

|            |   |  |
|------------|---|--|
| <b>STN</b> | <b>Točivé elektrické stroje<br/>Časť 2-3: Špecifické skúšobné metódy na<br/>určovanie strát a účinnosti striedavých motorov<br/>napájaných z meniča</b> | <b>STN<br/>EN IEC 60034-2-3</b><br><br>35 0000 |
|------------|---|--|

Rotating electrical machines - Part 2-3: Specific test methods for determining losses and efficiency of converter-fed AC motors

Táto norma obsahuje anglickú verziu európskej normy.  
This standard includes the English version of the European Standard.

Táto norma bola oznámená vo Vestníku ÚNMS SR č. 08/20

Obsahuje: EN IEC 60034-2-3:2020, IEC 60034-2-3:2020

**131443**

EUROPEAN STANDARD

**EN IEC 60034-2-3**

NORME EUROPÉENNE

EUROPÄISCHE NORM

May 2020

ICS 29.160.01

English Version

**Rotating electrical machines - Part 2-3: Specific test methods for determining losses and efficiency of converter-fed AC motors (IEC 60034-2-3:2020)**

Machines électriques tournantes - Partie 2-3: Méthodes d'essai spécifiques pour la détermination des pertes et du rendement des moteurs à courant alternatif alimentés par convertisseur  
(IEC 60034-2-3:2020)

Drehende elektrische Maschinen - Teil 2-3: Besondere Verfahren zur Bestimmung der Verluste und des Wirkungsgrades von umrichter gespeisten Wechselstrommaschinen  
(IEC 60034-2-3:2020)

This European Standard was approved by CENELEC on 2020-04-23. 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, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Norway, Poland, Portugal, Republic of North Macedonia, Romania, Serbia, 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: Rue de la Science 23, B-1040 Brussels**

**EN IEC 60034-2-3:2020 (E)****European foreword**

The text of document 2/1974/FDIS, future edition 1 of IEC 60034-2-3, prepared by IEC/TC 2 "Rotating machinery" was submitted to the IEC-CENELEC parallel vote and approved by CENELEC as EN IEC 60034-2-3:2020.

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) 2021-01-23
- latest date by which the national standards conflicting with the document have to be withdrawn (dow) 2023-04-23

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

**Endorsement notice**

The text of the International Standard IEC 60034-2-3:2020 was approved by CENELEC as a European Standard without any modification.

In the official version, for Bibliography, the following notes have to be added for the standards indicated:

|                      |      |   |
|----------------------|------|---|
| IEC/TS 60034-25:2014 | NOTE | Harmonized as CLC/TS 60034-25:— <sup>1</sup> (not modified) |
| IEC 61800-2:2015     | NOTE | Harmonized as EN 61800-2:2015 (not modified)                |
| IEC 61800-4:2002     | NOTE | Harmonized as EN 61800-4:2003 (not modified)                |

---

<sup>1</sup> To be published. Stage at the time of publication: CLC/prTS 60034-25:2017.

## Annex ZA (normative)

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

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.

NOTE 1 Where 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 60034-1        | 2017        | Rotating electrical machines - Part 1: Rating and performance  | -            | -           |
| IEC 60034-2-1      | 2014        | Rotating electrical machines - Part 2-1: Standard methods for determining losses and efficiency from tests (excluding machines for traction vehicles)  | EN 60034-2-1 | 2014        |
| IEC 61000-2-4      | 2002        | Electromagnetic compatibility (EMC) - Part 2-4: Environment - Compatibility levels in industrial plants for low-frequency conducted disturbances   | EN 61000-2-4 | 2002        |
| IEC 61800-9-2      | 2017        | Adjustable speed electrical power drive systems - Part 9-2: Ecodesign for power drive systems, motor starters, power electronics and their driven applications - Energy efficiency indicators for power drive systems and motor starters | EN 61800-9-2 | 2017        |



IEC 60034-2-3

Edition 1.0 2020-03

# INTERNATIONAL STANDARD

# NORME INTERNATIONALE



**Rotating electrical machines –  
Part 2-3: Specific test methods for determining losses and efficiency of  
converter-fed AC motors**

**Machines électriques tournantes –  
Partie 2-3: Méthodes d'essai spécifiques pour la détermination des pertes  
et du rendement des moteurs à courant alternatif alimentés par convertisseur**

**THIS PUBLICATION IS COPYRIGHT PROTECTED****Copyright © 2020 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 Central Office  
3, rue de Varembe  
CH-1211 Geneva 20  
Switzerland

Tel.: +41 22 919 02 11  
[info@iec.ch](mailto:info@iec.ch)  
[www.iec.ch](http://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](http://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](http://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](http://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](mailto:sales@iec.ch).

**Electropedia - [www.electropedia.org](http://www.electropedia.org)**

The world's leading online dictionary on electrotechnology, containing more than 22 000 terminological entries in English and French, with equivalent terms in 16 additional languages. Also known as the International Electrotechnical Vocabulary (IEV) online.

**IEC Glossary - [std.iec.ch/glossary](http://std.iec.ch/glossary)**

67 000 electrotechnical terminology entries in English and French extracted from the Terms and Definitions clause of IEC publications issued since 2002. Some entries have been collected from earlier publications of IEC TC 37, 77, 86 and CISPR.

**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](http://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](http://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](http://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](mailto:sales@iec.ch).

**Electropedia - [www.electropedia.org](http://www.electropedia.org)**

Le premier dictionnaire d'électrotechnologie en ligne au monde, avec plus de 22 000 articles terminologiques en anglais et en français, ainsi que les termes équivalents dans 16 langues additionnelles. Egalement appelé Vocabulaire Electrotechnique International (IEV) en ligne.

**Glossaire IEC - [std.iec.ch/glossary](http://std.iec.ch/glossary)**

67 000 entrées terminologiques électrotechniques, en anglais et en français, extraites des articles Termes et Définitions des publications IEC parues depuis 2002. Plus certaines entrées antérieures extraites des publications des CE 37, 77, 86 et CISPR de l'IEC.



IEC 60034-2-3

Edition 1.0 2020-03

# INTERNATIONAL STANDARD

# NORME INTERNATIONALE



**Rotating electrical machines –  
Part 2-3: Specific test methods for determining losses and efficiency of  
converter-fed AC motors**

**Machines électriques tournantes –  
Partie 2-3: Méthodes d'essai spécifiques pour la détermination des pertes  
et du rendement des moteurs à courant alternatif alimentés par convertisseur**

INTERNATIONAL  
ELECTROTECHNICAL  
COMMISSION

COMMISSION  
ELECTROTECHNIQUE  
INTERNATIONALE

ICS 29.160.01

ISBN 978-2-8322-7842-0

**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.**

## CONTENTS

|   |    |
|---|----|
| FOREWORD.....   | 4  |
| INTRODUCTION.....   | 6  |
| 1 Scope.....  | 8  |
| 2 Normative references .....  | 8  |
| 3 Terms and definitions .....   | 8  |
| 4 Symbols and abbreviated terms.....  | 9  |
| 5 Basic requirements.....   | 10 |
| 5.1 Instrumentation.....  | 10 |
| 5.1.1 General .....   | 10 |
| 5.1.2 Power analyser and transducers.....   | 10 |
| 5.1.3 Mechanical output of the motor.....   | 11 |
| 5.2 Converter set-up.....   | 11 |
| 5.2.1 General .....   | 11 |
| 5.2.2 Comparable converter set-up for rated voltages up to 1 kV.....  | 11 |
| 5.2.3 Testing with converters with rated voltages above 1 kV .....  | 12 |
| 5.2.4 Testing with other converters.....  | 12 |
| 6 Test method for the determination of the efficiency of converter-fed motors.....  | 12 |
| 6.1 Selection of determination method .....   | 12 |
| 6.2 Method 2-3-A – Direct measurement of input and output.....  | 13 |
| 6.2.1 Test set-up .....   | 13 |
| 6.2.2 Test procedure .....  | 13 |
| 6.2.3 Efficiency determination.....   | 13 |
| 6.2.4 Measurement at seven standardized operating points.....   | 14 |
| 6.3 Method 2-3-B – Summation of losses with determination of additional high frequency loss at converter supply at no-load operation..... | 14 |
| 6.3.1 General .....   | 14 |
| 6.3.2 Test set-up .....   | 14 |
| 6.3.3 Test procedure .....  | 14 |
| 6.3.4 Efficiency determination.....   | 15 |
| 6.4 2-3-C – Alternate Efficiency Determination Method (AEDM).....   | 15 |
| 6.5 2-3-D – Determination of efficiency by calculation.....   | 15 |
| 7 Interpolation of losses at any operating point.....   | 16 |
| 7.1 General.....  | 16 |
| 7.2 Interpolation procedure .....   | 16 |
| 7.3 Analytical determination of relative losses at any operating point.....   | 16 |
| 7.4 Additional losses due to frequency converter voltage drop.....  | 18 |
| 7.5 Alternate operating points to determine interpolation coefficients .....  | 18 |
| 7.6 Optional determination of interpolation error .....   | 19 |
| Annex A (informative) Losses of AC motors .....   | 21 |
| A.1 General.....  | 21 |
| A.2 Stator and rotor winding $I^2R$ losses $P_{LSR}$ ( $P_{LS} + P_{LR}$ ).....   | 21 |
| A.3 Iron losses ( $P_{Lfe}$ ).....  | 21 |
| A.4 Additional load losses ( $P_{LL}$ ) .....   | 22 |
| A.5 Friction and windage losses ( $P_{Lfw}$ ).....  | 22 |
| A.6 Additional high frequency losses ( $P_{LHL}$ ) .....  | 23 |



|   |    |
|---|----|
| Annex B (informative) Exemplary determination of losses and efficiency at various load points.....  | 24 |
| B.1 General.....  | 24 |
| B.2 Determination of the interpolation coefficients.....  | 24 |
| B.3 Calculation of losses and efficiency for certain operating points.....                          | 25 |
| Bibliography.....   | 27 |
| <br>  |    |
| Figure 1 – Standardized operating points.....   | 17 |
| <br>  |    |
| Table 1 – Preferred test methods.....   | 12 |
| Table 2 – Other test methods.....   | 13 |
| Table 3 – Normative operating points.....   | 17 |
| Table 4 – Non-normative alternate operating points.....   | 19 |
| Table A.1 – Recommended split of windage and friction losses for IC 411 self-ventilated motors..... | 22 |
| Table B.1 – Name plate data.....  | 24 |
| Table B.2 – Reference values.....   | 24 |
| Table B.3 – Losses for the 7 operating points.....  | 25 |
| Table B.4 – Interpolation coefficients.....   | 25 |
| Table B.5 – User-defined operating points.....  | 26 |
| Table B.6 – Calculated losses for the user-defined operating points.....                            | 26 |

## INTERNATIONAL ELECTROTECHNICAL COMMISSION

## ROTATING ELECTRICAL MACHINES –

**Part 2-3: Specific test methods for determining losses and efficiency of converter-fed AC motors**

## 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.

International Standard IEC 60034-2-3 has been prepared by IEC technical committee 2: Rotating machinery.

This first edition cancels and replaces IEC TS 60034-2-3, published in 2013.

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

|             |                  |
|-------------|------------------|
| FDIS        | Report on voting |
| 2/1974/FDIS | 2/1982/RVD       |

Full information on the voting for the approval of this International Standard can be found in the report on voting indicated in the above table.

This document has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts in the IEC 60034 series, published under the general title *Rotating electrical machines*, 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 "<http://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.

**IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.**

## INTRODUCTION

The objective of this document is to define test methods for determining total losses including additional high frequency motor losses and efficiency of converter-fed motors. Additional high frequency losses appear in addition to the losses on nominally sinusoidal power supply as determined by the methods of IEC 60034-2-1:2014. Results determined according to this document are intended to allow comparison of losses and efficiency of different motors when fed by converters.

Furthermore, the document gives seven standardized operating points to characterize the development of losses and efficiency across the whole torque/speed range. An interpolation procedure is provided to calculate losses and efficiency at any operating point (torque, speed).

In power-drive systems (PDS), the motor and the frequency converter are often manufactured by different suppliers. Motors of the same design are produced in large quantities. They may be operated from the grid or from frequency converters of many different types, supplied by many different manufacturers. The individual converter properties (switching frequency, DC link voltage level, etc.) will also influence the system efficiency. As it is impractical to determine motor losses for every combination of motor, frequency converter, connection cable, output filter and parameter settings, this document describes a limited number of approaches, depending on the voltage level and the rating of the machine under test.

The losses determined according to this document are not intended to represent the losses in the final application. They provide, however, an objective basis for comparing different motor designs with respect to suitability for converter operation.

In general, when fed from a converter, motor losses are higher than during operation on a nominally sinusoidal system. The additional high frequency losses depend on the harmonic spectrum of the impressed converter output quantity (either current or voltage) which is influenced by its circuitry and control method. For further information, see IEC TS 60034-25:2014.

It is not the purpose of this document to define test procedures either for power drive systems or for frequency converters alone.

### **Comparable converter**

Latest experience and theoretical analysis have shown that the additional high frequency motor losses generally do not increase much with load. The methods in this document are mainly based on supplies from converters with pulse width modulation (PWM).

With respect to these types of converters and the growing need for verification of compliance with national energy efficiency regulations, this document defines a so-called comparable converter for testing of low voltage motors.

In principle, the comparable converter is a voltage source with a typical high frequency harmonic content supplying the machine under test. It is not applicable to medium voltage motors.

### **Limitations for the application of the comparable converter**

It has to be noted that the test method with the comparable converter described herein is a standardized method intended to give comparable efficiency figures for standardized test conditions. A motor ranking with respect to suitability for converter operation may be derived, but it is not equivalent to determining of the actual motor losses for operation with a specific converter which requires a test of the whole power drive system (PDS) with the specific converter used in the final application.

Deviations are also expected for motors driven by multi-level voltage source or current source converters where the additional high frequency motor losses differ much more depending on speed and load than for two-level voltage source converters. Hence the determination of losses and efficiency should preferably use procedures where the motor is operated together with the same converter with which it is driven in service.

Another option is the determination of the additional high frequency motor losses by calculation. If this is requested by the customer, the pulse pattern of the converter is required. Such procedures are not part of this document.

The provided interpolation procedure for the determination of losses and efficiency at any operating point (torque, speed) is limited to the base speed range (constant torque range, constant flux range).

## ROTATING ELECTRICAL MACHINES –

### Part 2-3: Specific test methods for determining losses and efficiency of converter-fed AC motors

#### 1 Scope

This part of IEC 60034 specifies test methods and an interpolation procedure for determining losses and efficiencies of converter-fed motors within the scope of IEC 60034-1:2017. The motor is then part of a variable frequency power drive system (PDS) as defined in IEC 61800-9-2:2017.

Applying the approach of the comparable converter, the motor efficiency determined by use of this document is applicable for comparison of different motor designs only.

The document also specifies procedures to determine motor losses at any load point (torque, speed) within the base speed range (constant torque range, constant flux range) based on determination of losses at seven standardized load points. This procedure is applicable to any variable speed AC motor (induction and synchronous) rated according to IEC 60034-1:2017 for operation on a variable frequency and variable voltage power supply.

#### 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 60034-1:2017, *Rotating electrical machines – Part 1: Rating and performance*

IEC 60034-2-1:2014, *Rotating electrical machines – Part 2-1: Standard methods for determining losses and efficiency from tests (excluding machines for traction vehicles)*

IEC 61000-2-4:2002, *Electromagnetic compatibility (EMC) – Part 2-4: Environment – Compatibility levels in industrial plants for low-frequency conducted disturbances*

IEC 61800-9-2:2017, *Adjustable speed electrical power drive systems – Part 9-2: Ecodesign for power drive systems, motor starters, power electronics and their driven applications – Energy efficiency indicators for power drive systems and motor starters*

**koniec náhľadu – text ďalej pokračuje v platenej verzii STN**