IEC 60404-12

Edition 2.0 2023-02

INTERNATIONAL STANDARD

NORME INTERNATIONALE

Magnetic materials –
Part 12: Methods of test for the assessment of the thermal endurance of surface insulation coatings on electrical steel strip and sheet

Matériaux magnétiques –
Partie 12: Méthodes d’essai pour l'évaluation de l’endurance thermique des revêtements isolants superficiels des bandes et tôles en acier électrique



IEC 60404-12:2023-02(en-fr)



THIS PUBLICATION IS COPYRIGHT PROTECTED

Copyright © 2023 IEC, Geneva, Switzerland

All rights reserved. Unless otherwise specified, no part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from either IEC or IEC's member National Committee in the country of the requester. If you have any questions about IEC copyright or have an enquiry about obtaining additional rights to this publication, please contact the address below or your local IEC member National Committee for further information.

Droits de reproduction réservés. Sauf indication contraire, aucune partie de cette publication ne peut être reproduite ni utilisée sous quelque forme que ce soit et par aucun procédé, électronique ou mécanique, y compris la photocopie et les microfilms, sans l'accord écrit de l'IEC ou du Comité national de l'IEC du pays du demandeur. Si vous avez des questions sur le copyright de l'IEC ou si vous désirez obtenir des droits supplémentaires sur cette publication, utilisez les coordonnées ci-après ou contactez le Comité national de l'IEC de votre pays de résidence.

IEC Secretariat
3, rue de Varembé
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
info@iec.ch
www.iec.ch

About the IEC
The International Electrotechnical Commission (IEC) is the leading global organization that prepares and publishes International Standards for all electrical, electronic and related technologies.

About IEC publications
The technical content of IEC publications is kept under constant review by the IEC. Please make sure that you have the latest edition, a corrigendum or an amendment might have been published.

IEC publications search - webstore.iec.ch/advsearchform
The advanced search enables to find IEC publications by a variety of criteria (reference number, text, technical committee, …). It also gives information on projects, replaced and withdrawn publications.

IEC Just Published - webstore.iec.ch/justpublished
Stay up to date on all new IEC publications. Just Published details all new publications released. Available online and once a month by email.

IEC Customer Service Centre - webstore.iec.ch/csc
If you wish to give us your feedback on this publication or need further assistance, please contact the Customer Service Centre: sales@iec.ch.

IEC Products & Services Portal - products.iec.ch
Discover our powerful search engine and read freely all the publications previews. With a subscription you will always have access to up to date content tailored to your needs.

Electropedia - www.electropedia.org
The world's leading online dictionary on electrotechnology, containing more than 22 300 terminological entries in English and French, with equivalent terms in 19 additional languages. Also known as the International Electrotechnical Vocabulary (IEV) online.

A propos de l'IEC
La Commission Electrotechnique Internationale (IEC) est la première organisation mondiale qui élabore et publie des Normes internationales pour tout ce qui a trait à l'électricité, à l'électronique et aux technologies apparentées.

A propos des publications IEC
Le contenu technique des publications IEC est constamment revu. Veuillez vous assurer que vous possédez l'édition la plus récente, un corrigendum ou amendement peut avoir été publié.

Recherche de publications IEC - webstore.iec.ch/advsearchform
La recherche avancée permet de trouver des publications IEC en utilisant différents critères (numéro de référence, texte, comité d'études, …). Elle donne aussi des informations sur les projets et les publications remplacées ou retirées.

IEC Just Published - webstore.iec.ch/justpublished
Restez informé sur les nouvelles publications IEC. Just Published détaille les nouvelles publications parues. Disponible en ligne et une fois par mois par email.

Service Clients - webstore.iec.ch/csc
Si vous désirez nous donner des commentaires sur cette publication ou si vous avez des questions contactez-nous: sales@iec.ch.

IEC Products & Services Portal - products.iec.ch
Découvrez notre puissant moteur de recherche et consultez gratuitement tous les aperçus des publications. Avec un abonnement, vous aurez toujours accès à un contenu à jour adapté à vos besoins.

Electropedia - www.electropedia.org
Le premier dictionnaire d'électrotechnologie en ligne au monde, avec plus de 22 300 articles terminologiques en anglais et en français, ainsi que les termes équivalents dans 19 langues additionnelles. Egalement appelé Vocabulaire Electrotechnique International (IEV) en ligne.

IEC 60404-12

Edition 2.0 2023-02

INTERNATIONAL STANDARD

NORME INTERNATIONALE

Magnetic materials –
Part 12: Methods of test for the assessment of the thermal endurance of surface insulation coatings on electrical steel strip and sheet

Matériaux magnétiques –
Partie 12: Méthodes d’essai pour l'évaluation de l’endurance thermique des revêtements isolants superficiels des bandes et tôles en acier électrique

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

COMMISSION
ELECTROTECHNIQUE
INTERNATIONALE

ICS 17.220.01; 29.030

ISBN 978-2-8322-6445-4

Warning! Make sure that you obtained this publication from an authorized distributor.
Attention! Veuillez vous assurer que vous avez obtenu cette publication via un distributeur agréé.

® Registered trademark of the International Electrotechnical Commission
Marque déposée de la Commission Electrotechnique Internationale

CONTENTS

FOREWORD 3
INTRODUCTION 5
1 Scope 6
2 Normative references 6
3 Terms and definitions 7
4 General principles 7
4.1 General 7
4.2 Preparation of clamped stacks of test specimens 7
4.2.1 Procedure of stacking test specimens 7
4.2.2 Clamping stacks for temperature ratings up to 500 °C 7
4.2.3 Clamping stacks for temperature ratings above 500 °C 8
4.3 Heat treatment 8
4.3.1 For time ratings up to 2 500 h 8
4.3.2 For continuous exposure 9
5 Standard temperature/time performance designations T/t 9
6 Method of the test for adhesion 9
6.1 General 9
6.2 Test specimens 9
6.3 Procedure of test 9
6.4 Test report 10
7 Method of the test for surface insulation resistance 10
7.1 General 10
7.2 Test specimens 10
7.3 Procedure of test 10
7.4 Test report 11
8 Method of the test for stacking factor 11
8.1 General 11
8.2 Test specimen 11
8.3 Procedure of test 11
8.4 Test report 11
Annex A (informative) Method of test for the assessment of the thermal endurance for continuous exposure to elevated temperatures 12
A.1 General 12
A.2 Procedure of test 12
A.3 Temperature/time performance designations T/t for continuous exposure 12
Bibliography 13

Figure 1 – Example of clamped stack for 100 mm square test specimens 8

INTERNATIONAL ELECTROTECHNICAL COMMISSION

_____

MAGNETIC MATERIALS –

Part 12: Methods of test for the assessment of the thermal endurance of surface insulation coatings on electrical steel strip and sheet

FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
6) All users should ensure that they have the latest edition of this publication.
7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

IEC 60404-12 has been prepared by IEC technical committee 68: Magnetic alloys and steels. It is an International Standard.

This second edition cancels and replaces the first edition published in 1992. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

a) the method of test for adhesion has been modified to match to the method of bend test specified in ISO 1519 using a cylindrical mandrel of 32 mm in diameter instead of the 30 mm diameter mandrel specified in the first edition;
b) the method of test for interlaminar insulation resistance has been modified to match to the method specified in IEC 60404-11 and the modified Franklin test has been removed;
c) the method of test for compressibility has been modified to match to the method of test for stacking factor specified in IEC 60404-13;

d) the concept of "resistance grades" has been removed;

e) the clamping pressure to be used at temperature ratings above 500 °C has been reduced to (0,01 ± 0,001) N/mm^2;

f) the testing for continuous exposure has been made a subject to an agreement between the manufacturer and the purchaser and the procedure has been moved to an informative Annex A.

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

Draft	Report on voting
68/698/CDV	68/720/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/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

The surface insulation coatings on electrical steel strip and sheet are sometimes exposed to elevated temperatures in service or during processing by the purchaser. Therefore, the thermal endurance of the surface insulation coating is important.

Physicochemical models postulated for the aging processes lead to the almost universal assumption of the Arrhenius equations to describe the rate of aging (see Annex A of this document and IEC 60216-1).

Since the measurement of the properties of surface insulation coatings at elevated temperatures is expensive and time-consuming, the thermal endurance of a coating is usually assessed by evaluating the change of a specified coating property, at an ambient temperature, due to a heat treatment.

MAGNETIC MATERIALS –

Part 12: Methods of test for the assessment of the thermal endurance of surface insulation coatings on electrical steel strip and sheet

1 Scope

This part of IEC 60404 is applicable to surface insulation coatings on electrical steel strip and sheet classified in IEC 60404-1-1.

This document defines the general principles and technical details of the tests for the assessment of the thermal endurance of surface insulation coatings on electrical steel strip and sheet.

The assessment is made by evaluating the change of a specified property of the surface insulation coating due to a heat treatment at a specified temperature up to 850 °C for a specified duration time up to 2 500 h. The specified property is measured at an ambient temperature of (23 ± 5) °C both without heat treatment and after heat treatment.

This document is applicable to the following properties of surface insulation coatings:

– adhesion;
– surface insulation resistance;
– stacking factor.

This document is not applicable to other properties of surface insulation coatings, e.g. welding properties, or to other effects, e.g. discoloration and off-gassing, which can be caused by exposure to elevated temperatures.

NOTE Some of the tests take a very long time to perform and therefore they are often not appropriate for acceptance tests of material supplied on a specific order.

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

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

IEC 60404-1-1, *Magnetic materials – Part 1-1: Classification – Surface insulations of electrical steel sheet, strip and laminations*

IEC 60404-11, *Magnetic materials – Part 11: Methods of measurement of the surface insulation resistance of electrical steel strip and sheet*

IEC 60404-13, *Magnetic materials – Part 13: Methods of measurement of resistivity, density and stacking factor of electrical steel strip and sheet*

ISO 1519, *Paints and varnishes – Bend test (cylindrical mandrel)*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60050-121, 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 https://www.electropedia.org/
- ISO Online browsing platform: available at https://www.iso.org/obp

3.1
temperature/time performance designation *T/t*
designation consisting of a temperature T, expressed in °C, and a duration of time t, expressed in hours, of a heat treatment that a surface insulation coating can withstand with respect to a specified coating property

EXAMPLE The designations 200/2500 and 800/2 mean that the surface insulation coating can withstand heat treatments at 200 °C for 2 500 h and 800 °C for 2 h, respectively, with respect to a specified coating property.

Note 1 to entry: This designation serves for rating of the thermal endurance of a surface insulation coating with respect to specified coating properties.

Note 2 to entry: More than one designation can be assigned to a coating.

4 General principles

4.1 General

The thermal endurance of a surface insulation coating shall be assessed by evaluating changes of specified coating properties due to a heat treatment at a specified temperature T °C for a specified duration time t h. The coating properties shall be measured at an ambient temperature of (23 ± 5) °C.

The thermal endurance for the following coating properties shall be assessed separately:

– adhesion;
– surface insulation resistance;
– stacking factor.

4.2 Preparation of clamped stacks of test specimens

4.2.1 Procedure of stacking test specimens

The test specimens shall be stacked between two similar sized or larger sheets made of the same material as the test specimens. The stack shall then be clamped between two steel pressure plates. The dimensions of the steel pressure plates shall be larger than the size of the part of the test specimens to be tested, e.g. it is permitted to clamp only the part of the test specimens that will be bent at the bend test (see 6.3).

4.2.2 Clamping stacks for temperature ratings up to 500 °C

The stack of test specimens shall be clamped homogeneously between the two steel pressure plates under a pressure of (1 ± 0,1) N/mm^2. Figure 1 illustrates an example of clamped stack for 100 mm square test specimens for temperature rating up to 500 °C.