Magnetic materials - Part 15: Methods for the determination of the relative magnetic permeability of feebly magnetic materials (IEC 60404-15:2012)

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NATIONAL FOREWORD

See Eesti standard EVS-EN 60404-15:2012 sisaldab Euroopa standardi EN 60404-15:2012 ingliskeelset teksti.	This Estonian standard EVS-EN 60404-15:2012 consists of the English text of the European standard EN 60404-15:2012.
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 16.11.2012.	Date of Availability of the European standard is 16.11.2012.
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.

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Magnetic materials - Part 15: Methods for the determination of the relative magnetic permeability of feebly magnetic materials

(IEC 60404-15:2012)

Matériaux magnétiques - Partie 15: Méthodes de détermination de la perméabilité magnétique relative des matériaux faiblement magnétiques (CEI 60404-15:2012)

Magnetische Werkstoffe - Teil 15: Verfahren zur Bestimmung der Permeabilitätszahl schwachmagnetischer Werkstoffe (IEC 60404-15:2012)

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Foreword

The text of document 68/442/FDIS, future edition 1 of IEC 60404-15, prepared by IEC/TC 68 "Magnetic alloys and steels" was submitted to the IEC-CENELEC parallel vote and approved by CENELEC as EN 60404-15:2012.

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)	2013-07-23
• latest date by which the national standards conflicting with the document have to be withdrawn	(dow)	2015-10-23

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Endorsement notice

The text of the International Standard IEC 60404-15:2012 was approved by CENELEC as a European Standard without any modification.

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 When an international publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

Publication	Year	Title	EN/HD	Year
IEC 60050	Series	International electrotechnical vocabulary	-	-
ISO/IEC Guide 98-3	2008	Uncertainty of measurement - Part 3: Guide to the expression of uncertainty in measurement (GUM:1995)	-	-

CONTENTS

INTRODUCTION

The determination of the relative magnetic permeability of feebly magnetic materials is often required to assess their effect on the ambient magnetic field. Typical feebly magnetic materials are austenitic stainless steels and "non-magnetic" brass.

The relative magnetic permeability of some of these materials can vary significantly with the applied magnetic field strength. In the majority of cases, these materials find application in the ambient earth's magnetic field. This field in Europe is 35 A/m to 40 A/m, in the far East, it is 25 A/m to 35 A/m and in North America, it is 25 A/m to 35 A/m. However, at present, methods of measurement are not available to determine the relative magnetic permeability of feebly magnetic materials at such a low value of magnetic field strength.

Studies of the properties of feebly magnetic materials have been carried out, primarily with a view to the production of improved reference materials. These studies have shown [1][1] that it is possible to produce reference materials which have a substantially constant relative magnetic permeability over the range from the earth's magnetic field to at least a magnetic field strength of 100 kA/m.

Since conventional metallic materials can also be used as reference materials their relative magnetic permeability can be determined using the reference method. It is important that the magnetic field strength used during the determination of the relative magnetic permeability is stated for all materials but in particular for conventional materials since the changes with applied magnetic field can be large. This behaviour also needs to be considered when using reference materials made from conventional materials to calibrate comparator methods. This is because these methods use magnetic fields that vary through the volume of the material being tested and this makes it difficult to know the relative magnetic permeability to use for the calibration.

Where the effect of a feebly magnetic material on the ambient earth's magnetic field is critical, the direct measurement of this effect using a sensitive magnetometer should be considered.

1 Figures in square brackets refer to the bibliography.

MAGNETIC MATERIALS –

Part 15: Methods for the determination of the relative magnetic permeability of feebly magnetic materials

1 Scope

This part of IEC 60404 specifies a solenoid method, a magnetic moment method, a magnetic balance method and a permeability meter method for the determination of the relative magnetic permeability of feebly magnetic materials (including austenitic stainless steel). The magnetic balance and permeability meter methods are both comparison methods calibrated using reference materials to determine the value of the relative magnetic permeability of the test specimen. The relative magnetic permeability range for each of these methods is shown in Table 1. The methods given are for applied magnetic field strengths of between 5 kA/m and 100 kA/m.

Table 1 – Relative magnetic permeability ranges for the methods described

Measurement method	Relative magnetic permeability range
Solenoid	1,003 to 2
Magnetic moment	1,003 to 1,2
Magnetic balance	1,003 to 5
Permeability meter	1,003 to 2

NOTE 1 The relative magnetic permeability range given for the magnetic balance method covers the inserts provided with a typical instrument. These can only be assessed at values for which calibrated reference materials exist.

NOTE 2 For a relative magnetic permeability larger than 2, a reference material cannot be calibrated using this written standard. A note of this is given in the test report explaining that the values measured using the magnetic balance are for indication only.

The solenoid method is the reference method. The magnetic moment method described is used mainly for the measurement of the relative magnetic permeability of mass standards.

Two comparator methods used by industry are described. These can be calibrated using reference materials for which the relative magnetic permeability has been determined using the reference method. When suitable, the magnetic moment method can also be used. The dimensions of the reference material need to be given careful consideration when determining the uncertainty in the calibration value due to self-demagnetization effects. See Annex A for more information on correcting for self-demagnetization.

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/)

ISO/IEC Guide 98-3:2008, *Uncertainty of measurement – Part 3: Guide to the expression of uncertainty in measurement (GUM:1995)*

3 Terms and definitions

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

3.1
self-demagnetization
generation of a magnetic field within a magnetized body that opposes the magnetization

3.2
demagnetize
to bring a magnetic material to a magnetically neutral state

3.3
feebly magnetic material
material that is essentially non-magnetic in character

4 Solenoid and magnetic moment method

4.1 General

The methods that are described in Clause 4 are reference methods for determining the relative magnetic permeability of test specimens of feebly magnetic materials with a length to diameter ratio of at least 10:1. When the relative magnetic permeability is less than 1,2, it is possible to use a moment detection coil and a test specimen with a length to diameter ratio of 1:1. Both methods use similar equipment and involve similar calculations to determine the relative magnetic permeability. The descriptions of both methods are therefore presented together here with significant differences explained in the text.

4.2 Principle

The relative magnetic permeability of a feebly magnetic test specimen is determined from the magnetic polarization J and the corresponding magnetic field strength H measured using the circuit shown in Figure 1, using

$$\mu_r = 1 + \frac{J}{\mu_0 H} \tag{1}$$

where

μ_r is the relative magnetic permeability of the test specimen (ratio);

μ_0 is the magnetic constant ($4\pi \times 10^{-7}$) (in H/m);

J is the magnetic polarization (in T);

H is the magnetic field strength (as calculated from the magnetizing current and the magnetic field strength to current ratio (known as the coil constant) for the solenoid) (in A/m).