SLOVENSKI STANDARD
oSIST prEN IEC 60404-18:2024

01-oktober-2024

Magnetni materiali - 18. del: Materiali za permanentne (trdomagnetne) magnete - Metode merjenja magnetnih lastnosti v odprtem magnetnem krogu z uporabo superprevodnega magneta

Magnetic materials - Part 18: Permanent magnet (magnetically hard) materials - Methods of measurement of the magnetic properties in an open magnetic circuit using a superconducting magnet

Matériaux magnétiques - Partie 18: Matériaux (magnétiques durs) pour aimants permanents - Méthodes de mesure des propriétés magnétiques en circuit magnétique ouvert à l'aide d'un aimant supraconducteur

Ta slovenski standard je istoveten z: **prEN IEC 60404-18:2024**

ICS:

17.220.20	Merjenje električnih in magnetnih veličin	Measurement of electrical and magnetic quantities
29.030	Magnetni materiali	Magnetic materials

oSIST prEN IEC 60404-18:2024 **en**

68/768/CDV

COMMITTEE DRAFT FOR VOTE (CDV)

PROJECT NUMBER: **IEC 60404-18 ED1**	
DATE OF CIRCULATION: **2024-07-12**	CLOSING DATE FOR VOTING: **2024-10-04**
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IEC TC 68 : MAGNETIC ALLOYS AND STEELS	
SECRETARIAT: Germany	SECRETARY: Mr Richard Daniel Knobloch
OF INTEREST TO THE FOLLOWING COMMITTEES:	PROPOSED HORIZONTAL STANDARD: ☐ Other TC/SCs are requested to indicate their interest, if any, in this CDV to the secretary.
FUNCTIONS CONCERNED: ☐ EMC ☐ ENVIRONMENT ☒ QUALITY ASSURANCE ☐ SAFETY	
☒ SUBMITTED FOR CENELEC PARALLEL VOTING **Attention IEC-CENELEC parallel voting** The attention of IEC National Committees, members of CENELEC, is drawn to the fact that this Committee Draft for Vote (CDV) is submitted for parallel voting. The CENELEC members are invited to vote through the CENELEC online voting system.	☐ NOT SUBMITTED FOR CENELEC PARALLEL VOTING

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TITLE:

Magnetic materials - Part 18: Permanent magnet (magnetically hard) materials - Methods of measurement of the magnetic properties in an open magnetic circuit using a superconducting magnet

PROPOSED STABILITY DATE: 2028

NOTE FROM TC/SC OFFICERS:

This CDV document was prepared by the Project Leader on the basis of the second CD and the comments received from National Committees (see 68/767/CC) and the contributions from the Project Team, following the decision made by the TC 68 Chairman.

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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MAGNETIC MATERIALS –

Part 18: Permanent magnet (magnetically hard) materials – Methods of measurement of the magnetic properties in an open magnetic circuit using a superconducting magnet

FOREWORD

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

Draft	Report on voting
68/XX/FDIS	68/XX/RVD

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/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

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

INTRODUCTION

High-performance permanent magnet materials with high coercivity, e.g. Nd-Fe-B magnets, have been used in the electric and automobile industry and its usage increases rapidly to meet the need to improve energy saving and to increase efficiency of electromagnetic applications, e.g. traction motors for Electric Vehicle (EV) and Hybrid Electric Vehicle (HEV), which are urgently demanded to contribute to the problem of global warming.

However, there has been no standard method which can determine all the magnetic properties of the high-performance permanent magnet materials with coercivity H_{cJ} higher than 2 MA/m to meet the need of the industry. The method specified in IEC 60404-5, which is a method of measurement in a closed magnetic circuit, can lead to significant measurement errors for measurement of H_{cJ} ≥ 1,6 MA/m due to magnetic saturation in parts of the pole faces of the yoke (see IEC 60404-5).

In order to solve the problem, several methods of measurement in an open magnetic circuit without a yoke have been developed. The methods using a superconducting magnet (SCM) are thought to solve this problem and enable accurate measurements of the high-performance permanent magnet materials (see IEC TR 63304:2021 [1][1]).

Since the measurement in an open magnetic circuit is strongly affected by the self-demagnetizing field in the test specimen, a correction of the influence of self-demagnetizing field (demagnetizing field correction) on the demagnetization curve obtained in an open magnetic circuit is indispensable.

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

MAGNETIC MATERIALS –

Part 18: Permanent magnet (magnetically hard) materials – Methods of measurement of the magnetic properties in an open magnetic circuit using a superconducting magnet

1 Scope

The purpose of this part of IEC 60404 is to define the general principle and technical details of the methods of measurement of the DC magnetic properties of permanent magnet materials in an open magnetic circuit using a superconducting magnet (SCM).

This method is applicable to permanent magnet materials, such as those specified in IEC 60404-8-1, the properties of which are presumed homogeneous throughout their volume.

There are two methods:

– the SCM-Vibrating Sample Magnetometer (VSM) method;

– the SCM-Extraction method.

This document also specifies methods to correct the influence of the self-demagnetizing field in the test specimen on the demagnetization curve obtained in an open magnetic circuit. The magnetic properties are determined from the corrected demagnetization curve.

NOTE 1 These SCM-methods can determine the magnetic properties of high-performance permanent magnet materials with coercivity higher than 2 MA/m. For the magnetic materials with coercivity higher than 1,6 MA/m, the methods of measurement in a closed magnetic circuit in accordance with IEC 60404-5 can lead to significant measurement error due to magnetic saturation in parts of the pole faces of the yoke (see IEC 60404-5).

NOTE 2 There is another method of the measurement in an open magnetic circuit, i.e. the pulsed field magnetometer (PFM), which is described in IEC TR 62331[3]. The PFM is the method of measurement of the magnetic properties of permanent magnet materials applying the pulsed magnetic field instead of the DC magnetic field and is different from the methods described in this document. The PFM measures a steep AC magnetic response of a test specimen in a pulsed magnetic field. Consequently, additional correction is indispensable to remove the influence of eddy currents in the test specimen and the magnetic viscosity of the magnetic materials in order to obtain properties equivalent to the DC magnetic properties.

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 60404-5, *Magnetic materials – Part 5: Permanent magnet (magnetically hard) materials – Methods of measurement of magnetic properties*

IEC 60404-8-1, *Magnetic materials – Part 8-1: Specifications for individual materials – Magnetically hard materials*

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

IEC 60050-151, *International Electrotechnical Vocabulary – Part 151: Electrical and magnetic devices*

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

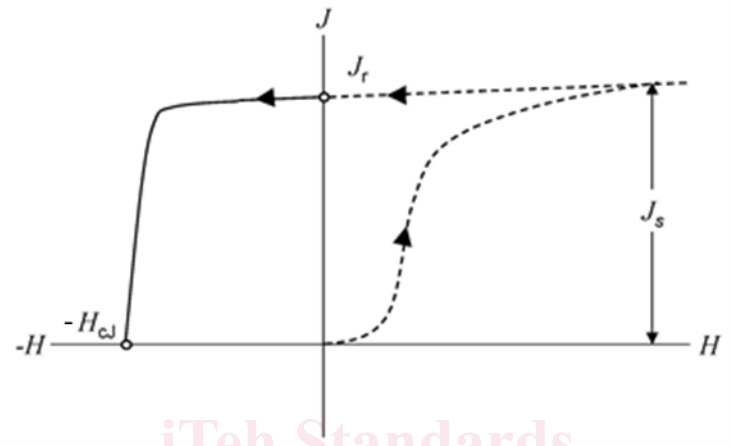
3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60050-121, IEC 60050-151, IEC 60050-221 and the following 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

3.1
demagnetization curve
part of a hysteresis loop in which the magnetic polarization goes from the remanent magnetic polarization to zero when the applied magnetic field strength varies monotonically, as illustrated in Figure 1



Key

J_s saturation magnetic polarization, in T

J_r remanent magnetic polarization, in T

H_{cJ} coercivity relating to the magnetic polarization, in A/m

Figure 1 – Demagnetization curve $J(H)$

Note 1 to entry: A demagnetization curve can be drawn from near magnetic saturation.

[SOURCE: IEC 60050-121:1998, 121-12-72, modified – magnetic flux density is replaced by magnetic polarization and Note 1 to entry and Figure 1 have been added]

3.2
magnetic dipole moment
m
vector quantity given by the volume integral of the magnetic polarization

[SOURCE: IEC 60050-221:1990, 221-01-07, modified – the symbol j is changed to m which is used industrially and the note has been removed]

3.3
***M* coil**
detection coil for magnetic dipole moment

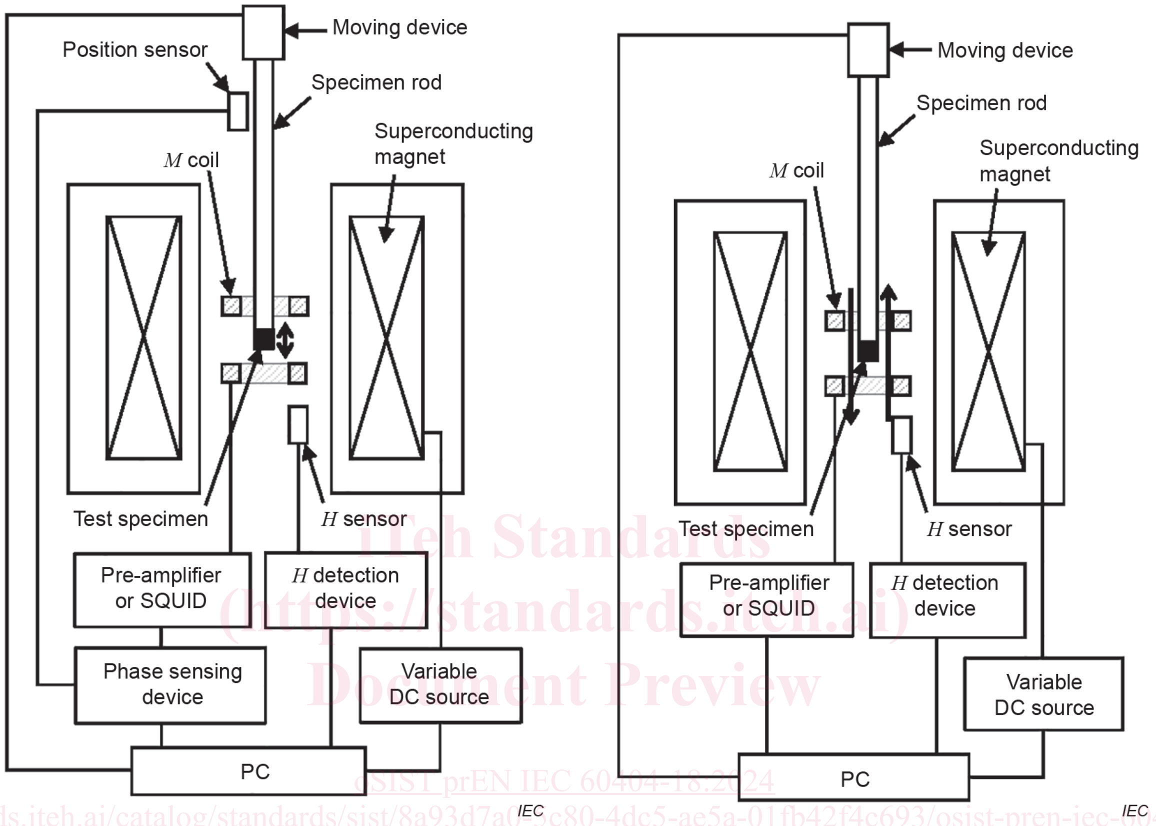
4 General principle

4.1 Principle of the method

Figure 2 illustrates schematic diagrams of the test apparatus corresponding to a) the SCM-VSM method and b) the SCM-Extraction method. The test apparatus consists of a superconducting magnet (SCM), a moving device, a specimen rod, a magnetic field sensor (hereafter H sensor), a magnetic dipole moment detection coil (hereafter M coil), measuring devices and a data processing device (PC).

The axis of the DC magnetic field generated by the SCM shall be vertical and coaxial with the M coil and the specimen rod so that the direction of magnetization is parallel to the axis of the specimen rod. The moving range of the test specimen shall be in a zone where the magnetic field strength is uniform with a tolerance of ±1 % at the centre of the SCM. The H sensor shall be placed in a position where the influence of the magnetic dipole moment of the test specimen can be ignored.

The test specimen shall be firmly attached at the bottom end of the specimen rod to avoid unexpected movement of the test specimen in the magnetic field and placed in the centre of the SCM as shown in Figure 2.



a) The SCM-VSM method **b) The SCM-Extraction method**

Figure 2 – Schematic diagrams of the test apparatus

The test specimen shall be initially magnetized to saturation (see 6.2) and be kept in the remanent state. A DC magnetic field shall be applied to the test specimen in the direction opposite to that used for the initial magnetization. The magnetic field strength is measured by the H sensor (see 4.3).

The magnetic dipole moment of the test specimen is detected by the voltage induced in the M coil due to the movement of the test specimen (see 4.4). The magnetic polarization of the test specimen is calculated from the magnetic dipole moment and the volume of the test specimen (see 7.2). For calibration aspects, see Clause 9.

There are two methods different in modes of the movement of the test specimen:

a) the SCM-VSM method: the test specimen is vibrated with a small amplitude in the M coil;

b) the SCM-Extraction method: the test specimen is extracted through the M coil.

The measurements shall be carried out at an ambient temperature of (23 ± 5) °C unless otherwise indicated.

NOTE The measurement at temperatures higher than the room temperature can be carried out using a heating unit (see Annex C).

For permanent magnet materials which are known to have significant temperature coefficients $\alpha(J_r)$ and $\alpha(H_{cJ})$, the temperature of the test specimen shall be controlled within ±1 °C in the range between 19 °C and 27 °C during the measurements (see IEC 60404-5). The temperature