Edition 2.0 2025-12

INTERNATIONAL STANDARD

Rotating electrical machines -
Part 30-1: Efficiency classes of line operated AC motors (IE code)

ICS 29.160.01

ISBN 978-2-8327-0823-1

IEC 60034-30-1:2025-12(en)

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IEC 60034-30-1 has been prepared by IEC Technical Committee 2: Rotating machinery. It is an International Standard.

This second edition of IEC 60034-30-1 cancels and replaces the first edition of IEC 60034-30-1 published in 2014. This edition constitutes a technical revision.

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

a) Table 1 in Clause 4 revised and IE5 efficiency introduced.
b) New efficiency tables (Table 11 and Table 12) added for IE5 nominal efficiency limits.
c) Table 13 for interpolation coefficients revised based on IE5 limits and the coefficients limited from 0,12 kW to 0,75 kW 0,12 kW to 0,55 kW. A linear interpolation shall be applied to obtain minimum efficiency between 0,55 kW and 0,75 kW.

tolerance.

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

Draft	Report on voting
2/2235/FDIS	2/2279/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 are English and French.

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.

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– withdrawn, or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.

This first part of the IEC 60034-30 series, IEC 60034-30-1, provides for the global harmonization of energy efficiency classes of electric motors. It deals with all kinds of electric motors that are rated for line operation (including starting at reduced voltage). This includes either 50 Hz or 60 Hz, or both single- and three-phase low voltage induction motors, regardless of their rated voltage, as well as line-start synchronous motors.

The second part of this standard series (IEC 60034-30-2) is prepared for motors rated for variable voltage and frequency supply.

This second edition of IEC 60034-30-1 introduces a new efficiency class, IE5. It is important to note that International Energy efficiency (IE) class definition is generally independent of the output power – frame size assignment. As standardized dimensions and outputs in the IEC 60072 series are based on today's technology (up to IE4), it can be challenging to implement highest IE classes according to existing frame sizes.

It is possible that motors, especially those with lower output power ratings, are designed and manufactured in one frame size bigger than frame size assigned in IEC 60072-1 to reach IE4 and IE5 efficiency levels.

For a given power and frame size it is generally easier to achieve a higher motor efficiency when the motor is designed for and operated directly on-line with a 60 Hz supply frequency rather than on 50 Hz as explained in Note 1.

NOTE 1 As the utilization and size of motors are related to torque rather than power the theoretical power of single-speed motors increases linearly with supply frequency (and hence with speed), i.e. by 20 % from 50 Hz to 60 Hz.

I^2R winding-losses are dominant especially in small and medium sized induction motors. They basically remain constant at 50 Hz and 60 Hz as long as the torque is kept constant. Although windage, friction and iron losses increase with frequency, they play a minor role especially in motors with a number of poles of four and higher. Therefore, at 60 Hz, the losses increase less than the 20 % power increase when compared to 50 Hz and consequently, the efficiency is improved.

In practice, both 60 Hz and 50 Hz power designations of single-speed motors usually conform to standard power levels in accordance with IEC 60072-1. Therefore, an increased rating of motor power by 20 % is not always possible. However, the general advantage of 60 Hz still applies when the motor design is optimized for the respective supply frequency rather than just re-rated.

The difference in efficiency between 50 Hz and 60 Hz varies with the number of poles and the size of the motor. In general, the 60 Hz efficiency of three-phase, cage-induction motors in the power range from 0,75 kW up to 375 kW is between 2,5 percentage points to less than 0,5 percentage points greater when compared to the 50 Hz efficiency. Only large 2-pole motors can experience a reduced efficiency at 60 Hz due to their high share of iron, windage and friction losses.

It is not expected that all manufacturers will produce motors for all efficiency classes, nor all ratings of a given class.

Users should dimension motors to be suitable for the intended applications based on the load profile, operating hours in order to maximize energy savings considering most energy efficient solutions in addition that all other requirements set by the application are covered. It is possible that selecting motors of a high efficiency class for intermittent or short time duty due to increased inertia and start-up losses is not energy efficient.

NOTE 2 The application guide IEC TS 60034-31 gives further information on useful applications of high-efficient electric motors.

national or regional standards for assigned powers in relation to mechanical dimensions (such as frame-size, flanges). IEC 60072-1 defines the relationship between mechanical dimensions and rated output as well. There are several national or regional frame assignment standards (JIS C 4212, NBR 17094, NEMA MG13, SANS 1804 and others). As this document (IEC 60034-30-1) defines energy efficiency classes independent of dimensional constraints, it is possible that producing motors with higher efficiency classes, whilst maintaining the mechanical dimensions of national or regional standards, will not be feasible in all markets.

To meet the demands of higher energy efficiency classes, the designs of components and equipment and the selection of efficient materials should not be overlooked. There can be a need to use more materials such as electrical steel, copper and aluminium to enable the design of high efficiency motors. Consequently, the develop IE5 class motors using the same frames sizes as IE4 class motors is not always possible. The higher efficiency class motors are likely to be heavier. This will drive the need to re-design the application of the high efficiency motor.

IE codes are not limited only to motors and are used to classify other components such as frequency converters (IEC 61800-9-2). The same standard defines also IES classes to combinations of components (such as power drive systems).

However, it is anticipated that other components are rated with a comparable system: IE1 meaning low efficiency up to IE5 meaning the highest efficiency.

The efficiency levels in this document for 50 Hz and 60 Hz are not always entirely consistent across all numbers of poles and over the whole power range.

NOTE 3 The efficiency levels for 60 Hz motors were assigned for compatibility with U.S. and North American legal requirements.

This part of IEC 60034 specifies efficiency classes for single-speed electric motors that are rated in accordance with IEC 60034-1 or IEC 60079-0 and are rated for operation on a sinusoidal either 50 Hz or 60 Hz, or both voltage supply.

The motors within this document:

– have a rated power P_N from 0,12 kW to 1 000 kW;

– have a rated voltage U_N from 50 V up to and including 1 000 V;

– have 2, 4, 6 or 8 poles;

– are capable of continuous operation at their rated power with a temperature rise within the specified insulation temperature class;

NOTE 1 Most motors covered by this document are rated for duty type S1 (continuous duty). However, some motors that are rated for other duty cycles are still capable of continuous operation at their rated power, and these motors are also covered by this document.

– are marked with any ambient temperature within the range of –30 °C to +60 °C;

NOTE 2 The rated efficiency and efficiency classes are based on 25 °C ambient temperature in accordance with IEC 60034-2-1.

NOTE 3 Motors exclusively rated for temperatures outside the range –30 °C and +60 °C are considered to be of special construction and are consequently excluded from this document.

NOTE 4 Smoke extraction motors with a temperature class of up to and including 400 °C are covered by this document.

– are marked with an altitude up to 4 000 m above sea level.

NOTE 5 The rated efficiency and efficiency class are based on a rating for altitudes up to 1 000 m above sea level.

This document establishes a set of nominal efficiency values based on supply frequency, number of poles and motor output power. No distinction is made between motor technologies, supply voltage or motors with increased insulation designed specifically for converter operation even though not all motor technologies are capable of reaching the higher efficiency classes (see Table 1). This makes different motor technologies fully comparable with respect to their energy efficiency potential.

The efficiency of power-drive systems is not covered by this document. Motor losses due to harmonic content of the supply voltage, losses in cables, filters and frequency-converters, are not covered.

Motors with flanges, feet or shafts with mechanical dimensions different from IEC 60072-1 are covered by this document.

Geared motors are covered by this document including those incorporating non-standard shafts and flanges.

Totally enclosed air-over machines (TEAO, IC418), i.e. totally enclosed frame-surface cooled machines intended for exterior cooling by a ventilating means external to the machine, are covered by this document. Efficiency testing of such motors can be performed with the fan removed and the cooling provided by an external blower with a similar airflow rate as the original fan.

This document does not apply to the following:

– Single-speed motors with 10 or more poles or multi-speed motors.

– Motors with mechanical commutators (such as DC motors).

cannot be practically tested separately from the machine even with provision of a temporary end-shield and drive-end bearing. This means the motor: a) shares common components (apart from connectors such as bolts) with the driven unit (for example, a shaft or housing) and b) is not designed in such a way as to enable the motor to be separated from the driven unit as an entire motor that can operate independently of the driven unit. That is, for a motor to be excluded from this document, the process of separation shall render the motor inoperative.

– Motors with integrated frequency converters (compact drives) when the motor cannot be tested separately from the converter. Energy efficiency classification of compact drives is based on the complete product (PDS, ie. Power Drive System) and is defined in IEC 61800-9-2.

NOTE 6 A motor is not excluded when the motor and frequency-converter can be separated, and the motor can be tested independently of the converter.

– Brake motors when the brake is an integral part of the inner motor construction and can neither be removed nor supplied by a separate power source during the testing of motor efficiency.

NOTE 7 Brake motors with a brake coil that is integrated into the flange of the motor are covered as long as it is possible to test motor efficiency without the losses of the brake (for example by dismantling the brake or by energizing the brake coil from a separate power source).

When the manufacturer offers a motor of the same design with and without a brake the test of motor efficiency can be done on a motor without the brake. The determined efficiency may then be used as the rating for a motor with or without the brake.

– Submersible motors specifically designed to operate wholly immersed in a liquid.

– Smoke extraction motors with a temperature class above 400 °C.

2 Normative references

The following documents are referred to in the text in such a way that some or all their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

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

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

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

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

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

IEC 60038, *IEC standard voltages*

IEC TS 60034-31, *Rotating electrical machines - Part 31: Selection of energy-efficient motors including variable speed applications - Application guidelines*

IEC 60072-1, *Rotating electrical machines - Dimensions and output series - Part 1: Frame numbers 56 to 400 and flange numbers 55 to 1080*

IEC 60079-0, *Explosive atmospheres - Part 0: Equipment - General requirements*

IEC 61800-9-2, *Adjustable speed electrical power drive systems (PDS) - Part 9-2: Ecodesign for motor systems - Energy efficiency determination and classification*

ISO 3, *Preferred numbers - Series of preferred numbers*

EN 12101-3, *Smoke and heat control systems - Part 3: Specification for powered smoke and heat control ventilators (Fans)*

JIS C 4212 (Japanese Industrial Standard), *Low-voltage three-phase squirrel-cage high efficiency induction motors*

NBR 17094-1, *Rotating electrical machines - Induction motors - Specification*

NEMA MG1, *Motors and Generators*

SANS 1804-1 (South African Standard), *Induction motors - Part 1: IEC requirements*

SASO 2893 (Kingdom of Saudi Arabia), *Part 30-1: Efficiency classes of line operated AC motors* (IE code) (IEC 60034-30-1:2014 Ed 1.0, MOD)

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