/obp
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3.1
butterfly loop
butterfly curve
hysteresis loop of magnetostriction strain versus magnetic polarization along the direction of applied AC magnetic field for a period of magnetization, as illustrated in Figure 1

EXAMPLE



Key

$\lambda_{p\text{-}p}$ peak-to-peak value

$\lambda_{0\text{-}p}$ zero-to-peak value

Figure 1 – Illustrations of butterfly loop, peak-to-peak value and zero-to-peak value

3.2
$\lambda_{p\text{-}p}$
peak-to-peak value
peak-to-peak amplitude of magnetostriction strain along the direction of applied AC magnetic field, taking an absolute value, expressed in µm/m

Note 1 to entry: The peak-to-peak value can be read from the butterfly loop as shown in Figure 1.

3.3
$\lambda_{0\text{-}p}$
zero-to-peak value
difference in magnetostriction strain along the direction of applied AC magnetic field between the values at the prescribed peak magnetic polarization and at the zero value of the magnetic polarization, taking a positive or negative value, expressed in µm/m

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