IEC 60034-1

Edition 15.0 2026-03

INTERNATIONAL STANDARD

REDLINE VERSION

Rotating electrical machines -
Part 1: Rating and performance

ICS 29.160.01

ISBN 978-2-8327-1151-4

IEC 60034-1:2026-03 RLV(en)

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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Rotating electrical machines - Part 1: Rating and performance

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.
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This redline version of the official IEC Standard allows the user to identify the changes made to the previous edition IEC 60034-1:2022. A vertical bar appears in the margin wherever a change has been made. Additions are in green text, deletions are in strikethrough red text.

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

This fifteenth edition cancels and replaces the fourteenth edition published in 2022. This edition constitutes a technical revision.

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

Clause, subclause or table number	Change
1	Clarification with respect to machines with integrated EMC-active components added
2	Normative references updated
3	Note on meaning of “agreement” deleted; list of abbreviations added
4.2.9, 4.2.10	References to IEC TS 60034-25 deleted, as converter duty is now defined in 3.36
5.1	Reference to IEC TS 60034-25 converted into note
6.6	Clarification of requirements
7.2.1	Reference to IEC TS 60034-25 converted into note
7.5	Clarification of requirements
7.6	Reference to IEC TS 60034-25 converted into note
8.1	Clarification of references
8.6.1	Clarification on choice of method for large machines
Table 11	Updated values for thermal class 200 (N)
8.10.3	Clarification of requirements
9.2	Clarification on test voltage for old machines after rewinding
Table 17	Items 9 and 10 merged and clarified
9.7	Clarification on overspeed test for machines held at stock added
Table 20	Clarification on test speed for converter duty machines
10.2	Clarification of term ‘digital form’
10.3	Note on QR code deleted
11.1	Reference to protective earth test added
13.1	Clarifying flowchart added
13.2.2	Clarification on motors with integrated VSD added
13.3	Clarification of requirements after consultation with ACEC
13.5	Clarification of requirements after consultation with ACEC
14	Note on safety converted to normal text

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

Draft	Report on voting
2/2257/FDIS	2/2296/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/standardsdev/publications.

A list of all parts of the IEC 60034 series, published under the general title *Rotating electrical machines*, can be found on the IEC website.

NOTE A table of cross-references of all IEC TC 2 publications can be found on the IEC TC 2 dashboard 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.

1 Scope

This part of IEC 60034 is applicable to all rotating electric~~al~~ machines, except rotating electric~~al~~ machines for rail and road vehicles, which are covered by the IEC 60349 series of standards.

Machines with integrated EMC-active components such as a variable frequency converter are considered being a power drive system (see the IEC 61800 series of standards). In such cases, this document applies to the motor component of the power drive system only.

Machines within the scope of this document ~~may~~ can also be subject to superseding, modifying or additional requirements in other standards, for example, IEC 60079 and IEC 60092.

NOTE If particular clauses of this document are modified to meet special applications, for example machines subject to radioactivity or machines for aerospace, all other clauses apply insofar as they are compatible.

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~~:1992~~, *Letters symbols to be used in electrical technology - Part 1: General*
~~IEC 60027-1:1992/AMD1:1997~~
~~IEC 60027-1:1992/AMD2:2005~~

IEC 60027-4~~:2006~~, *Letter symbols to be used in electrical technology - Part 4: Rotating electric machines*

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

IEC 60034-3~~:2020~~, *Rotating electrical machines - Part 3: Specific requirements for synchronous generators driven by steam turbines or combustion gas turbines and for synchronous compensators*

IEC 60034-5~~:2020~~, *Rotating electrical machines - Part 5: Degrees of protection provided by the integral design of rotating electrical machines (IP code) - Classification*

IEC 60034-6~~:1991~~, *Rotating electrical machines - Part 6: Methods of cooling (IC code)*

IEC 60034-8~~:2007~~, *Rotating electrical machines - Part 8: Terminal markings and direction of rotation*
~~IEC 60034-8:2007/AMD1:2014~~

IEC 60034-12:2016, *Rotating electrical machines - Part 12: Starting performance of single-speed three-phase cage induction motors*

IEC 60034-15~~:2009~~, *Rotating electrical machines - Part 15: Impulse voltage withstand levels of form-wound stator coils for rotating a.c. machines*

~~IEC 60034-18 (all parts), *Rotating electrical machines – Part 18: Functional evaluation of insulation systems*~~

IEC 60034-18-41~~:2014~~, *Rotating electrical machines - Part 18-41: Partial discharge free electrical insulation systems (Type I) used in rotating electrical machines fed from voltage converters - Qualification and quality control* tests
~~IEC 60034-18-41:2014/AMD1:2019~~

IEC 60034-18-42~~:2017~~, *Rotating electrical machines - Part 18-42: Partial discharge resistant electrical insulation systems (Type II) used in rotating electrical machines fed from voltage converters - Qualification tests*
~~IEC 60034-18-42:2017/AMD1:2020~~

~~IEC 60034-19:2014, *Rotating electrical machines – Part 19: Specific test methods for d.c. machines on conventional and rectifier-fed supplies*~~

~~IEC TS 60034-25:2014, *Rotating electrical machines – Part 25: AC electrical machines used in power drive systems – Application guide*~~

IEC 60034-27-4, *Rotating electrical machines - Part 27-4: Measurement of insulation resistance and polarization index of winding insulation of rotating electrical machines*

IEC 60034-29~~:2008~~, *Rotating electrical machines - Part 29: Equivalent loading and superposition techniques - Indirect testing to determine temperature rise*

IEC 60034-30-1~~:2014~~, *Rotating electrical machines - Part 30-1: Efficiency classes of line operated AC motors (IE code)*

~~IEC TS 60034-30-2, *Rotating electrical machines – Part 30-2: Efficiency classes of variable speed AC motors (IE-code)*~~

IEC 60034-30-3, *Rotating electrical machines - Part 30-3: Efficiency classes of high voltage AC motors (IE-code)*

IEC 60034-33, *Rotating electrical machines - Part 33: ~~Specific technical requirements for hydro generators~~ Synchronous hydrogenerators including motor-generators - Specific requirements*

IEC 60050-411:1996, *International Electrotechnical Vocabulary (IEV) - Part 411: Rotating* machinery
~~IEC 60050-411:1996/AMD1:2007~~
~~IEC 60050-411:1996/AMD2:2021~~

IEC 60060-1~~:2010~~, *High-voltage test techniques - Part 1: General terminology and test requirements*

IEC 60085~~:2007~~, *Electrical insulation - Thermal evaluation and designation*

IEC 60204-1~~:2016~~, *Safety of machinery - Electrical equipment of machines - Part 1: General requirements*

IEC 60204-11~~:2018~~, *Safety of machinery - Electrical equipment of machines - Part 11: Requirements for equipment for voltages above 1 000 V AC or 1 500 V DC and not exceeding 36 kV*

IEC 60335-1:2020, *Household and similar electrical appliances - Safety - Part 1: General requirements*

IEC 60364 (all parts), *Low-voltage electrical installations*

IEC 60417, *Graphical symbols for use on equipment - 12-month subscription to regularly updated online database comprising all graphical symbols published in IEC 60417*

IEC 60445~~:2017~~, *Basic and safety principles for man-machine interface, marking and identification - Identification of equipment terminals, conductor terminations and conductors*

IEC 60664-1~~:2020~~, *Insulation coordination for equipment within low-voltage systems - Part 1: Principles, requirements and tests*

~~IEC 61148:2011, *Terminal markings for valve device stacks and assemblies and for power conversion equipment*~~

~~IEC TS 61800-8, *Adjustable speed electrical power drive systems – Part 8: Specification of voltage on the power interface*~~

CISPR 11:~~2015~~2024, *Industrial, scientific and medical equipment - Radio-frequency disturbance characteristics - Limits and methods of measurement*
~~CISPR 11:2015/AMD1:2016~~
~~CISPR 11:2015/AMD2:2019~~

CISPR 14 (all parts), *Electromagnetic compatibility - Requirements for household appliances, electric tools and similar apparatus*

CISPR 16 (all parts), S*pecification for radio disturbance and immunity measuring apparatus and methods*

3 Terms, definitions and abbreviated terms

3.1 Terms and definitions

For the purposes of this document, the terms and definitions in IEC 60050-411, and the following apply.

~~NOTE 2 For the purposes of this document, the term 'agreement' means 'agreement between the manufacturer and purchaser'.~~

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

NOTE For definitions concerning cooling and coolants, other than those in 3.17 to 3.22, IEC 60034-6 applies.

3.1.1
rated value
quantity value assigned, generally by a manufacturer, for a specified operating condition of a machine

Note 1 to entry: The rated voltage or voltage range is the rated voltage or voltage range between lines at the machine terminals.

[SOURCE: IEC 60050-411:1996, 411-51-23, modified – Note 1 to entry has been added.]

3.1.2
rating
set of rated values and operating conditions

[SOURCE: IEC 60050-411:1996, 411-51-24]

3.1.3
rated output
<of a machine> value of the output included in the rating

3.1.4
load
all the values of the, in case of a generator, electrical and, in case of a motor, mechanical quantities that signify the demand made on a rotating machine by an electrical circuit or a mechanism at a given instant

[SOURCE: IEC 60050-411:1996, 411-51-01, modified~~: modification indicated in italics~~ – "in case of a generator" and "in case of a motor" have been added.]

3.1.5
no-load
<operation> state of a machine rotating with zero output power (but under otherwise normal operating conditions)

[SOURCE: IEC 60050-411:1996, 411-51-02, modified~~: modification indicated in italics~~ – "(but under otherwise normal operating conditions)" has been added.]

3.1.6
full load
load which causes a machine to operate at its rating

[SOURCE: IEC 60050-411:1996, 411-51-10]

3.1.7
full load value
quantity value for a machine operating at full load

Note 1 to entry: This concept applies to power (for example "full load power"), torque, current, speed, etc.

[SOURCE: IEC 60050-411:~~1996~~2007, ~~411-51-11~~ 411-50-25, modified – Note 1 to entry has been added.]

3.1.8
rest and de-energized
complete absence of all movement and of all electrical supply or mechanical drive

[SOURCE: IEC 60050-411:1996, 411-51-03]

3.1.9
duty
statement of the load(s) to which the machine is subjected, including, if applicable, starting, electric braking, no-load and rest and de-energized periods, and including their durations and sequence in time

[SOURCE: IEC 60050-411:1996, 411-51-06]

3.1.10
duty type
continuous, short-time or periodic duty, comprising one or more loads remaining constant for the duration specified, or a non-periodic duty in which generally load and speed vary within the permissible operating range

[SOURCE: IEC 60050-411:1996, 411-51-13]

3.1.11
cyclic duration factor
ratio between the period of loading, including starting and electric braking, and the duration of the duty cycle, expressed as a percentage

[SOURCE: IEC 60050-411:1996, 411-51-09]

3.1.12
locked-rotor torque
minimum measured torque the motor develops at its shaft end with the rotor locked, over all its angular positions, at rated voltage and frequency

[SOURCE: IEC 60050-411:1996, 411-48-06, modified – “smallest” has been replaced with “minimum”.]

3.1.13
locked-rotor current
greatest steady-state root mean square (RMS) current taken from the line with the rotor locked, over all angular positions of its rotor, at rated voltage and frequency

[SOURCE: IEC 60050-411:1996, 411-48-16, modified – “motor held at rest” has been replaced with “rotor locked”.]

3.1.14
pull-up torque
<of an AC motor> minimum steady-state asynchronous torque which the motor develops between zero speed and the speed which corresponds to the breakdown torque, when the motor is supplied at the rated voltage and frequency

Note 1 to entry: This definition does not apply to those asynchronous motors of which the torque continually decreases with increase in speed.

Note 2 to entry: In addition to the steady-state asynchronous torques, harmonic synchronous torques, which are a function of rotor load angle, will be present at specific speeds. At such speeds, the accelerating torque may be negative for some rotor load angles.

Note 3 to entry: Experience and calculation show this to be an unstable operating condition, and therefore, harmonic synchronous torques do not prevent motor acceleration, and are excluded from this definition.

[SOURCE: IEC 60050-411:1996, 411-48-42, modified – “smallest” has been replaced with “minimum”. Note 2 to entry has been modified. Note 3 to entry has been added.]

3.1.15
breakdown torque
<of an AC motor> maximum steady-state asynchronous torque which the motor develops without an abrupt drop in speed, when the motor is supplied at the rated voltage and frequency

Note 1 to entry: This definition does not apply to motors with torques that continually decrease with increase in speed.

[SOURCE: IEC 60050-411:1996, 411-48-43]

3.1.16
pull-out torque
<of a synchronous motor> maximum torque which the synchronous motor develops at synchronous speed with rated voltage, frequency and field current

[SOURCE: IEC 60050-411:1996, 411-48-44]

3.1.17
cooling
procedure by means of which heat resulting from losses occurring in a machine is given up to a primary coolant, which may be continuously replaced or may itself be cooled by a secondary coolant in a heat exchanger

[SOURCE: IEC 60050-411:1996, 411-44-01]

3.1.18
coolant
medium, liquid or gas, by means of which heat is transferred

[SOURCE: IEC 60050-411:1996, 411-44-02]

3.1.19
primary coolant
medium, liquid or gas, which, being at a lower temperature than a part of a machine and in contact with it, removes heat from that part

[SOURCE: IEC 60050-411:1996, 411-44-03]

3.1.20
secondary coolant
medium, liquid or gas, which, being at a lower temperature than the primary coolant, removes the heat given up by this primary coolant by means of a heat exchanger or through the external surface of the machine

[SOURCE: IEC 60050-411:1996, 411-44-04]

3.1.21
direct cooled winding
inner cooled winding
winding mainly cooled by coolant flowing in direct contact with the cooled part through hollow conductors, tubes, ducts or channels which, regardless of their orientation, form an integral part of the winding inside the main insulation

Note 1 to entry: In all cases when ‘indirect’ or ‘direct’ is not stated, an indirect cooled winding is implied.

[SOURCE: IEC 60050-411:1996, 411-44-08, modified – Note1 to entry has been added.]

3.1.22
indirect cooled winding
any winding other than a direct cooled winding

Note 1 to entry: In all cases when ‘indirect’ or ‘direct’ is not stated, an indirect cooled winding is implied.

[SOURCE: IEC 60050-411:1996, 411-44-09]

3.1.23
supplementary insulation
<of a machine> independent insulation applied in addition to the main insulation in order to ensure protection against electric shock in the event of failure of the main insulation

3.1.24
moment of inertia
<of a machine> sum (integral) of the products of the mass elements of a body and the squares of their distances (radii) from a given axis

3.1.25
thermal equilibrium
the state reached when the temperature rises of the several parts of the machine do not vary by more than a gradient of 1 K per half hour

Note 1 to entry: Thermal equilibrium may be determined from the time-temperature rise plot when the straight lines between points at the beginning and end of two successive intervals of half hour each have a gradient of 1 K or less per half hour or 2 K or less per hour.

[SOURCE: IEC 60050-411:1996, 411-51-08, modified~~: modification indicated in italics~~ – "2 K per hour" has been replaced with "1 K per half hour". Note 1 to entry has been added.]

3.1.26
thermal equivalent time constant
time constant, replacing several individual time constants, which determines approximately the temperature course in a winding after a step-wise current change

3.1.27
encapsulated winding
winding which is completely enclosed or sealed by moulded insulation

[SOURCE: IEC 60050-411:1996, 411-39-06]

3.1.28
rated form factor of direct current supplied to a DC motor armature from a static power converter
ratio of the RMS maximum permissible value of the current $I_{\mathrm{rms,maxN}}$ to its average value I_{avN} (mean value integrated over one period) at rated conditions:

$$k_{\mathrm{fN}} = \frac{I_{\mathrm{rms,maxN}}}{I_{\mathrm{avN}}}$$

Note 1 to entry: In the document, the short form "rated form factor" of the term is used synonymously.

[SOURCE: IEC 60050-411:2007, 411-50-25]

3.1.29
current ripple factor
ratio of the difference between the maximum value I_{max} and the minimum value I_{min} of an undulating current to two times the average value I_{av} (mean value integrated over one period):

$$q_{\mathrm{i}} = \frac{I_{\mathrm{max}} - I_{\mathrm{min}}}{2 \times I_{\mathrm{av}}}$$

Note 1 to entry: For small values of current ripple, the ripple factor may be approximated by the following formula:

$$q_{\mathrm{i}} = \frac{I_{\mathrm{max}} - I_{\mathrm{min}}}{I_{\mathrm{max}} + I_{\mathrm{min}}}$$

Note 2 to entry: The above formula may be used as an approximation if the resulting calculated value of q_i is equal to or less than 0,4.

Note 3 to entry: The basis for determining this variation should be by oscillograph measurement (or a comparable device) and not by ammeter readings. A line should be drawn on the oscillogram through the consecutive peaks of the current wave. This line is the envelope of the current wave. The variation is the difference between the maximum (I_{max}) and minimum (I_{min}) ordinates of this envelope.

[SOURCE: IEC 60050-411:1996, 411-50-26, modified – The formula has been added. Notes 1, 2 and 3 to entry have been added.]

3.1.30
tolerance
permitted deviation between the declared value of a quantity and the measured value

[SOURCE: IEC 60050-411:1996, 411-36-19]

3.1.31
type test
test of one or more machines made to a certain design to show that the design meets certain specifications

Note 1 to entry: The type test may also be considered valid if it is made on a machine which has minor deviations of rating or other characteristics. These deviations should be subject to agreement.

[SOURCE: IEC 60050-411:1996, 411-53-01, modified – Note 1 to entry has been added.]

3.1.32
routine test
test to which each individual machine is subjected during or after manufacture to ascertain whether it complies with certain criteria

[SOURCE: IEC 60050-411:1996, 411-53-02]

3.1.33
runaway speed
maximum speed attained by the motor-generator set after removal of the full load of the generator if the speed regulator does not function

Note 1 to entry: The motor can be also a turbine or an internal combustion engine.

Note 2 to entry: For motors, the maximum overspeed at loss of supply is meant that a motor might reach driven by the coupled equipment.

[SOURCE: ~~IEC 60050-411:1996, 411-17-23~~ IEC 60050-811:1996, 811-17-23, modified – Notes 1 and 2 to entry have been added.]

3.1.34
main insulation
basic insulation ~~(see IEC 60664-1)~~ of a rotating electric~~al~~ machine

Note 1 to entry: For insulation coordination of equipment in low-voltage systems, IEC 60664-1 applies.

3.1.35
converter capable machine
electric~~al~~ machine designed for direct online start and suitable for operation on a power electronic frequency converter without special filtering

Note 1 to entry: Such motors include but are not limited to IEC Design N, NE, H, or HE, or NEMA Design A, B, or C which may be subject to energy efficiency regulation in the EU, North America or other locations.

Note 2 to entry: The intent of the converter capable motor is to run within the thermal class of the insulation system; but as the harmonic content of the converter output voltage varies between different drive topologies, coordination with the manufacturer may be required by the end user.

Note 3 to entry: IEC TS 60034-25 provides information on performance variations of all characteristics such as efficiency and acoustic noise when operating a converter capable motor on a frequency converter.

3.1.36
converter duty machine
electric~~al~~ machine designed specifically for operation fed by a power electronic frequency converter with a temperature rise within the specified insulation thermal class or thermal class

Note 1 to entry: Such motors have no IEC Design or NEMA Design letter and may be exempted from energy efficiency regulation in the EU, North America and other locations.

3.1.37
shaft voltage
voltage of mainly supply frequency measured between the shaft ends of an electric~~al~~ machine, which may occur due to magnetic asymmetries

Note 1 to entry: IEC TS 60034-24:2009, 5.5 and Clause 6, provide more information on the root cause of the shaft voltage.

Note 2 to entry: The shaft voltage of (mainly) supply frequency should not be mixed-up with the HF shaft voltage which can be caused in converter-fed machines by a high frequency (HF) common mode current impulse.

3.2 Abbreviated terms

CW clockwise
CCW counterclockwise
ETD embedded temperature detector
HCF harmonic current factor
HVF harmonic voltage factor
IVIC impulse voltage insulation class
RMS root mean square
SELV safety extra low voltage
THD total harmonic distortion
VSD variable speed drive

4 Duty

4.1 Declaration of duty

It is the responsibility of the purchaser to declare the duty. The purchaser may describe the duty by one of the following:

– numerically, where the load does not vary or where it varies in a known manner;
– as a time sequence graph of the variable quantities;
– by selecting one of the duty types S1 to S10 that is no less onerous than the expected duty.

The duty type shall be designated by the appropriate abbreviation, specified in 4.2, written after the value of the load.

An expression for the cyclic duration factor is given in the relevant duty type figure.

The purchaser normally cannot provide values for the moment of inertia of the machine (J_M) or the relative thermal life expectancy (TL), see Annex A. These values are provided by the manufacturer.