

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

## EESTI STANDARDI EESSÕNA

## NATIONAL FOREWORD

See Eesti standard EVS-EN 60404-5:2015 sisaldab Euroopa standardi EN 60404-5:2015 ingliskeelset teksti.	This Estonian standard EVS-EN 60404-5:2015 consists of the English text of the European standard EN 60404-5:2015.
Standard on jõustunud sellekohase teate avaldamisega EVS Teatajas	This standard has been endorsed with a notification published in the official bulletin of the Estonian Centre for Standardisation.
Euroopa standardimisorganisatsioonid on teinud Euroopa standardi rahvuslikele liikmetele kättesaadavaks 29.05.2015.	Date of Availability of the European standard is 29.05.2015.
Standard on kättesaadav Eesti Standardikeskusest.	The standard is available from the Estonian Centre for Standardisation.

Tagasisidet standardi sisu kohta on võimalik edastada, kasutades EVS-i veebilehel asuvat tagasiside vormi või saates e-kirja meiliaadressile [standardiosakond@evs.ee](mailto:standardiosakond@evs.ee).

ICS 17.220.20, 29.030

Standardite reprodutseerimise ja levitamise õigus kuulub Eesti Standardikeskusele

Andmete paljundamine, taastekitamine, kopeerimine, salvestamine elektroonsesse süsteemi või edastamine ükskõik millises vormis või millisel teel ilma Eesti Standardikeskuse kirjaliku loata on keelatud.

Kui Teil on küsimusi standardite autorikaitse kohta, võtke palun ühendust Eesti Standardikeskusega:

Aru 10, 10317 Tallinn, Eesti; koduleht [www.evs.ee](http://www.evs.ee); telefon 605 5050; e-post [info@evs.ee](mailto:info@evs.ee)

The right to reproduce and distribute standards belongs to the Estonian Centre for Standardisation

No part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying, without a written permission from the Estonian Centre for Standardisation.

If you have any questions about copyright, please contact Estonian Centre for Standardisation:

Aru 10, 10317 Tallinn, Estonia; homepage [www.evs.ee](http://www.evs.ee); phone +372 605 5050; e-mail [info@evs.ee](mailto:info@evs.ee)

EUROPEAN STANDARD

**EN 60404-5**

NORME EUROPÉENNE

EUROPÄISCHE NORM

May 2015

ICS 17.220.20; 29.030

Supersedes EN 60404-5:2007

English Version

**Magnetic materials - Part 5: Permanent magnet (magnetically hard) materials - Methods of measurement of magnetic properties  
(IEC 60404-5:2015)**

Matériaux magnétiques - Partie 5: Aimants permanents (magnétiques durs) - Méthodes de mesure des propriétés magnétiques  
(IEC 60404-5:2015)

Magnetische Werkstoffe - Teil 5: Dauermagnet- (hartmagnetische) Werkstoffe - Verfahren zur Messung magnetischer Eigenschaften  
(IEC 60404-5:2015)

This European Standard was approved by CENELEC on 2015-05-21. CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the CEN-CENELEC Management Centre or to any CENELEC member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CENELEC member into its own language and notified to the CEN-CENELEC Management Centre has the same status as the official versions.

CENELEC members are the national electrotechnical committees of Austria, Belgium, Bulgaria, Croatia, Cyprus, the Czech Republic, Denmark, Estonia, Finland, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.



European Committee for Electrotechnical Standardization  
Comité Européen de Normalisation Electrotechnique  
Europäisches Komitee für Elektrotechnische Normung

**CEN-CENELEC Management Centre: Avenue Marnix 17, B-1000 Brussels**

## Foreword

The text of document 68/497/FDIS, future edition 3 of IEC 60404-5, prepared by IEC/TC 68 "Magnetic alloys and steels" was submitted to the IEC-CENELEC parallel vote and approved by CENELEC as EN 60404-5:2015.

The following dates are fixed:

- latest date by which the document has to be implemented at national level by publication of an identical national standard or by endorsement (dop) 2016-02-21
- latest date by which the national standards conflicting with the document have to be withdrawn (dow) 2018-05-21

This document supersedes EN 60404-5:2007.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CENELEC [and/or CEN] shall not be held responsible for identifying any or all such patent rights.

## Endorsement notice

The text of the International Standard IEC 60404-5:2015 was approved by CENELEC as a European Standard without any modification.

In the official version, for Bibliography, the following note has to be added for the standard indicated :

IEC 60404-8-1	NOTE	Harmonized as EN 60404-8-1.
---------------	------	-----------------------------

**Annex ZA**  
(normative)

**Normative references to international publications  
with their corresponding European publications**

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

NOTE 1 When 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](http://www.cenelec.eu).

<u>Publication</u>	<u>Year</u>	<u>Title</u>	<u>EN/HD</u>	<u>Year</u>
IEC 60050	series	International electrotechnical vocabulary	-	-

## CONTENTS

FOREWORD.....	3
INTRODUCTION.....	5
1 Scope.....	6
2 Normative references .....	6
3 Terms and definitions .....	6
4 Electromagnet and conditions for magnetization .....	6
4.1 General.....	6
4.2 Geometrical conditions .....	8
4.3 Electromagnetic conditions .....	8
5 Test specimen.....	9
6 Determination of the magnetic flux density .....	10
7 Determination of the magnetic polarization .....	10
8 Measurement of the magnetic field strength.....	11
9 Determination of the demagnetization curve .....	12
9.1 General.....	12
9.2 Principle of determination of the demagnetization curve, test specimen magnetized in the electromagnet .....	12
9.3 Principle of determination of the demagnetization curve, test specimen magnetized in a superconducting coil or pulse magnetizer .....	13
10 Determination of the principal characteristics.....	14
10.1 Remanent flux density .....	14
10.2 $(BH)_{\max}$ product.....	14
10.3 Coercivities $H_{CB}$ and $H_{CJ}$ .....	14
10.4 Determination of the recoil line and the recoil permeability.....	14
11 Reproducibility.....	15
12 Test report.....	15
Annex A (normative) Influence of the air-gap between the test specimen and the pole pieces.....	17
Annex B (informative) Influence of the ambient temperature on measurement results .....	18
Bibliography.....	19
Figure 1 – Demagnetization curve showing $(BH)_{\max}$ point.....	7
Figure 2 – Schematic diagram of electromagnet.....	8
Figure 3 – Measuring circuit (schematic).....	13
Figure 4 – Demagnetization curve and recoil loop.....	15
Figure A.1 – Air-gap.....	17
Table 1 – Reproducibility of the measurement of the magnetic characteristics of permanent magnet materials.....	15
Table A.1 – $dH$ ratios.....	17
Table B.1 – Temperature coefficients of $B_r$ and $H_{CJ}$ of permanent magnet materials.....	18

## INTRODUCTION

The previous edition of IEC 60404-5 was issued in October 1993 and amended in 2007. Since then, new applications of NdFeB sintered magnetic materials with intrinsic coercivity,  $H_{cJ}$ , higher than 2 MA/m for hybrid electric vehicles and fully electric vehicles have appeared. Thus, IEC TC68 decided in 2011 at their meeting in Ghent to revise IEC 60404-5.

For the measurement of the coercivity relating to polarization,  $H_{cJ}$ , at values higher than 2 MA/m and the measurement of magnetic properties at elevated temperatures, the methods described in the non-normative Technical Reports IEC TR 61807 and IEC TR 62331 can be considered.

The ambient temperature previously recommended was  $(23 \pm 5)$  °C. However, for permanent magnet materials such as NdFeB and hard ferrites that have large temperature coefficients, it is strongly recommended that the ambient temperature should be controlled within this range to  $\pm 1$  °C or better. It is desirable to apply this temperature recommendation for other hard magnet materials. This recommendation was already included in IEC 60404-5:1993/AMD1:2007.

This document is a preview generated by EVS

## MAGNETIC MATERIALS –

### Part 5: Permanent magnet (magnetically hard) materials – Methods of measurement of magnetic properties

#### 1 Scope

The purpose of this part of IEC 60404 is to define the method of measurement of the magnetic flux density, magnetic polarization and the magnetic field strength and also to determine the demagnetization curve and recoil line of permanent magnet materials, such as those specified in IEC 60404-8-1 [1]<sup>1</sup>, the properties of which are presumed homogeneous throughout their volume.

The performance of a magnetic system is not only dependent on the properties of the permanent magnet material but also on the dimensions of the system, the air-gap and other elements of the magnetic circuit. The methods described in this part of IEC 60404 refer to the measurement of the magnetic properties in a closed magnetic circuit.

#### 2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60050 (all parts), *International Electrotechnical Vocabulary* (available at <http://www.electropedia.org>)

#### 3 Terms and definitions

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

#### 4 Electromagnet and conditions for magnetization

##### 4.1 General

For permanent magnet materials, this part of IEC 60404 deals with both the coercivity  $H_{CB}$  (the coercivity relating to the magnetic flux density) and the intrinsic coercivity  $H_{cJ}$  (the coercivity relating to the magnetic polarization).

The measurements specified in this part of IEC 60404 are for both the magnetic flux density,  $B$ , and the magnetic polarization,  $J$ , as a function of the magnetic field strength,  $H$ . These quantities are related by the following equation:

$$B = \mu_0 H + J \quad (1)$$

---

<sup>1</sup> Numbers in square brackets refer to the Bibliography.