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

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Introduction

This draft standard is based on national and international discussions. Your comments on this draft are invited and will assist in the preparation of the consequent standard.

For international standards, comments will be reviewed by the relevant UK national committee before sending the consensus UK vote and comments to the international committee, which will then decide appropriate action. If the international standard is approved, it is usual for the text to be published as a British Standard.

For national standards, comments will be reviewed by the relevant UK national committee and the resulting standards published as a British Standard.

UK Vote

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Submission of Comments

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Template for comments and secretariat observations

Date: xx/xx/20xx	Document: ISO/DIS xxxx
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1	2	(3)	4	5	(6)	7
MB	Clause No./ Subclause No./Annex (e.g. 3.1)	Paragraph/Figure/ Table/Note	Type of comment	Commend (justification for change) by the MB	Proposed change by the MB	Secretariat observations on each comment submitted
	3.1	Definition 1	ed	Definition is ambiguous and needs clarifying.	Amend to read '...so that the mains connector to which no connection...'	
	6.4	Paragraph 2	te	The use of the UV photometer as an alternative cannot be supported as serious problems have been encountered in its use in the UK.	Delete reference to UV photometer.	



68/757/CD

COMMITTEE DRAFT (CD)

PROJECT NUMBER:

IEC 60404-18 ED1

DATE OF CIRCULATION:

2023-12-01

CLOSING DATE FOR COMMENTS:

2024-02-23

SUPERSEDES DOCUMENTS:

68/735/CD, 68/744/CC

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 CD to the secretary.

FUNCTIONS CONCERNED:

☐ EMC

☐ ENVIRONMENT

☒ QUALITY ASSURANCE

☐ SAFETY

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Recipients of this document are invited to submit, with their comments, notification of any relevant patent rights of which they are aware and to provide supporting documentation.

Recipients of this document are invited to submit, with their comments, notification of any local regulations or technical reasons that may exist and should be considered should this proposal proceed, recognizing that failure to address such requirements could result in the need for new or existing "In Some Countries" clauses. (SEE [AC/22/2007](#) OR [NEW GUIDANCE DOC](#)).

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

NOTE FROM TC/SC OFFICERS:

Following the results of the discussions and comments on document 68/735/CD presented in 68/744/CC, the Project Leader and the Project Team have prepared this second CD of the project.

National Committees are invited to submit the comments of their experts

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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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IEC 60404-18 has been prepared by IEC technical committee 68: Magnetic alloys and steels. It is an International Standard.

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.

128 This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in
129 accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available
130 at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are
131 described in greater detail at www.iec.ch/publications.

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

134 The committee has decided that the contents of this document will remain unchanged until the
135 stability date indicated on the IEC website under webstore.iec.ch in the data related to the
136 specific document. At this date, the document will be

- 137 • reconfirmed,
- 138 • withdrawn,
- 139 • replaced by a revised edition, or
- 140 • amended.

141

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 $H_{cJ} \geq 1,6$ 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) is 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.

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.

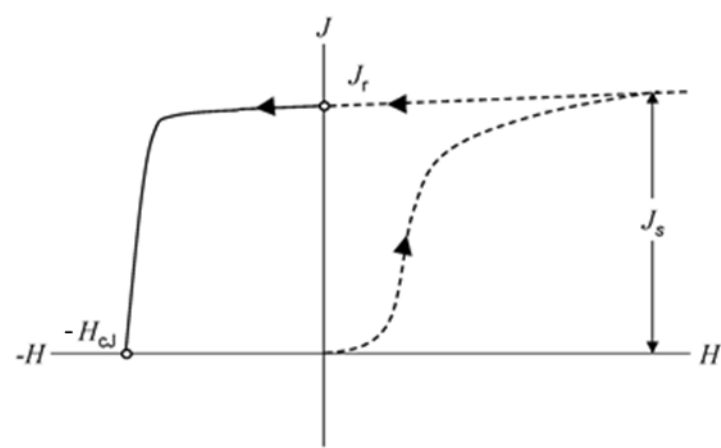
ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- 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 test apparatus shall be equipped with an open magnetic circuit.

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