IEC 60034-30-3

Edition 1.0 2024-02

INTERNATIONAL STANDARD

NORME INTERNATIONALE

colour inside

Rotating electrical machines –
Part 30-3: Efficiency classes of high voltage AC motors (IE-code)

Machines électriques tournantes –
Partie 30-3: Classes de rendement des moteurs à courant alternatif à haute tension (code IE)

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

ROTATING ELECTRICAL MACHINES –

Part 30-3: Efficiency classes of high voltage AC motors (IE-code)

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

Draft	Report on voting
2/2131/CDV	2/2160/RVC

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- withdrawn, or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.

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

INTRODUCTION

This document provides the global harmonization of energy-efficiency classes of three-phase cage induction motors with rated voltage above 1 000 V that are rated for direct online starting and fixed-speed operation at a 50 Hz or 60 Hz supply with sinusoidal voltage.

For these motors, the demands of the power supply and of the driven equipment in many cases govern the design of the electrical machine. Due to the large size and power of high-voltage (HV) motors, these demands are more complex than for low-voltage motors and often limit the design. Vice versa, the properties of the electrical machine itself influence the grid considerably in many cases.

In order to ensure an easy applicability of this document, the scope is limited to the most relevant applications, i.e. motors for driving the vast majority of pumps, fans, or compressors, which cover approximately 80 % to 90 % of all applications. Motors for special applications, e.g. for accelerating very high load inertia, for very low supply voltage during starting, for very low locked-rotor current or for accelerating against high load torque, are therefore out of the scope of this document.

Despite this, the motor technology, namely

- rated voltage,
- method of cooling,
- locked-rotor current,

have a significant influence on the achievable motor efficiency as well as the rated frequency, the rated power and the number of poles, and are considered when specifying the efficiency class.

NOTE When specifying or designing a power drive system, low voltage motors will mostly have a higher efficiency than high voltage motors with the same rated power. However, considering the losses of the complete system, i.e. including cabling and transformer losses, high voltage solution might be advantageous.

ROTATING ELECTRICAL MACHINES –

Part 30-3: Efficiency classes of high voltage AC motors (IE-code)

1 Scope

This part of IEC 60034 specifies efficiency classes for fixed-speed three-phase high-voltage cage induction motors in accordance with IEC 60034-1 that

- have a rated voltage exceeding 1 000 V, but not exceeding 11 kV;
- have a rated power from 200 kW to 2 000 kW;

  NOTE 1 Motors with rated power above 2 000 kW are produced in such small numbers and are designed and produced with a focus on achieving an optimum efficiency anyway, even though fulfilling increasingly special requirements that assigning efficiency classes would be an additional effort without the result of any countable energy saving.

- have two, four or six poles;
- are rated for single-speed line-operation;
- are intended for direct-on-line starting at rated or at reduced voltage and rated frequency;
- are constructed to any degree of protection;
- are designed for cooling methods IC411, IC511, IC611, IC01 or IC81W;
- are capable of continuous operation at their rated operating point (torque/power, speed) with a temperature rise within the specified insulation temperature class;

  NOTE 2 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.

- are rated for any ambient temperature or coolant temperature within the range of – 20 °C to + 60 °C;

  NOTE 3 Motors rated for temperatures outside the range – 20 °C and + 60 °C are considered to be of special construction and are consequently excluded from this document.

- are rated for an operating altitude up to 2 000 m above sea level;

  NOTE 4 The rated efficiency and the efficiency class are based on a rating for altitudes up to 1 000 m above sea level.

- have a locked-rotor current I_l at stand-still and supply with rated voltage and frequency before application of any IEC or agreed tolerance in the range I_l / I_N ≥ 4,5;
- are designed for a customer load torque during starting not exceeding an envelope with a minimum of 25 % of the rated torque at low speed and a square shape $T \sim n^2$ up to a maximum load torque at full speed of 60 % of the rated torque in case of 2 pole motors or 100 % of the rated torque in case of 4 pole or 6 pole motors, respectively, (see Figure 1), After starting is completed, the load torque of 2 pole motors is increased to 100 % of the rated torque;
- have to accelerate an external moment of inertia as defined by the customer requirements not exceeding the values given in Table 1 considering all start up conditions defined in this document for not more than three consecutive starts from cold condition or two starts from hot condition, respectively;
- are designed for a minimum locked-rotor steady state supply voltage of at least 80 % of the rated voltage during starting.

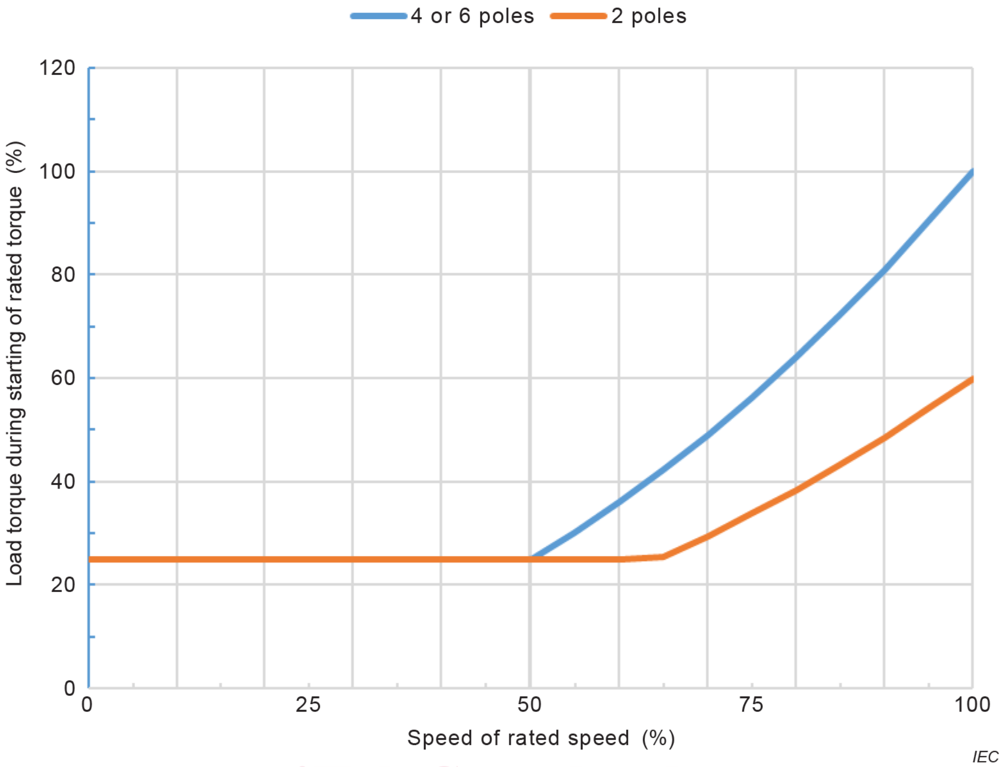

Figure 1 – Envelope of the load torque during starting:
Load torque during starting in % of rated torque over speed in % of rated speed

Table 1 – Maximum external moment of inertia

Number of poles	**2**		**4**		**6**	
Frequency Hz	**50**	**60**	**50**	**60**	**50**	**60**
Rated output kW	**Moment of inertia *J*** kg m^2					
200	25	15	115	75	310	200
220	25	15	120	80	330	210
250	25	15	130	85	360	230
280	30	20	140	90	400	250
315	30	20	150	100	440	270
355	35	20	170	110	480	300
400	35	25	190	120	530	330
450	40	25	210	130	580	360
500	45	30	230	140	640	400
560	50	30	250	150	700	440
630	55	35	280	170	780	490
710	60	35	310	190	870	550
800	65	40	340	210	970	610
900	70	45	380	230	1 100	680
1 000	80	50	420	260	1 200	750
1 120	90	55	460	290	1 300	830
1 250	100	60	510	320	1 450	920
1 400	110	65	570	360	1 650	1 000
1 600	120	70	640	400	1 850	1 150
1 800	130	80	720	440	2 050	1 300
2 000	150	90	800	490	2 300	1 450

NOTE 1 The values of the moment of inertia given are in terms of mr^2 where m is the mass and r is the mean radius of gyration.

NOTE 2 Moment of inertia is defined in ISO 3: 1973, 3.7.

NOTE 3 If necessary, linear interpolation is permitted between two adjacent values.

Excluded are:

- Motors with mechanical commutators or slip-rings;
- Motors with 8 or more poles;
- Multi-speed motors;
- Motors with customer starting torque requirements exceeding the load torque envelope above, and motors exceeding the maximum external inertia defined in Table 1;
- Motors designed specifically for operation fed by a power electronic frequency converter with a temperature rise within the specified insulation thermal class or thermal class;
- Motors completely integrated with the driven machine (for example pumps, fans and compressors). This means that the motor cannot be designed in such a way as to enable the motor to be separated from the driven unit, i.e. it is not possible to operate the separated motor without the driven unit;
- Submersible motors specifically designed to operate wholly immersed in a liquid;

- Smoke extraction motors;
- Motors dedicated to operate in explosive atmospheres;
- Motors for operation in nuclear plants, especially nuclear power plants.

2 Normative references

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

IEC 60034-1:2022, *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 60050-411:1996, *International Electrotechnical Vocabulary (IEV) – Part 411: Rotating machinery*
IEC 60050-411:1996/AMD1:2007
IEC 60050-411:1996/AMD2:2021

3 Terms, definitions and symbols

For the purposes of this document, the terms and definitions in IEC 60050-411, IEC 60034-1, and the following apply.

NOTE 1 For definitions concerning cooling and coolants, other than those in 3.17 to 3.22, see IEC 60034-6.

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

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

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

3.1 Terms and definitions

3.1.1
reference efficiency
efficiency value required to meet a certain efficiency class according to the efficiency tables in this document before technology factors for voltage, cooling or starting conditions are applied

3.1.2
nominal efficiency
efficiency value that a motor’s assigned rated efficiency must meet or exceed at rated operation for a certain efficiency class, considering starting requirements and motor technology

3.1.3
rated efficiency
efficiency value assigned by the manufacturer to the motor for operation at rated conditions before the application of any IEC or agreed tolerance

3.1.4
average motor torque
mean value of the steady-state torque at the motor shaft between stand-still and no-load operation when supplied with rated voltage and frequency

3.1.5
load torque
speed-dependent torque requirement of the driven equipment at the motor shaft during start-up of the motor between stand-still and full speed

3.2 Symbols

I_l is the locked-rotor current at rated voltage before application of any IEC or agreed tolerance

I_N is the rated current

T_{av} is the average motor torque as defined in 3.1.4

T_N is the rated torque

P_N is the rated power

$2p$ is the number of poles

U_N is the rated voltage

η_n is the nominal efficiency

η_r is the reference efficiency

η_N is the rated efficiency

4 Efficiency classification

4.1 Determination

4.1.1 General

For assigning an efficiency class, efficiency and losses of AC motors within the scope shall be tested according to IEC 60034-2-1 using method 2-1-1B or method 2-1-1C from this document.

4.1.2 Auxiliary devices

Some electric motors covered by this document may be equipped with auxiliary devices such as shaft seals, mechanical brakes, back-stops and unidirectional bearings, speed sensors, tacho-generators in various combinations.

However, as long as these auxiliary devices are not an integral part of the basic motor design, the determination of efficiency in all possible combinations is not practical. Tests for efficiency of such modified standard motors shall be performed on basic motors with original cooling without auxiliary devices installed.

Angular-contact bearings (thrust bearings) for vertical mounted motors may be replaced by standard bearings during efficiency testing. All vertical motors may be tested horizontally.

Some types of motors (like pump motors and others) are equipped with shaft seals to prevent ingress of oil or water into the motor. External seals may be removed for efficiency testing. This applies only to seals that are accessible from the outside without dismantling of the motor (dismantling of the fan-cover and the fan is accepted).

Electro-mechanical brakes shall be removed during testing of motor efficiency. When the motor construction prohibits the removal of the brake, the brake-coil shall be energized from a separate power source and the energy consumption of the brake-coil shall be disregarded in the calculation of motor efficiency.

4.2 Efficiency rating – General procedure

A motor's rated efficiency η_N is determined from the losses at rated operation obtained by measurement according to IEC 60034-2-1.

The reference efficiency η_r (i.e. not considering starting conditions and motor technology) for a certain IE class depends on the rated power P_N, the number of poles $2p$ and the rated frequency f_N. It is given in Table 2 to Table 7.

IE4 levels of efficiency are added for future consideration and might be unachievable for some power ratings.

Table 2 – Reference efficiency values η_r for $2p = 2$, $f_N = 50$ Hz

IE-class / $2p = 2$ / P_N in kW	IE1	IE2	IE3	IE4
200	90,65 %	91,79 %	92,79 %	93,67 %
220	90,91 %	92,03 %	93,00 %	93,86 %
250	91,18 %	92,27 %	93,22 %	94,06 %
280	91,46 %	92,52 %	93,44 %	94,26 %
315	91,79 %	92,81 %	93,70 %	94,49 %
355	92,12 %	93,11 %	93,97 %	94,73 %
400	92,39 %	93,36 %	94,20 %	94,93 %
450	92,67 %	93,60 %	94,42 %	95,13 %
500	92,94 %	93,85 %	94,64 %	95,32 %
560	93,22 %	94,09 %	94,86 %	95,52 %
630	93,49 %	94,34 %	95,08 %	95,72 %
710	93,71 %	94,53 %	95,25 %	95,88 %
800	93,92 %	94,73 %	95,43 %	96,04 %
900	94,08 %	94,87 %	95,56 %	96,16 %
1 000	94,23 %	95,00 %	95,68 %	96,26 %
1 120	94,41 %	95,17 %	95,83 %	96,40 %
1 250	94,59 %	95,33 %	95,97 %	96,53 %
1 400	94,76 %	95,48 %	96,11 %	96,65 %
1 600	94,95 %	95,64 %	96,25 %	96,78 %
1 800	95,08 %	95,77 %	96,36 %	96,88 %
2 000	95,22 %	95,89 %	96,47 %	96,98 %

Table 3 – Reference efficiency values η_r for $2p = 4$, $f_N = 50$ Hz

IE-class / $2p = 4$ P_N in kW	IE1	IE2	IE3	IE4
200	90,88 %	92,00 %	92,97 %	93,83 %
220	91,14 %	92,23 %	93,18 %	94,02 %
250	91,41 %	92,47 %	93,39 %	94,21 %
280	91,68 %	92,71 %	93,61 %	94,40 %
315	92,00 %	93,00 %	93,87 %	94,63 %
355	92,32 %	93,29 %	94,13 %	94,87 %
400	92,59 %	93,53 %	94,35 %	95,06 %
450	92,86 %	93,77 %	94,57 %	95,26 %
500	93,13 %	94,01 %	94,77 %	95,44 %
560	93,40 %	94,25 %	94,99 %	95,64 %
630	93,67 %	94,49 %	95,21 %	95,84 %
710	93,88 %	94,68 %	95,38 %	95,99 %
800	94,09 %	94,87 %	95,55 %	96,15 %
900	94,24 %	95,01 %	95,68 %	96,26 %
1 000	94,39 %	95,14 %	95,80 %	96,37 %
1 120	94,57 %	95,31 %	95,95 %	96,51 %
1 250	94,74 %	95,46 %	96,08 %	96,63 %
1 400	94,91 %	95,61 %	96,22 %	96,75 %
1 600	95,09 %	95,77 %	96,36 %	96,88 %
1 800	95,22 %	95,89 %	96,47 %	96,98 %
2 000	95,36 %	96,01 %	96,58 %	97,07 %