BSI Standards Publication

Rotating electrical machines

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

Documents
Document Sharing Hub

Full document details: BS EN IEC 60034-2-1:2024

National foreword

This British Standard is the UK implementation of EN IEC 60034-2-1:2024. It is identical to IEC 60034-2-1:2024. It supersedes BS EN 60034-2-1:2014, which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee PEL/2, Rotating electrical machinery.

A list of organizations represented on this committee can be obtained on request to its committee manager.

Contractual and legal considerations

This publication has been prepared in good faith, however no representation, warranty, assurance or undertaking (express or implied) is or will be made, and no responsibility or liability is or will be accepted by BSI in relation to the adequacy, accuracy, completeness or reasonableness of this publication. All and any such responsibility and liability is expressly disclaimed to the full extent permitted by the law.

This publication is provided as is, and is to be used at the recipient's own risk.

The recipient is advised to consider seeking professional guidance with respect to its use of this publication.

This publication is not intended to constitute a contract. Users are responsible for its correct application.

© The British Standards Institution 2024
Published by BSI Standards Limited 2024

ISBN 978 0 539 15860 1

ICS 29.160.01

Compliance with a British Standard cannot confer immunity from legal obligations.

This British Standard was published under the authority of the Standards Policy and Strategy Committee on 30 April 2024.

Amendments/corrigenda issued since publication

Date	Text affected

Documents
Document Sharing Hub

Full document details: BS EN IEC 60034-2-1:2024

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN IEC 60034-2-1

April 2024

ICS 29.160.01

Supersedes EN 60034-2-1:2014

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

© 2024 CENELEC All rights of exploitation in any form and by any means reserved worldwide for CENELEC Members.

Ref. No. EN IEC 60034-2-1:2024 E

Documents
Document Sharing Hub

Full document details: BS EN IEC 60034-2-1:2024

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

Documents
Document Sharing Hub

Full document details: BS EN IEC 60034-2-1:2024

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.cencenelec.eu.

Publication	Year	Title	EN/HD	Year
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.

Documents
Document Sharing Hub

Full document details: BS EN IEC 60034-2-1:2024

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

AVA Documents
Document Sharing Hub

Full document details: BS EN IEC 60034-2-1:2024

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

AVA Documents
Document Sharing Hub
Full document details: BS EN IEC 60034-2-1:2024

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

Documents
Document Sharing Hub
Full document details: BS EN IEC 60034-2-1:2024

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.

Documents
Document Sharing Hub

Full document details: BS EN IEC 60034-2-1:2024

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.

Documents
Document Sharing Hub

Full document details: BS EN IEC 60034-2-1:2024

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*

AVA Documents
Document Sharing Hub

Full document details: BS EN IEC 60034-2-1:2024

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60034-1, IEC 60051-1 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

3.1
efficiency
ratio of output power to input power expressed in the same units and usually given as a percentage

3.2
direct efficiency determination
method by which the determination of efficiency is made by measuring directly the input power and the output power

3.3
dual-supply back-to-back test
test in which two identical machines are mechanically coupled together, and the total losses of both machines are calculated from the difference between the electrical input to one machine and the electrical output of the other machine

3.4
indirect efficiency determination
method by which the determination of efficiency is made by measuring the input power or the output power and determining the total losses. Those losses are added to the output power, thus giving the input power, or subtracted from the input power, thus giving the output power

3.5
single-supply back-to-back test
test in which two identical machines are mechanically coupled together and are both connected electrically to the same power system. The total losses of both machines are taken as the input power drawn from the system

3.6
no-load test
test in which a machine is run as a motor providing no useful mechanical output from the shaft, or if run as a generator with its terminals open-circuited

3.7
zero power factor test
no-load test on a synchronous machine, which is over-excited and operates at a power factor very close to zero

3.8
equivalent circuit method
test on an induction machine in which the losses are determined by help of an equivalent circuit model

Documents
Document Sharing Hub
Full document details: BS EN IEC 60034-2-1:2024

3.9
test with rotor removed and reverse rotation test
combined test on an induction machine in which the additional load losses are determined from a test with rotor removed and a test with the rotor running in reverse direction to the rotating magnetic field of the stator

3.10
short-circuit test
test on a synchronous machine in which a machine is run as a generator with its terminals short-circuited

3.11
locked rotor test
test in which the rotor is locked to prevent rotation

3.12
Eh-star test
test in which the motor is run in star connection on unbalanced voltage

3.13
losses

3.13.1
total losses
P_T
difference between the input power and the output power, equivalent to the sum of the constant losses (see 3.13.2), the load losses (see 3.13.4), the additional load losses (see 3.13.5) and the excitation circuit losses (see 3.13.3)

3.13.2
constant losses
P_c
losses incorporating the sum of windage, friction and iron losses

Note 1 to entry: Although these losses change with voltage and load, they are historically called “constant” losses and the name is retained in this document.

3.13.2.1
iron losses
P_{fe}
losses in active iron and additional no-load losses in other magnetic and conductive parts

3.13.2.2
friction and windage losses
P_{fw}
losses incorporating the sum of windage and friction

3.13.2.2.1
friction losses
losses due to friction (bearings and brushes, if not lifted at rated conditions) not including any losses in a separate lubricating system

AVA Documents
Document Sharing Hub
Full document details: BS EN IEC 60034-2-1:2024

3.13.2.2.2
windage losses
total losses due to aerodynamic friction in all parts of the machine, including power absorbed in shaft mounted fans, and in auxiliary machines forming an integral part of the machine

Note 1 to entry: Losses in a separate ventilating system should be listed separately.

Note 2 to entry: For machines indirectly or directly cooled by hydrogen, see IEC 60034-1.

3.13.3
excitation circuit losses

3.13.3.1
excitation circuit losses
P_e
sum of the excitation winding losses (see 3.13.3.2), the exciter losses (see 3.13.3.3) and, for synchronous machines, electrical brush loss (see 3.13.3.5), if any

3.13.3.2
excitation winding losses
P_f
excitation (field) winding losses are equal to the product of the exciting current I_e and the excitation voltage U_e

3.13.3.3
exciter losses
P_{Ed}
exciter losses for the different excitation systems (see Annex B) are defined as follows:

a) shaft driven exciter

exciter losses are the power absorbed by the exciter at its shaft (reduced by friction and windage losses) plus the power P_{1E} drawn from a separate source at its excitation winding terminals, minus the useful power which the exciter provides at its terminals. The useful power at the terminals of the exciter is equal to the excitation winding losses as per 3.13.3.2 plus (in the case of a synchronous machine) the electrical brush losses as per 3.13.3.5.

Note 1 to entry: If the exciter can be decoupled and tested separately its losses can be determined according to 7.1.3.2.1.5.

Note 2 to entry: Whenever the exciter makes use of separate auxiliary supplies, their consumptions are to be included in the exciter losses unless they are considered together with the main machine auxiliaries consumption.

b) brushless exciter

exciter losses are the power absorbed by the exciter at its shaft, reduced by friction and windage losses (when the relevant test is performed on the set of main machine and exciter), plus the electrical power P_{1E} from a separate source (if any) absorbed by its field winding or its stator winding (in the case of an induction exciter), minus the useful power which the exciter provides at the rotating power converter terminals.

Note 3 to entry: Whenever the exciter makes use of separate auxiliary supplies their consumptions are to be included in the exciter losses unless they are considered together with the main machine auxiliaries consumption.

Note 4 to entry: If the exciter can be decoupled and tested separately, its losses can be determined according to 7.1.3.2.1.

c) separate rotating exciter

exciter losses are the difference between the power absorbed by the driving motor, plus the power absorbed by separate auxiliary supplies, of both driving and driven machines, including the power supplied by separate source to their excitation winding terminals, and the excitation power supplied as per 3.13.3.2 and 3.13.3.4. The exciter losses may be determined according to 7.1.3.2.1.

Documents
Document Sharing Hub
Full document details: BS EN IEC 60034-2-1:2024

d) static excitation system

static exciter

excitation system losses are the difference between the electrical power drawn from its power source, plus the power absorbed by separate auxiliary supplies, and the excitation supplied as per 3.13.3.2 and 3.13.3.4.

Note 5 to entry: In the case of systems fed by transformers, the transformer losses shall be included in the exciter losses.

e) excitation from auxiliary winding

auxiliary winding exciter

exciter losses are the copper losses in the auxiliary (secondary) winding and the additional iron losses produced by increased flux harmonics. The additional iron losses are the difference between the losses which occur when the auxiliary winding is loaded and when it is unloaded.

Note 6 to entry: Because separation of the excitation component of losses is difficult, it is recommended to consider these losses as an integral part of the stator losses when determining overall losses.

In the cases c) and d) no allowance is made for the losses in the excitation source (if any) or in the connections between the source and the brushes (synchronous machine) or between the source and the excitation winding terminals (DC machine).

If the excitation is supplied by a system having components as described in b) to e) the exciter losses shall include the relevant losses of the components pertaining to the categories listed in Annex B as applicable.

3.13.3.4
separately supplied excitation power
P_{1E}
excitation power P_{1E} supplied from a separate power source is:

– for exciter types a) and b) the exciter excitation power (DC or synchronous exciter) or stator winding input power (induction exciter). It covers a part of the exciter losses P_{Ed} (and further losses in induction exciters) while a larger part of P_e is supplied via the shaft;

– for exciter types c) and d) equal to the excitation circuit losses, $P_{1E} = P_e$;

– for exciter type e) $P_{1E} = 0$, the excitation power being delivered entirely by the shaft. Also, $P_{1E} = 0$ for machines with permanent magnet excitation.

Exciter types shall be in accordance with 3.13.3.3.

3.13.3.5
brush losses (excitation circuit)
P_b
electrical brush loss (including contact loss) of separately excited synchronous machines

3.13.4
load losses

3.13.4.1
load losses
P_L
sum of the winding (I^2R) losses (see 3.13.4.2) and the electrical brush losses (see 3.13.3.5), if any

AVA Documents Document Sharing Hub

Full document details: BS EN IEC 60034-2-1:2024

3.13.4.2
winding losses
winding losses are I^2R losses:

– in the armature circuit of DC machines;
– in the stator and rotor windings of induction machines;
– in the armature and field windings of synchronous machines

3.13.4.3
brush losses
P_b
electrical brush loss (including contact loss) in the armature circuit of DC machines and in wound-rotor induction machines

3.13.5
additional load losses
P_{LL}
losses produced in active iron and other magnetic and conductive parts by alternating stray fluxes when the machine is loaded; eddy current losses in winding conductors caused by load current-dependent flux pulsations and additional brush losses caused by commutation

Note 1 to entry: These losses do not include the additional no-load losses of 3.13.2.2.

3.13.6
short-circuit losses
P_{sc}
current-dependent losses in a synchronous machine and in a DC machine when the armature winding is short-circuited

3.14
test quantities <polyphase AC machines>

3.14.1
terminal voltage
for polyphase AC machines, the arithmetic average of line voltages

3.14.2
line current
for polyphase AC machines, the arithmetic average of line currents

3.14.3
line-to-line resistance
for polyphase AC machines, the arithmetic average of resistances measured between each pair of terminals

Note 1 to entry: For Y-connected three-phase machines, the phase-resistance is 0,5 times the line-to-line resistance. For Δ-connected machines, the phase-resistance is 1,5 times the line-to-line resistance.

Note 2 to entry: In Clauses 6 and 7 explanations and formulae given are for three-phase machines, unless otherwise indicated.

3.14.4
temperature rise
is the machine temperature minus the cooling medium (coolant) temperature as defined by IEC 60034-1

Documents
Document Sharing Hub
Full document details: BS EN IEC 60034-2-1:2024

4 Symbols and abbreviated terms

4.1 Symbols

$\cos \varphi$	is the power factor[1]
f	is the supply frequency, Hz
I	is the line current (average of all phases), A
k_θ	is the temperature correction factor
n	is the operating speed, s^{-1}
p	is the number of pole pairs
P	is the power, W
P_0	is the input power at no-load, W
P_1	is the input power, excluding excitation[2], W
P_2	is the output power, W
P_b	is the brush loss, W
P_D	is the output power (shaft power) of a drive motor, W
P_e	is the excitation circuit losses, W
P_{1E}	is the excitation power supplied by a separate source, W
P_{Ed}	is the exciter losses, W
P_{el}	is the electrical power, excluding excitation, W
P_f	is the excitation (field) winding losses, W
P_{fe}	is the iron losses, W
P_{fw}	is the friction and windage losses, W
P_c	is the constant losses, W
P_L	is the load losses, W
P_{Lr}	is the residual losses, W
P_{LL}	is the additional-load losses, W
P_{sc}	is the short-circuit losses, W
P_{mech}	is the mechanical power, W
P_T	is the total losses, W
P_w	is the winding losses, W, where subscript w is generally replaced by a, f, e, s or r (see 4.2)
R	is a winding resistance, Ω
R_{eh}	is the actual value of the auxiliary resistor for the Eh-star test (see 6.2.5), Ω
R'_{eh}	is the typical value of the auxiliary resistor, Ω
R_f	is the field winding resistance, Ω

[1] This definition assumes sinusoidal voltage and current.

[2] Unless otherwise indicated, the tests in this document are described for motor operation, where P_1 and P_2 are electrical input and mechanical output power, respectively.

AVA Documents Document Sharing Hub

Full document details: BS EN IEC 60034-2-1:2024

R_{ll}	is the line-to-line-resistance (average of all phases), Ω
R_{ph}	is the phase-resistance (average of all phases), Ω
s	is the slip, in per unit value of synchronous speed
T	is the machine torque, N·m
T_d	is the reading of the torque measuring device, N·m
U	is the terminal voltage (average of all phases), V
U_0	is the terminal voltage at no-load (average of all phases), V
U_N	is the rated terminal voltage, V
X	is the reactance, Ω
$\underline{Z} = R + j \times X$	is the notation for a complex quantity (impedance as example)
$Z = \lvert\underline{Z}\rvert = \sqrt{R^2 + X^2}$	is the absolute value of a complex quantity (impedance as example)
Z	is the impedance, Ω
α	is a temperature coefficient
η	is the efficiency
θ_0	is the initial winding temperature, °C
θ_a	is the ambient temperature, °C
θ_c	primary coolant inlet temperature, °C
θ_w	is the winding temperature, °C
τ	is a time constant, s

4.2 Additional subscripts

The following subscripts may be added to symbols to clarify the machine function and to differentiate values.

Machine components:

a	armature
e	excitation
f	field winding
r	rotor
s	stator
w	winding
U,V,W	phase designations

Machine categories:

B	booster
E	exciter
G	generator
M	motor

Documents
Document Sharing Hub
Full document details: BS EN IEC 60034-2-1:2024

Operating conditions:

0	no-load
1	input
2	output
av	average, mean
d	dissipated
el	electrical
i	internal
sc	short circuit
L	test load
lr	locked rotor
mech	mechanical
N	rated
red	at reduced voltage
t	test
zpf	zero power factor test
θ	corrected to a reference coolant temperature.

NOTE Further additional subscripts are introduced in relevant subclauses.

5 Basic requirements

5.1 Direct and indirect efficiency determination

Tests can be grouped into the three following categories:

a) input-output power measurement on a single machine. This involves the direct measurement of electrical or mechanical power into, and mechanical or electrical power out of a machine;

b) electrical input and output measurement on two identical machines mechanically connected back-to-back. This is done to eliminate the measurement of mechanical power into or out of the machine;

c) determination of the actual loss in a machine under a particular condition. This is usually not the total loss but comprises certain loss components.

The methods for determining the efficiency of machines are based on a number of assumptions. Therefore, it is not recommended that a comparison be made between the values of efficiency obtained by different methods, because the figures may not necessarily agree.

5.2 Uncertainty

Uncertainty as used in this standard is the uncertainty of determining a true efficiency. It reflects variations in the test procedure and the test equipment.

Although uncertainty shall be expressed as a numerical value, such a requirement needs sufficient testing to determine representative and comparative values.

5.3 Preferred methods and methods for customer-specific acceptance tests, field-tests or routine-tests

It is difficult to establish specific rules for the determination of efficiency. The choice of test to be made depends on the information required, the accuracy required, the type and size of the machine involved and the available field test equipment (supply, load or driving machine).

AVA Documents Document Sharing Hub

Full document details: BS EN IEC 60034-2-1:2024

In the following, the test methods suitable for asynchronous and synchronous machines are separated into preferred methods and methods for customer-specific acceptance tests, field-tests or routine tests.

5.4 Power supply

5.4.1 Voltage

The supply voltage shall be in accordance with 7.2 (and 8.3.1 for thermal tests) of IEC 60034-1:2022.

5.4.2 Frequency

During tests, the average supply frequency shall be within ±0,1 % of the frequency required for the test being conducted.

5.5 Instrumentation

5.5.1 General

Environmental conditions shall be within the recommended range given by the instrument manufacturer. If appropriate, temperature corrections according to the instrument manufacturer's specification shall be made.

Digital instruments shall be used whenever possible.

For analogue instruments accuracy is generally expressed as a percentage of full scale, the range of the instruments chosen shall be as small as practical.

The full scale of the instrument, particularly the current sensors, shall be adapted to the power of the machine under test.

For analogue instruments the observed values should be in the upper third of the instrument range.

When testing electric machines under load, slow fluctuations in the output power and other measured quantities may be unavoidable. Therefore, for each load point many readings (typically many hundred readings) shall be taken automatically by a suitable digital meter over a period of several fluctuation cycles, at least 5 s but not more than 60 s and this average shall be used for the determination of efficiency.

5.5.2 Measuring instruments for electrical quantities

The measuring instruments shall have the equivalent of an accuracy class of 0,2 in case of a direct test and 0,5 in case of an indirect test in accordance with IEC 60051. The measuring equipment shall reach a maximum overall uncertainty of 0,2 % of reading at power factor 1,0 and shall include all errors of instrument transformers or transducers, if used.

NOTE For a routine test as described in IEC 60034-1 an accuracy class of 0,5 is sufficient.

In the case of AC machines, unless otherwise stated in this standard, the arithmetic average of the line currents and voltages shall be used.

5.5.3 Torque measurement

The torque measuring device shall have a minimum class of 0,2. The minimum torque measured shall be at least 10 % of the torque meter’s nominal torque. This applies also to part load measurements, because of increased instrument uncertainty at small readings. If a better class instrument is used, the allowed torque range can be extended accordingly.

AVA Documents
Document Sharing Hub

Full document details: BS EN IEC 60034-2-1:2024

NOTE For example class 0,1 means 5 % of the torque meter's nominal torque.

Allowed torque measuring device are an inline torque meter or a reaction torque sensor between the machine and its base. In the latter case the machine is directly coupled to the load. See Figure 2.

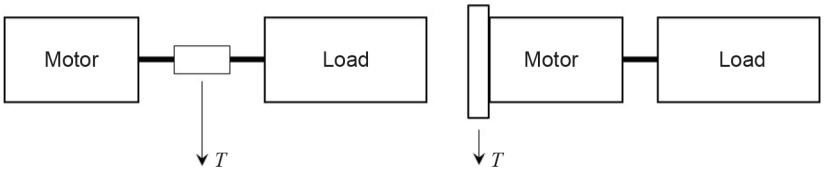

Figure 1 – Torque measuring devices

It shall be noted that the temperature of the torque sensor (i.e., due to proximity to the rotor) may be higher than the ambient temperature and is acknowledged to have a significant contribution to overall uncertainty. In that case the contribution of temperature to the uncertainty shall be limited to 0,15 % of full scale. If that is not practical, an appropriate temperature correction shall be applied.

Parasitic loads should be minimized by shaft alignment and the use of flexible couplings.

5.5.4 Speed and frequency measurement

The instrumentation used to measure supply frequency shall have an accuracy of ±0,1 % of full scale. The speed measurement should be accurate within 0,1 revolution per minute.

NOTE For asynchronous machines, the measurement of slip by a suitable method may replace speed measurement (see Annex C).

5.5.5 Temperature measurement

The instrumentation used to measure temperatures shall have an accuracy of ±1 K.

5.6 Units

Unless otherwise specified, the units of values are SI-units as listed in IEC 60027-1.

5.7 Resistance

5.7.1 Test resistance

Winding resistance R is the ohmic value, determined by appropriate methods.

For DC machines, R is the total resistance of all windings carrying armature current (armature, commutation, compensating winding, compound winding).

For DC and synchronous machines, R_f is the field winding resistance.

For polyphase AC machines, $R = R_{ll}$ is the line-to-line average resistance of the stator or armature winding according to 3.14.3. In the case of wound rotor induction machines, $R_{r,ll}$ is the rotor line-to-line average resistance.

Documents
Document Sharing Hub
Full document details: BS EN IEC 60034-2-1:2024

The measured resistance at the end of the thermal test shall be determined as soon as possible but not after more than twice the interval as specified in Table 6 of IEC60034-1:2022. Additional readings shall be taken at intervals of approximately 1 min until these readings have begun a distinct decline from their maximum value. A curve of these readings shall be plotted as a function of time and extrapolated to zero. The value of temperature thus obtained shall be considered as the temperature at shutdown.

The measured temperature of windings shall be determined according to 5.7.2.

5.7.2 Winding temperature

The measured winding temperature shall be determined by one of the following methods (shown in order of preference):

a) temperature determined from the rated load test resistance R_N by the extrapolation procedure as described in 5.7.1;

b) temperature measured directly by either ETD or thermocouple; if the temperature is measured by more than one ETD or thermocouple, the average of all readings shall be taken;

c) temperature determined according to a) on a duplicate machine of the same construction and electrical design;

d) if load capability is not available, determine operating temperature according to IEC 60034-29;

e) if the rated load test resistance R_N cannot be measured directly, the winding temperature shall be assumed to be equal to the reference temperature of the rated thermal class as given in Table 1.

Table 1 – Reference temperature

Thermal class of the insulation system	Reference temperature °C
130 (B)	95
155 (F)	115
180 (H)	135

If the rated temperature rise or the rated temperature is specified as that of a lower thermal class than that used in the construction, the reference temperature shall be that of the lower thermal class.

Motors that are subject to check testing for regulatory purposes are not to be dismantled. In that case, measurement of winding temperature shall be by the change of resistance method;

5.7.3 Correction to reference coolant temperature

If required, the winding resistance values recorded during test shall be referred to a standard reference temperature of 25 °C. The correction factor to adjust the winding resistance (and the slip in the case of cage induction machines) to a standard reference coolant temperature of 25 °C shall be determined by

$$k_\theta = \frac{235 + \theta_w + 25 - \theta_c}{235 + \theta_w} \quad (1)$$

Documents
Document Sharing Hub
Full document details: BS EN IEC 60034-2-1:2024

where

k_θ is the temperature correction factor for windings;

θ_c is the primary coolant temperature during test;

θ_w is the winding temperature according to 5.7.2.

The temperature constant 235 is for copper; this should be replaced by 225 for aluminium conductors.

For machines with water as the primary or secondary coolant, the water reference temperature shall be 25 °C according to Table 5 of IEC 60034-1:2022. Alternative values may be specified by agreement.

5.8 State of the machine under test and test categories

Tests shall be conducted on an assembled machine with the essential components in place, to obtain test conditions equal or very similar to normal operating conditions.

For handling of sealing systems for efficiency classification related measurements see IEC 60034-30-1.

It is preferable that the machine be selected randomly from series production without special considerations.

The sub-tests that make up a test procedure shall be performed in the sequence listed. It is not essential that the tests be carried out immediately one after another. However, if the sub-tests are performed with delay, then the specified thermal conditions shall be re-established prior to obtaining the test data.

For machines with adjustable brushes, the brushes shall be placed in the position corresponding to the specified rating. For induction motors with wound rotor having a brush lifting device, the brushes shall be lifted during tests, with the rotor winding short-circuited. For measurements on no-load, the brushes shall be placed in the neutral axis on DC machines.

For machines having brushes, during the rated load test, and prior to any measurement, a visual inspection shall be done to check if the brushes are fully bedded, and a proper skin is developed.

The bearing losses depend on the operating temperatures of the bearings, the type of lubricant and lubricant temperature.

If the losses in a separate lubricating system of bearings are required these should be listed separately.

In the case of motors which are furnished with thrust bearings, only that portion of the thrust bearing loss produced by the motor itself shall be included in the total losses.

Friction losses due to thrust load may be included by agreement.

If the tested machine uses direct flow cooling of the bearings, these losses are distributed between the tested machine and any other one coupled to it mechanically, such as a turbine, in proportion to the masses of their rotating parts. If there is no direct flow cooling, the distribution of bearing losses shall be determined from empirical formulae by agreement.

AVA Documents
Document Sharing Hub
Full document details: BS EN IEC 60034-2-1:2024

5.9 Excitation circuit measurements

Determination of voltage U_e and current I_e (see 3.13.3.2) depends on the configurations of the excitation system (see 3.13.3.3). Where applicable, test data shall be recorded according to the following:

a) for machines excited by shaft driven, separate rotating, static and auxiliary winding exciters (see 3.13.3.3 a), c), d) and e)), voltage U_e and current I_e are measured:
   - at the excitation winding terminals of DC machines;
   - at the field winding slip-rings of synchronous machines;

b) for machines excited by brushless exciters (see 3.13.3.3 b)), test data shall be recorded by either of the following methods:
   - voltage U_e measured using auxiliary (provisional) slip-rings connected to the field winding ends. From the voltage and resistance R_e determine the field winding current $I_e = \frac{U_e}{R_e} = \frac{U_f}{R_f}$. The field winding resistance is to be measured after switching off the machine using the extrapolation procedure according to 5.7.1;
   - voltage U_e and current I_e measured using power slip-rings suitable for direct measurement of field winding current.

NOTE The difference between U_e and U_f (voltage drop of brushes) is in practice almost negligible.

Voltages and currents shall be measured at stabilized temperatures.

The excitation circuit losses P_e are determined according to 7.1.3.2.1.5 (synchronous machines) or 8.3.2.1.5 (DC machines).

5.10 Ambient temperature during testing

The ambient temperature should be in the range of 15 °C to 40 °C.

6 Test methods for the determination of the efficiency of induction machines

6.1 Preferred testing methods

6.1.1 General

This document defines three different preferred methods with low uncertainty within the given range of application, see Table 2. The specific method to be used depends on the type or rating of the machine under test:

Method 2-1-1A: Direct measurement of input and output power by using a torque measuring device. To be applied for all single phase machines.

Method 2-1-1B: Summation of separate losses. Additional load loss determined by the method of residual loss. To be applied for all three phase machines with rated output power up to 2 MW. See also Annex D.

Method 2-1-1C: Summation of separate losses. Additional load loss determined by the method of assigned value. To be applied for all three phase machines with rated output power greater than 2 MW.

Documents
Document Sharing Hub
Full document details: BS EN IEC 60034-2-1:2024

Table 2 – Induction machines: preferred testing methods

Reference	Method	Description	Subclause	Application	Required facility
2-1-1A	**Direct measurement:** **Input-output**	Torque measurement	6.1.2	All single phase machines	Torque measuring device for full-load
2-1-1B	**Summation of losses:** **Residual losses**	P_{LL} determined from residual loss	6.1.3	Three phase machines with rated output power up to 2 MW	Torque measuring device for 1,25 × full-load, or load machine for 1,25 × full-load with torque measuring device
2-1-1C	**Summation of losses:** **Assigned value**	P_{LL} from assigned value	6.1.4	Three phase machines with rated output power greater than 2 MW	

6.1.2 Method 2-1-1A – Direct measurement of input and output

6.1.2.1 General

This is a test method in which the mechanical power P_{mech} of a machine is determined by measurement of the shaft torque and speed. The electrical power P_{el} of the stator is measured in the same test.

Input and output power are:

in motor operation: $P_1 = P_{el}$; $P_2 = P_{mech}$ (see Figure 2); (2)

in generator operation: $P_1 = P_{mech}$; $P_2 = P_{el}$ (3)

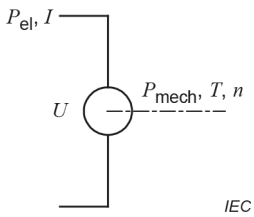

Figure 2 – Sketch for torque measurement test

For an overview, Figure 3 provides a flowchart for efficiency determination by this test method.

Documents
Document Sharing Hub
Full document details: BS EN IEC 60034-2-1:2024

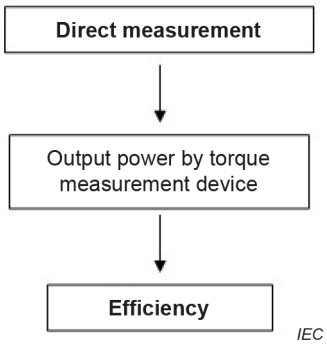

Figure 3 – Efficiency determination according to method 2-1-1A

6.1.2.2 Test procedure

Couple the machine under test to a load machine with torque measuring device. Operate the machine under test at the required load until thermal equilibrium is achieved (rate of change 1 K or less per half hour).

Record U, I, P_{el}, n, T, θ_c.

Immediately after the test, the drift of the torque measuring device shall be checked. In case of a deviation above the allowed tolerance of the torque measuring device, adjust it and repeat the measurements.

6.1.2.3 Efficiency determination

The efficiency is:

$$\eta = \frac{P_2}{P_1} \tag{4}$$

Input power P_1 and output power P_2 are:

in motor operation: $P_1 = P_{el}$; $P_2 = P_{mech}$; (5)

in generator operation: $P_1 = P_{mech}$; $P_2 = P_{el}$ (6)

where

$$P_{mech} = 2\pi \times T \times n \tag{7}$$

Documents
Document Sharing Hub
Full document details: BS EN IEC 60034-2-1:2024

6.1.3 Method 2-1-1B – Summation of losses, additional load losses according to the method of residual loss

6.1.3.1 General

This is a test method in which the efficiency is determined by the summation of separate losses. The respective loss components are:

– iron loss;
– windage and friction losses;
– stator and rotor copper losses;
– additional load losses.

For an overview, Figure 4 provides a flowchart for efficiency determination by this test method.

Documents
Document Sharing Hub
Full document details: BS EN IEC 60034-2-1:2024

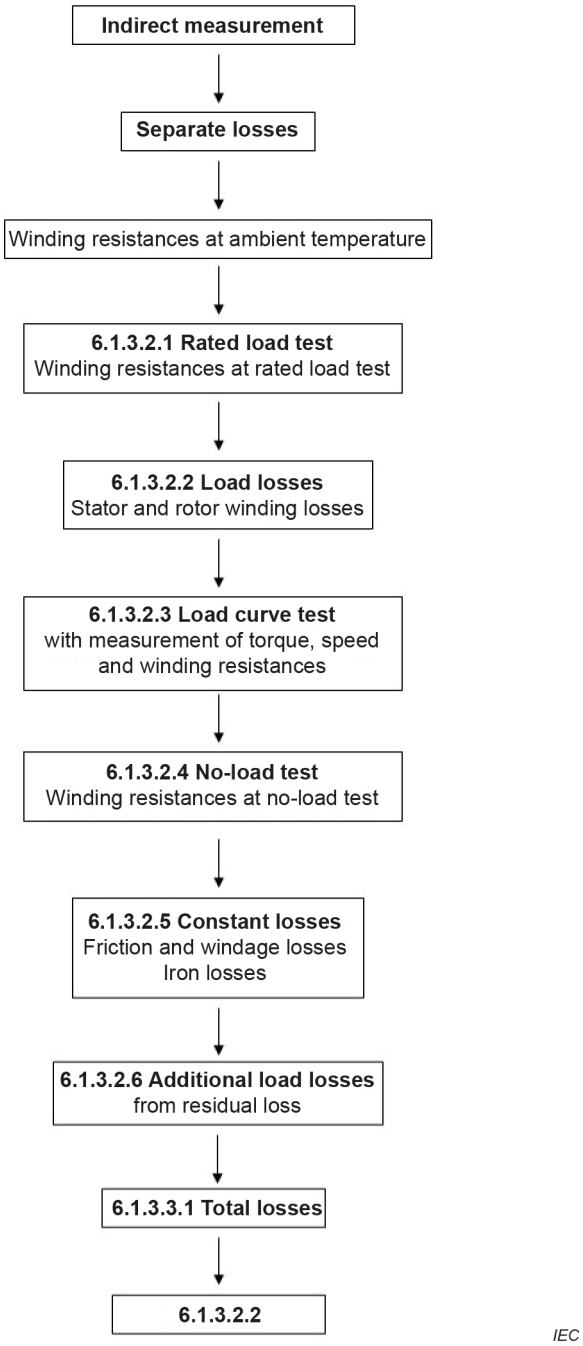

Figure 4 – Efficiency determination according to method 2-1-1B

6.1.3.2 Test procedure

6.1.3.2.1 Rated load test

Before this load test, measure the temperature and the winding resistance of the motor with the motor at ambient temperature.

The machine shall be loaded by suitable means with rated output power and operated until thermal equilibrium is achieved (rate of change 1 K or less per half hour). Record the following quantities:

– P_1, T, I, U, n, f, θ_c, θ;

– $R_N = R$ (the test resistance for rated load according to 5.7.1);

Documents
Document Sharing Hub
Full document details: BS EN IEC 60034-2-1:2024

– θ (the winding temperature at rated load according to 5.7.2).

Immediately after the load test, the drift of the torque transducer shall be checked. In case of a deviation above the allowed tolerance of the transducer, adjust it and repeat the measurements.

6.1.3.2.2 Load losses

6.1.3.2.2.1 Stator-winding losses and temperature correction

The uncorrected stator-winding losses at rated load are:

$$P_s = 1{,}5 \times I^2 \times R \tag{8}$$

where I and R are determined in 5.7.1.

Determine the stator-winding losses, using the stator winding resistance R_N from the rated load test, corrected to a reference coolant temperature of 25 °C:

$$P_{s,\theta} = P_s \times k_\theta \tag{9}$$

where k_θ is the correction according to 5.7.3 for the stator winding.

6.1.3.2.2.2 Rotor winding losses and temperature correction

For the uncorrected rotor winding losses use the formula:

$$P_r = \left(P_1 - P_s - P_{fe}\right) \times s \tag{10}$$

where

$$s = 1 - \frac{p \times n}{f} \tag{11}$$

P_1, n and f are according to the rated load test;

P_s according to the load test as stated above;

P_{fe} is according to 6.1.3.2.5.

The corrected rotor winding losses are determined using the corrected value of the stator winding losses:

$$P_{r,\theta} = \left(P_1 - P_{s,\theta} - P_{fe}\right) \times s_\theta$$

where

P_{fe} is according to 6.1.3.2.5 for a reference coolant temperature of 25 °C;

$s_\theta = s \times k_\theta$ is the slip corrected to a reference coolant temperature of 25 °C (see 5.7.3);

AVA Documents Document Sharing Hub

Full document details: BS EN IEC 60034-2-1:2024

k_θ is the correction according to 5.7.3.

6.1.3.2.2.3 Temperature correction of input power (for a motor)

With the corrected stator and rotor winding losses, the corrected input power is:

$$P_{1,\theta} = P_1 - (P_s - P_{s,\theta} + P_r - P_{r,\theta}) \quad (12)$$

6.1.3.2.3 Load curve test

This test shall be carried out immediately after the rated load test with the motor at operating temperature.

If that is not possible, prior to the start of recording data for this test, the temperature rise of the windings shall be within 5 K of the initial temperature rise θ_N, obtained from a rated load temperature test.

Apply the load (shaft power) to the machine at the following six load points: approximately 125 %, 115 %, 100 %, 75 %, 50 % and 25 % of rated load. These tests shall be performed as quickly as possible to minimize temperature changes in the machine during testing.

NOTE 1 As an indication, the applied load may vary by ± 5 % from the figures given above. The impact on the further evaluation of the residual losses is limited.

Supply frequency variation between all points shall be less than 0,1 %.

Measure R before the highest and after the lowest load reading. The resistance for 100 % load and higher loads shall be the value determined before the highest load reading. The resistance used for loads less than 100 % shall then be determined as varying linearly with load, using the reading before the test for the highest load and after the lowest reading for 25 % load.

NOTE 2 Resistances may also be determined by measuring the stator winding temperature using a temperature-sensing device installed on the winding. Resistances for each load point may then be determined from measured resistance before load curve test multiplied with the ratio of the temperature of the winding at that load point to the temperature of the winding measured before the start of the test.

Record for each load point: U, I, P_1, n, f, T.

The stator-winding losses at each of the load points are:

$$P_s = 1{,}5 \times I^2 \times R \quad (13)$$

where I and R are determined according to 6.1.3.2.2 for each load point.

For the rotor winding losses for each of the load points use the formula:

$$P_r = \left(P_1 - P_s - P_{fe}\right) \times s \quad (14)$$

where

Documents
Document Sharing Hub
Full document details: BS EN IEC 60034-2-1:2024