

© Copyright SEK Svensk Elstandard. Reproduction in any form without permission is prohibited.

Roterande elektriska maskiner – Del 2-1: Bestämning av förluster och verkningsgrad hos elektriska maskiner – Provningsmetoder (exklusive motorer för traktionsfordon)

Rotating electrical machines –

*Part 2-1: Standard methods for determining losses and efficiency from tests
(excluding machines for traction vehicles)*

Som svensk standard gäller europastandarden EN IEC 60034-2-1:2024. Den svenska standarden innehåller den officiella engelska språkversionen av EN IEC 60034-2-1:2024.

Nationellt förord

Europastandarden EN IEC 60034-2-1:2024

består av:

- **europastandardens ikraftsättningsdokument**, utarbetat inom CENELEC
- **IEC 60034-2-1, Third edition, 2024 - Rotating electrical machines – Part 2-1: Standard methods for determining losses and efficiency from tests (excluding machines for traction vehicles)**

utarbetad inom International Electrotechnical Commission, IEC.

Tidigare fastställd svensk standard SS-EN 60034-2-1, utg 2:2014 med eventuella tillägg, ändringar och rättelser gäller ej fr o m 2027-04-16.

Standarder underlättar utvecklingen och höjer elsäkerheten

Det finns många fördelar med att ha gemensamma tekniska regler för bl a mätning, säkerhet och provning och för utförande, skötsel och dokumentation av elprodukter och elanläggningar.

Genom att utforma sådana standarder blir säkerhetsfordringar tydliga och utvecklingskostnaderna rimliga samtidigt som marknadens acceptans för produkten eller tjänsten ökar.

Många standarder inom elområdet beskriver tekniska lösningar och metoder som åstadkommer den elsäkerhet som föreskrivs av svenska myndigheter och av EU.

SEK är Sveriges röst i standardiseringsarbetet inom elområdet

SEK Svensk Elstandard svarar för standardiseringen inom elområdet i Sverige och samordnar svensk medverkan i internationell och europeisk standardisering. SEK är en ideell organisation med frivilligt deltagande från svenska myndigheter, företag och organisationer som vill medverka till och påverka utformningen av tekniska regler inom elektrotekniken.

SEK samordnar svenska intressenters medverkan i SEKs tekniska kommittéer och stödjer svenska experters medverkan i internationella och europeiska projekt.

Stora delar av arbetet sker internationellt

Utformningen av standarder sker i allt väsentligt i internationellt och europeiskt samarbete. SEK är svensk nationalkommitté av International Electrotechnical Commission (IEC) och Comité Européen de Normalisation Electrotechnique (CENELEC).

Standardiseringsarbetet inom SEK är organiserat i referensgrupper bestående av ett antal tekniska kommittéer som speglar hur arbetet inom IEC och CENELEC är organiserat.

Arbetet i de tekniska kommittéerna är öppet för alla svenska organisationer, företag, institutioner, myndigheter och statliga verk. Den årliga avgiften för deltagandet och intäkter från försäljning finansierar SEKs standardiseringsverksamhet och medlemsavgift till IEC och CENELEC.

Var med och påverka!

Den som deltar i SEKs tekniska kommittéarbete har möjlighet att påverka framtida standarder och får tidig tillgång till information och dokumentation om utvecklingen inom sitt teknikområde. Arbetet och kontakterna med kollegor, kunder och konkurrenter kan gynnsamt påverka enskilda företags affärsutveckling och bidrar till deltagarnas egen kompetensutveckling.

Du som vill dra nytta av dessa möjligheter är välkommen att kontakta SEKs kansli för mer information.

SEK Svensk Elstandard

Box 1042
172 21 Sundbyberg
Tel 08-444 14 00
elstandard.se

English Version

Rotating electrical machines - Part 2-1: Standard methods for
determining losses and efficiency from tests (excluding
machines for traction vehicles)
(IEC 60034-2-1:2024)

Machines électriques tournantes - Partie 2-1: Méthodes
normalisées pour la détermination des pertes et du
rendement à partir d'essais (à l'exclusion des machines
pour véhicules de traction)
(IEC 60034-2-1:2024)

Drehende elektrische Maschinen - Teil 2-1:
Standardverfahren zur Bestimmung der Verluste und des
Wirkungsgrades aus Prüfungen (ausgenommen Maschinen
für Schienen- und Straßenfahrzeuge)
(IEC 60034-2-1:2024)

This European Standard was approved by CENELEC on 2024-04-16. 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, Türkiye 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

European foreword

The text of document 2/2165/FDIS, future edition 3 of IEC 60034-2-1, prepared by IEC/TC 2 "Rotating machinery" was submitted to the IEC-CENELEC parallel vote and approved by CENELEC as EN IEC 60034-2-1:2024.

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) 2025-01-16
- latest date by which the national standards conflicting with the document have to be withdrawn (dow) 2027-04-16

This document supersedes EN 60034-2-1:2014 and all of its amendments and corrigenda (if any).

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.

This document has been prepared under a standardization request addressed to CENELEC by the European Commission. The Standing Committee of the EFTA States subsequently approves these requests for its Member States.

Any feedback and questions on this document should be directed to the users' national committee. A complete listing of these bodies can be found on the CENELEC website.

Endorsement notice

The text of the International Standard IEC 60034-2-1:2024 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 standard indicated:

IEC 60034-2-2 NOTE Approved as EN 60034-2-2

IEC 60034-2-3 NOTE Approved as EN IEC 60034-2-3

IEC 60072-1 NOTE Approved as EN IEC 60072-1

IEC 60085 NOTE Approved as EN 60085

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.

<u>Publication</u>	<u>Year</u>	<u>Title</u>	<u>EN/HD</u>	<u>Year</u>
IEC 60027-1	-	Letters symbols to be used in electrical technology - Part 1: General	EN 60027-1	-
IEC 60034-1	2022	Rotating electrical machines - Part 1: Rating and performance	EN IEC 60034-1	— ¹
IEC 60034-4-1	2018	Rotating electrical machines - Part 4-1: Methods for determining electrically excited synchronous machine quantities from tests	EN IEC 60034-4-1	2018
IEC 60034-19	-	Rotating electrical machines - Part 19: Specific test methods for d.c. machines on conventional and rectifier-fed supplies	EN 60034-19	-
IEC 60034-29	-	Rotating electrical machines - Part 29: Equivalent loading and superposition techniques - Indirect testing to determine temperature rise	EN 60034-29	-
IEC 60034-30-1	-	Rotating electrical machines - Part 30-1: Efficiency classes of line operated AC motors (IE code)	EN 60034-30-1	-
IEC 60051	series	Direct acting indicating analogue electrical measuring instruments and their accessories	EN 60051	series
IEC 60051-1	-	Direct acting indicating analogue electrical measuring instruments and their accessories - Part 1: Definitions and general requirements common to all parts	EN 60051-1	-

¹ To be published. Stage at time of publication: FprEN IEC 60034-1:2021.

INTERNATIONAL STANDARD

NORME INTERNATIONALE

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

**Machines électriques tournantes –
Partie 2-1: Méthodes normalisées pour la détermination des pertes et du
rendement à partir d'essais (à l'exclusion des machines pour véhicules de
traction)**

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

COMMISSION
ELECTROTECHNIQUE
INTERNATIONALE

ICS 29.160.01

ISBN 978-2-8322-8170-3

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	5
1 Scope	7
2 Normative references	7
3 Terms and definitions	8
4 Symbols and abbreviated terms	13
4.1 Symbols	13
4.2 Additional subscripts	14
5 Basic requirements	15
5.1 Direct and indirect efficiency determination	15
5.2 Uncertainty	15
5.3 Preferred methods and methods for customer-specific acceptance tests, field-tests or routine-tests	15
5.4 Power supply	16
5.4.1 Voltage	16
5.4.2 Frequency	16
5.5 Instrumentation	16
5.5.1 General	16
5.5.2 Measuring instruments for electrical quantities	16
5.5.3 Torque measurement	16
5.5.4 Speed and frequency measurement	17
5.5.5 Temperature measurement	17
5.6 Units	17
5.7 Resistance	17
5.7.1 Test resistance	17
5.7.2 Winding temperature	18
5.7.3 Correction to reference coolant temperature	18
5.8 State of the machine under test and test categories	19
5.9 Excitation circuit measurements	20
5.10 Ambient temperature during testing	20
6 Test methods for the determination of the efficiency of induction machines	20
6.1 Preferred testing methods	20
6.1.1 General	20
6.1.2 Method 2-1-1A – Direct measurement of input and output	21
6.1.3 Method 2-1-1B – Summation of losses, additional load losses according to the method of residual loss	23
6.1.4 Method 2-1-1C – Summation of losses with additional load losses from assigned allowance	31
6.2 Testing methods for field or routine-testing	35
6.2.1 General	35
6.2.2 Method 2-1-1D – Dual supply back-to-back-test	36
6.2.3 Method 2-1-1E – Single supply back-to-back-test	37
6.2.4 Method 2-1-1F – Summation of losses with additional load losses determined by test with rotor removed and reverse rotation test	38
6.2.5 Method 2-1-1G – Summation of losses with additional load losses determined by Eh-star method	42
6.2.6 Method 2-1-1H – Determination of efficiency by use of the equivalent circuit parameters	46
7 Test methods for the determination of the efficiency of synchronous machines	52

7.1	Preferred testing methods	52
7.1.1	General	52
7.1.2	Method 2-1-2A – Direct measurement of input and output.....	53
7.1.3	Method 2-1-2B – Summation of separate losses with a rated load temperature test and a short circuit test.....	54
7.1.4	Method 2-1-2C – Summation of separate losses without a full load test	60
7.2	Testing methods for field or routine testing	62
7.2.1	General	62
7.2.2	Method 2-1-2D – Dual supply back-to-back-test.....	62
7.2.3	Method 2-1-2E – Single supply back-to-back-test	63
7.2.4	Method 2-1-2F – Zero power factor test with excitation current from Potier-, ASA- or Swedish-diagram	65
7.2.5	Method 2-1-2G – Summation of separate losses with a load test without consideration of additional load losses	69
8	Test methods for the determination of the efficiency of DC machines	70
8.1	Testing methods for field or routine testing	70
8.2	Method 2-1-3A – Direct measurement of input and output.....	71
8.2.1	General	71
8.2.2	Test procedure	72
8.2.3	Efficiency determination.....	72
8.3	Method 2-1-3B – Summation of losses with a load test and DC component of additional load losses from test.....	73
8.3.1	General	73
8.3.2	Test procedure	74
8.4	Method 2-1-3C – Summation of losses with a load test and DC component of additional load losses from assigned value	80
8.4.1	General	80
8.4.2	Test procedure	81
8.4.3	Efficiency determination.....	82
8.5	Method 2-1-3D – Summation of losses without a load test	83
8.5.1	General	83
8.5.2	Test procedure	84
8.5.3	Efficiency determination.....	85
8.6	Method 2-1-3E – Single supply back-to-back test.....	86
8.6.1	General	86
8.6.2	Test procedure	86
8.6.3	Efficiency determination.....	87
Annex A (normative)	Calculation of values for the Eh-star method	88
Annex B (informative)	Types of excitation systems	91
Annex C (informative)	Induction machine slip measurement.....	92
Annex D (informative)	Test report template for method 2-1-1B.....	94
Bibliography		95
Figure 1	– Torque measuring devices	17
Figure 2	– Sketch for torque measurement test.....	21
Figure 3	– Efficiency determination according to method 2-1-1A	22
Figure 4	– Efficiency determination according to method 2-1-1B	24
Figure 5	– Smoothing of the residual loss data.....	30

Figure 6 – Efficiency determination according to method 2-1-1C	32
Figure 7 – Vector diagram for obtaining current vector from reduced voltage test	33
Figure 8 – Assigned allowance for additional load losses P_{LL}	34
Figure 9 – Efficiency determination according to method 2-1-1D	36
Figure 10 – Sketch for dual supply back-to-back test	36
Figure 11 – Efficiency determination according to method 2-1-1E	37
Figure 12 – Efficiency determination according to method 2-1-1F	39
Figure 13 – Efficiency determination according to method 2-1-1G	43
Figure 14 – Eh-star test circuit	44
Figure 15 – Induction machine, T-model with equivalent iron loss resistor	46
Figure 16 – Efficiency determination according to method 2-1-1H	47
Figure 17 – Induction machines, reduced model for calculation	50
Figure 18 – Sketch for torque measurement test	53
Figure 19 – Efficiency determination according to method 2-1-2A	53
Figure 20 – Efficiency determination according to method 2-1-2B	55
Figure 21 – Efficiency determination according to method 2-1-2C	61
Figure 22 – Efficiency determination according to method 2-1-2D	62
Figure 23 – Sketch for dual supply back-to-back test ($I_M = I_G, f_M = f_G$)	63
Figure 24 – Efficiency determination according to method 2-1-2E	64
Figure 25 – Single supply back-to-back test for synchronous machines	64
Figure 26 – Efficiency determination according to method 2-1-2F	65
Figure 27 – Efficiency determination according to method 2-1-2G	70
Figure 28 – Sketch for torque measurement test	71
Figure 29 – Efficiency determination according to method 2-1-3A	72
Figure 30 – Efficiency determination according to method 2-1-3B	74
Figure 31 – Sketch for single supply back-to-back test for determination of DC component of additional load losses	78
Figure 32 – Efficiency determination according to method 2-1-3C	81
Figure 33 – Efficiency determination according to method 2-1-3D	84
Figure 34 – Efficiency determination according to method 2-1-3E	86
Figure 35 – Sketch for single supply back-to-back test	86
Figure C.1 – Slip measurement system block diagram	93
Table 1 – Reference temperature	18
Table 2 – Induction machines: preferred testing methods	21
Table 3 – Induction machines: other methods	36
Table 4 – Synchronous machines with electrical excitation: preferred testing methods	52
Table 5 – Synchronous machines with permanent magnets: preferred testing methods	52
Table 6 – Synchronous machines: other methods	62
Table 7 – DC machines: test methods	71
Table 8 – Multiplying factors for different speed ratios	82

INTERNATIONAL ELECTROTECHNICAL COMMISSION

ROTATING ELECTRICAL MACHINES –

**Part 2-1: Standard methods for determining losses and efficiency
from tests (excluding machines for traction vehicles)**

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) IEC draws attention to the possibility that the implementation of this document may involve the use of (a) patent(s). IEC takes no position concerning the evidence, validity or applicability of any claimed patent rights in respect thereof. As of the date of publication of this document, IEC had not received notice of (a) patent(s), which may be required to implement this document. However, implementers are cautioned that this may not represent the latest information, which may be obtained from the patent database available at <https://patents.iec.ch>. IEC shall not be held responsible for identifying any or all such patent rights.

IEC 60034-2-1 has been prepared by IEC technical committee 2: Rotating machinery. It is an International Standard.

This third edition cancels and replaces the second edition of IEC 60034-2-1 published in 2014. This edition constitutes a technical revision.

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

Harmonization of layout and requirements with IEC 60034-2-2 and IEC 60034-2-3.

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

Draft	Report on voting
2/2165/FDIS	2/2177/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.

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 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 webstore.iec.ch in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn, or
- revised.

ROTATING ELECTRICAL MACHINES –

Part 2-1: Standard methods for determining losses and efficiency from tests (excluding machines for traction vehicles)

1 Scope

This part of IEC 60034 is intended to establish methods of determining efficiencies from tests, and also to specify methods of obtaining specific losses.

This document applies to DC machines and to AC synchronous and induction machines of all sizes within the scope of IEC 60034-1 rated for mains operation.

NOTE These methods may be applied to other types of machines such as rotary converters, AC commutator motors and single-phase induction motors.

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 60027-1, *Letter symbols to be used in electrical technology – Part 1: General*

IEC 60034-1:2022, *Rotating electrical machines – Part 1: Rating and performance*

IEC 60034-4-1:2018, *Rotating electrical machines – Part 4-1: Methods for determining electrically excited synchronous machine quantities from tests*

IEC 60034-19, *Rotating electrical machines – Part 19: Specific test methods for DC machines on conventional and rectifier-fed supplies*

IEC 60034-29, *Rotating electrical machines – Part 29: Equivalent loading and superposition techniques – Indirect testing to determine temperature rise*

IEC 60034-30-1, *Rotating electrical machines – Part 30-1: Efficiency classes of line operated AC motors (IE code)*

IEC 60051(all parts), *Direct acting indicating analogue electrical measuring instruments and their accessories*

IEC 60051-1, *Direct acting indicating analogue electrical measuring instruments and their accessories – Part 1: Definitions and general requirements common to all parts*