
Magnetni materiali - 17. del: Metode merjenja magnetostrikcijskih značilnosti zrnato usmerjenih jeklenih magnetnih trakov in plošč z uporabo enolistnega preskuševalnika in optičnega senzorja (IEC 60404-17:2021)

Magnetic materials - Part 17: Methods of measurement of the magnetostriction characteristics of grainoriented electrical steel strip and sheet by means of a single sheet tester and an optical sensor (IEC 60404-17:2021)

Magnetische Werkstoffe - Teil 17: Verfahren zur Messung der Magnetostriktionseigenschaften von kornorientiertem Elektroband und -blech mit einem Tafelmessgerät und einem optischen Sensor (IEC 60404-17:2021)

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)

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(IEC 60404-17:2021)**

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EN IEC 60404-17:2021 (E)**European foreword**

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IEC 60404-16:2018 NOTE Harmonized as EN IEC 60404-16:2018 (not modified)
 IEC 60076-10:2016 NOTE Harmonized as EN 60076-10:2016 (not modified)

Annex ZA (normative)

Normative references to international publications with their corresponding European publications

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.

NOTE 1 Where an International Publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

NOTE 2 Up-to-date information on the latest versions of the European Standards listed in this annex is available here: www.cenelec.eu.

<u>Publication</u>	<u>Year</u>	<u>Title</u>	<u>EN/HD</u>	<u>Year</u>
IEC 60050-103	-	International Electrotechnical Vocabulary - - Part 103: Mathematics - Functions	-	-
IEC 60050-121	-	International Electrotechnical Vocabulary - - Part 121: Electromagnetism	-	-
IEC 60050-221	-	International Electrotechnical Vocabulary. - Chapter 221: Magnetic materials and components	-	-
IEC 60050-801	-	International Electrotechnical Vocabulary - - Chapter 801: Acoustics and electroacoustics	-	-
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	EN 61672-1	2013

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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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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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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.

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

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- withdrawn,
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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.

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

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 λ_{p-p} ;
- the zero-to-peak value λ_{0-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>
- IEC Electropedia: available at <http://www.electropedia.org/>

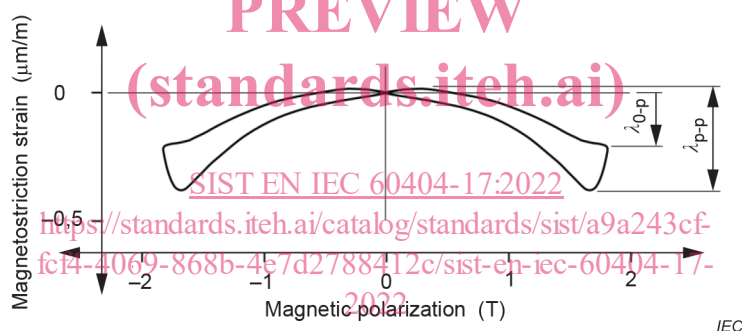
3.1

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

- λ_{p-p} peak-to-peak value
- λ_{0-p} zero-to-peak value

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

3.2

λ_{p-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 $\mu\text{m/m}$

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

3.3

λ_{0-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 $\mu\text{m/m}$

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

3.4

L_v

velocity level

indicator of magnetostriction velocity comprising all harmonic components of magnetostriction strain of interest, expressed in dB

Note 1 to entry: The frequency weighting filter "A" defined in IEC 61672-1:2013 can be applied to the velocity level resulting as A-weighted velocity level, L_{vA} , expressed in dB(A).

3.5

L_a

acceleration level

indicator of magnetostriction acceleration comprising all harmonic components of magnetostriction strain of interest, expressed in dB

Note 1 to entry: The frequency weighting filter "A" defined in IEC 61672-1:2013 can be applied to the acceleration level resulting as A-weighted acceleration level, L_{aA} , expressed in dB(A).

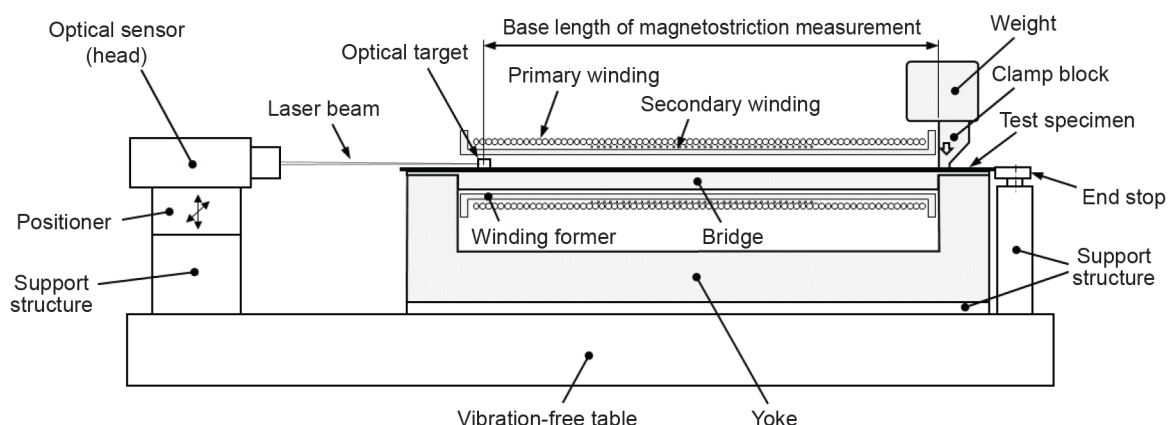
4 General principles

4.1 Principle of the method

A length change of a test specimen for a base length under an AC magnetic field is measured by means of a single sheet tester and an optical sensor. Magnetostriction characteristics of the material are determined from the length change of the base length of the test specimen for prescribed peak values of the magnetic polarization and at a specified magnetizing frequency.

A schematic diagram of a test apparatus is illustrated in Figure 2. The test apparatus consisting of windings, a winding former, a bridge, a yoke, a clamp block, a weight, an end stop, an optical sensor and auxiliary support structures shall be fixed to a vibration-free table. The test apparatus may be assembled on a rigid base plate which is non-magnetic and fixed to the vibration-free table.

NOTE 1 Methods of measurement under an externally applied compressive stress are described in Annex B.



IEC

Figure 2 – Schematic diagram of a test apparatus (cross-sectional)

The test specimen shall be placed on the bridge inside the following two windings wound on the winding former (see 4.3.3):

- an exterior primary winding (magnetizing winding);
- an interior secondary winding (induced voltage winding).