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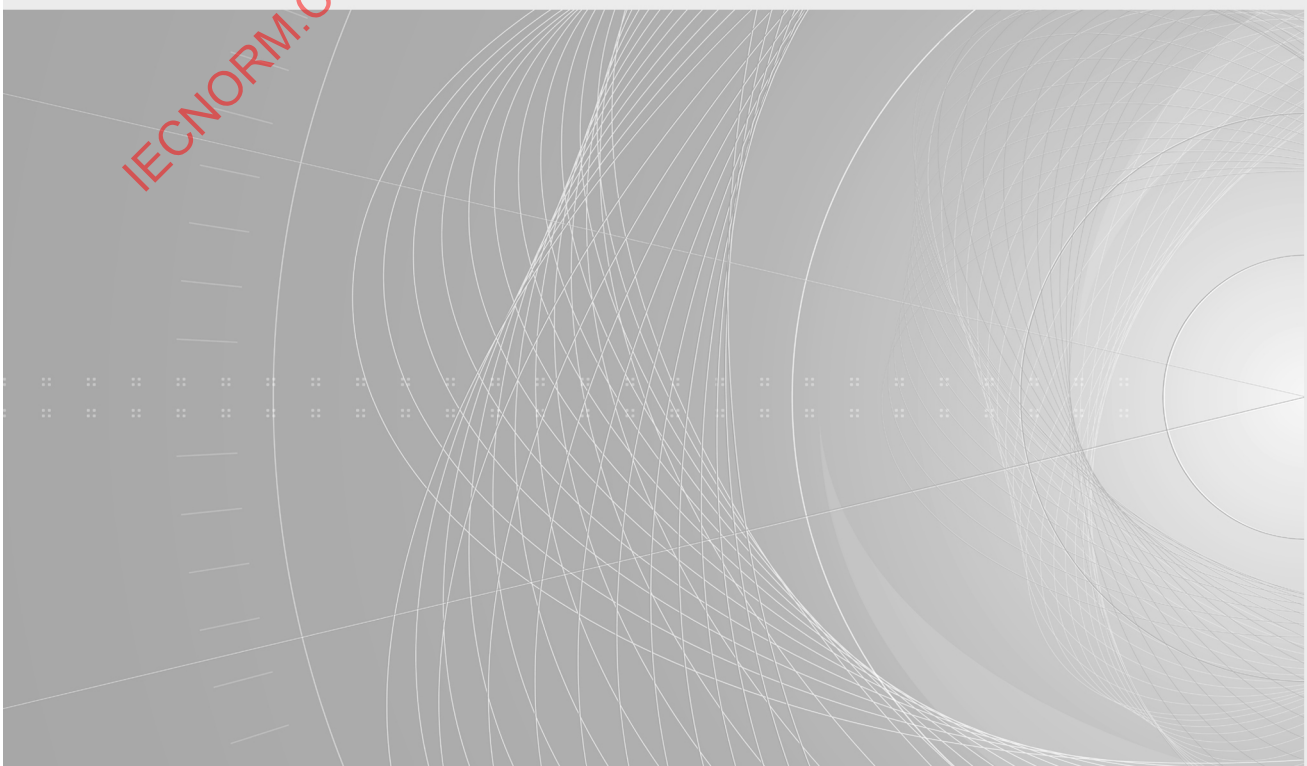
Rotating electrical machines –
Part 12: Starting performance of single-speed three-phase cage induction motors



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Rotating electrical machines – Part 12: Starting performance of single-speed three-phase cage induction motors

INTERNATIONAL ELECTROTECHNICAL COMMISSION

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CONTENTS

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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ROTATING ELECTRICAL MACHINES –

Part 12: Starting performance of single-speed three-phase cage induction motors

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International Standard IEC 60034-12 has been prepared by IEC technical committee 2: Rotating machinery.

This third edition cancels and replaces the second edition, published in 2002, and its amendment 1, published in 2007. It constitutes a technical revision.

The main technical changes with regard to the previous edition are as follows:

Clause or subclause	Change
1	Part of note 3 moved to the regular text
3	Definition of locked rotor current and of rated voltage added
5	New design letter E for extended efficiency motors, explanation of all design letters and description of new designs NE, NEY, HE, and HEY
6.2 and 9.2	Limits for locked rotor apparent power for E(Ex)e motors replaced by a reference to IEC 60079-7
	Formula added to calculate locked rotor current from apparent power
7 and 10	Definition of new limits for locked rotor apparent power for extended efficiency motors (new table 3)
Tables	Tables 1 and 4 to 7 extended down to P_N = 120 W
	Name of type of protection updated according to IEC 60079-7 Ed. 5

The text of this standard is based on the following documents:

CDV	Report on voting
2/1789/CDV	2/1821A/RVC

Full information on the voting for the approval of this standard can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

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 in the IEC TC 2 dashboard on the IEC website.

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC website under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

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ROTATING ELECTRICAL MACHINES –

Part 12: Starting performance of single-speed three-phase cage induction motors

1 Scope

This part of IEC 60034 specifies the parameters for ~~four~~ eight designs of starting performance of single-speed three-phase 50 Hz or 60 Hz cage induction motors in accordance with IEC 60034-1 that:

– have a rated voltage up to 1 000 V;
– are intended for direct-on-line or star-delta starting;
– are rated on the basis of duty type S1;
– are constructed to any degree of protection and explosion protection.

This document also applies to dual voltage motors provided that the flux saturation level is the same for both voltages ~~and to motors having type of protection 'e – increased safety' with temperature classes T1 to T3 complying with IEC 60079-0 and IEC 60079-7~~.

The values of torque, apparent power and current given in this document are limiting values (that is, minimum or maximum without tolerance).

NOTE 1 It is not expected that all manufacturers will produce machines for all ~~four~~ eight designs. The selection of any specific design in accordance with this document will be a matter of agreement between the manufacturer and the purchaser.

NOTE 2 Designs other than the ~~four~~ eight specified may be necessary for particular applications.

NOTE 3 It should be noted that values given in manufacturers' catalogues may include tolerances in accordance with IEC 60034-1.

NOTE 4 The values tabled for locked rotor apparent power are based on r.m.s. symmetrical steady state locked rotor currents; at motor switch on there will be a one-half cycle asymmetrical instantaneous peak current which may range from 1,8 to 2,8 times the steady state locked rotor value. The current peak and decay time are a function of the motor design and switching angle.

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, *Rotating electrical machines – Part 1: Rating and performance*~~

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

~~IEC 60079-0, *Electrical apparatus for explosive gas atmospheres – Part 0: General requirements*~~

IEC 60079-7:2015, ~~*Electrical apparatus for*~~ *Explosive* ~~*gas*~~ *atmospheres – Part 7: Equipment protection by increased safety "e"*

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3 Terms and definitions

For the purposes of this document, the following terms and definitions 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
rated torque
T_N
torque the motor develops at its shaft end at rated output and speed

[SOURCE: IEC 60050-411:1996, 411-48-05]

3.2
locked-rotor torque
T_l
smallest 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]

3.3
pull-up torque
T_u
smallest 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 motors whose 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. 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.

3.4
breakdown torque
T_b
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 those motors whose torque continually decreases with increase in speed.

3.5
rated output
P_N
value of the output included in the rating

3.6
rated voltage
U_N
value of the voltage included in the rating

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3.7
locked rotor apparent power
S_I
apparent power input with the motor held at rest at rated voltage and frequency

3.8
locked rotor current
I_I
steady state current with the motor held at rest at rated voltage and frequency

4 Symbols

Symbol	Quantity
J	External moment of inertia
p	Number of pole pairs
P_N	Rated output
S_I	Locked rotor apparent power
T_N	Rated torque
T_I	Locked rotor torque
T_u	Pull-up torque
T_b	Breakdown torque

5 Designation

5.1 General

Motors designed according to this document are classified according to 5.2 to 5.7. The letters used to specify the different designs stand for:

N: normal starting torque

H: high starting torque

Y: star-delta starting

E: motors utilizing extended / higher locked rotor apparent power and current to achieve a higher efficiency class according to IEC 60034-30-1

5.2 Design N

Normal starting torque three-phase cage induction motors, intended for direct-on-line starting, having 2, 4, 6 or 8 poles, rated from ~~0,4~~ 0,12 kW to 1 600 kW.

5.3 Design NE

Normal starting torque three-phase cage induction motors having higher locked rotor apparent power than design N, intended for direct-on-line starting, having 2, 4, 6 or 8 poles, rated from 0,12 kW to 1 600 kW.

5.4 Designs NY and NEY

Motors similar to designs N or NE, respectively, but intended for star-delta starting. For these motors in star-connection, minimum values for T_I and T_u are 25 % of the values of design N or NE, respectively, see Table 1.

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5.5 Design H

High starting torque three-phase cage induction motors with 4, 6 or 8 poles, intended for direct-online starting, rated from ~~0,4~~ 0,12 kW to 160 kW at a frequency of 60 Hz.

5.6 Design HE

High starting torque three-phase cage induction motors having higher locked rotor apparent power than design H, with 4, 6 or 8 poles, intended for direct-online starting, rated from 0,12 kW to 160 kW at a frequency of 60 Hz.

5.7 Designs HY and HEY

Motors similar to designs H or HE, respectively, but intended for star-delta starting. For these motors in star-connection, minimum values for T_l and T_u are 25 % of the values of design H or HE, respectively, see Table 5.

6 Design N requirements

6.1 Torque characteristics

The starting torque is represented by three characteristic features. These features shall be in accordance with the appropriate values given in Table 1 or Table 6. The values in Table 1 and Table 6 are minimum values at rated voltage. Higher values are allowed.

The motor torque at any speed between zero and that at which breakdown torque occurs shall be not less than 1,3 times the torque obtained from a curve varying as the square of the speed and being equal to rated torque at rated speed. However, for 2-pole motors with type of protection '~~e~~ Ex eb – increased safety' having a rated output greater than 100 kW, the motor torque at any speed between zero and that at which breakdown torque occurs shall not be less than 1,3 times the torque obtained from a curve varying as the square of the speed and being equal to 70 % rated torque at rated speed. For motors with type of protection '~~e~~ Ex eb', the three characteristic torques shall be in accordance with the appropriate values given in Table 6.

NOTE The factor 1,3 has been chosen with regard to an undervoltage of 10 % in relation to the rated voltage at the motor terminals during the acceleration period.

6.2 Locked rotor current and apparent power

The locked rotor apparent power shall be not greater than the appropriate value given in Table 2 ~~or table 6~~. The values given in Table 2 ~~and table 6~~ are independent of the number of poles and are maximum values at rated voltage. For motors with type of protection 'e', locked rotor apparent power shall be in accordance with the appropriate values ~~given in table 6~~ specified in IEC 60079-7.

The locked rotor current is calculated from the locked rotor apparent power according to:

$$I_l = \frac{S_l}{P_N} \times \frac{P_N}{\sqrt{3} U_N}$$

NOTE The advantage of specifying S_l/P_N instead of I_l/I_N is that the locked rotor current can be calculated from rated power and rated voltage only, not requiring to know the rated current which depends on quantities such as power factor and efficiency that are usually not known in early stages of a project.

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6.3 Starting requirements

Motors shall be capable of withstanding two starts in succession (coasting to rest between starts) from cold conditions and one start from hot after running at rated conditions. The retarding torque due to the driven load will be in each case proportional to the square of the speed and equal to the rated torque at rated speed with the external moment of inertia given in Table 4 or Table 7.

In each case, a further start is permissible only if the motor temperature before starting does not exceed the steady temperature at rated load. However, for 2-pole motors with type of protection '~~e~~ Ex eb – increased safety' having a rated output greater than 100 kW, the retarding torque due to the driven load is proportional to the square of the speed and equal to 70 % rated torque at rated speed, with the external moment of inertia given in Table 7. After this starting, load with rated torque is possible.

NOTE It should be recognized that the number of starts should be minimized since these affect the life of the motor.

7 Design ~~NY~~ NE starting requirements

The starting requirements are as for design N, except that the limits for locked rotor apparent power in Table 3 apply, as increasing efficiency values require physically increasing values for locked rotor apparent power.

8 Designs NY and NEY starting requirements

The starting requirements are as for designs N or NE, respectively. In addition, however, a reduced retarding torque is necessary as the starting torque in 'star connection' may be insufficient to accelerate some loads to an acceptable speed.

NOTE It should be recognized that the number of starts should be minimized since these affect the life of the motor.

9 Design H requirements

9.1 Starting torque

The starting torque is represented by three characteristic features. These features shall be in accordance with the appropriate values given in Table 5. These values are minimum values at rated voltage. Higher values are allowed.

9.2 Locked rotor current and apparent power

The locked rotor apparent power shall be not greater than the appropriate value given in Table 2. The values in Table 2 are independent of the number of poles and are maximum values at rated voltage.

The locked rotor current is calculated from the locked rotor apparent power according to the formula given in 6.2.

9.3 Starting requirements

Motors shall be capable of withstanding two starts in succession (coasting to rest between starts) from cold conditions, and one start from hot after running at rated conditions. The retarding torque due to the driven load is assumed to be constant and equal to rated torque, independent of speed, with an external moment of inertia of 50 % of the values given in Table 4.

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In each case, a further start is permissible only if the motor temperature before starting does not exceed the steady temperature at rated load.

NOTE It should be recognized that the number of starts should be minimized since these affect the life of the motor.

10 Design ~~HY~~ HE starting requirements

The starting requirements are as for design H, except that the limits for locked rotor apparent power in Table 3 apply, as increasing efficiency values require physically increasing values for locked rotor apparent power.

11 Designs HY and HEY starting requirements

The starting requirements are as for design H or HE, respectively. In addition, however, a reduced retarding torque is necessary as the starting torque in 'star connection' may be insufficient to accelerate some loads to an acceptable speed.

NOTE It should be recognized that the number of starts should be minimized since these affect the life of the motor.

Table 1 – Minimum values of torques for design N

Range of rated output kW	Number of poles											
	2			4			6			8		
	T_l	T_u	T_b	T_l	T_u	T_b	T_l	T_u	T_b	T_l	T_u	T_b
~~0,4~~ 0,12 ≤ P_N ≤ 0,63	1,9	1,3	2,0	2,0	1,4	2,0	1,7	1,2	1,7	1,5	1,1	1,6
0,63 < P_N ≤ 1,0	1,8	1,2	2,0	1,9	1,3	2,0	1,7	1,2	1,8	1,5	1,1	1,7
1,0 < P_N ≤ 1,6	1,8	1,2	2,0	1,9	1,3	2,0	1,6	1,1	1,9	1,4	1,0	1,8
1,6 < P_N ≤ 2,5	1,7	1,1	2,0	1,8	1,2	2,0	1,6	1,1	1,9	1,4	1,0	1,8
2,5 < P_N ≤ 4,0	1,6	1,1	2,0	1,7	1,2	2,0	1,5	1,1	1,9	1,3	1,0	1,8
4,0 < P_N ≤ 6,3	1,5	1,0	2,0	1,6	1,1	2,0	1,5	1,1	1,9	1,3	1,0	1,8
6,3 < P_N ≤ 10	1,5	1,0	2,0	1,6	1,1	2,0	1,5	1,1	1,8	1,3	1,0	1,7
10 < P_N ≤ 16	1,4	1,0	2,0	1,5	1,1	2,0	1,4	1,0	1,8	1,2	0,9	1,7
16 < P_N ≤ 25	1,3	0,9	1,9	1,4	1,0	1,9	1,4	1,0	1,8	1,2	0,9	1,7
25 < P_N ≤ 40	1,2	0,9	1,9	1,3	1,0	1,9	1,3	1,0	1,8	1,2	0,9	1,7
40 < P_N ≤ 63	1,1	0,8	1,8	1,2	0,9	1,8	1,2	0,9	1,7	1,1	0,8	1,7
63 < P_N ≤ 100	1,0	0,7	1,8	1,1	0,8	1,8	1,1	0,8	1,7	1,0	0,7	1,6
100 < P_N ≤ 160	0,9	0,7	1,7	1,0	0,8	1,7	1,0	0,8	1,7	0,9	0,7	1,6
160 < P_N ≤ 250	0,8	0,6	1,7	0,9	0,7	1,7	0,9	0,7	1,6	0,9	0,7	1,6
250 < P_N ≤ 400	0,75	0,6	1,6	0,75	0,6	1,6	0,75	0,6	1,6	0,75	0,6	1,6
400 < P_N ≤ 630	0,65	0,5	1,6	0,65	0,5	1,6	0,65	0,5	1,6	0,65	0,5	1,6
630 < P_N ≤ 1 600	0,5	0,3	1,6	0,5	0,3	1,6	0,5	0,3	1,6	0,5	0,3	1,6
NOTE The values given are per unit T_N.												

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Table 2 – Maximum values of locked rotor apparent power for designs N and H

Range of rated output kW	S_I/P_N
$P_N \leq 0,4$	22
~~$0,4 \leq P_N \leq 6,3$~~	~~13~~
$0,4 < P_N \leq 0,63$	19
$0,63 < P_N \leq 1,0$	17
$1,0 < P_N \leq 1,8$	15
$1,8 < P_N \leq 4,0$	14
$4,0 < P_N \leq 6,3$	13
$6,3 < P_N \leq 25$	12
$25 < P_N \leq 63$	11
$63 < P_N \leq 630$	10
$630 < P_N \leq 1\ 600$	9
~~NOTE S_I is expressed as a per unit value of PN (kVA/kW).~~	

Table 3 – Maximum values of locked rotor apparent power for designs NE and HE

Range of rated output kW	S_I/P_N
$P_N \leq 0,4$	22
$0,4 < P_N \leq 0,63$	19
$0,63 < P_N \leq 1,0$	17
$1,0 < P_N \leq 6,3$	15
$6,3 < P_N \leq 25$	14
$25 < P_N \leq 63$	13
$63 < P_N \leq 630$	12
$630 < P_N \leq 1\ 600$	11

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Table 4 – External moment of inertia (J)

Number of poles	2		4		6		8	
Frequency Hz	50	60	50	60	50	60	50	60
Rated output kW	Moment of inertia kg m^2							
0,12	0,006	0,004	0,034	0,025	0,092	0,069	0,190	0,142
0,25	0,011	0,009	0,065	0,049	0,179	0,134	0,368	0,276
0,4	0,018	0,014	0,099	0,074	0,273	0,205	0,561	0,421
0,63	0,026	0,020	0,149	0,112	0,411	0,308	0,845	0,634
1,0	0,040	0,030	0,226	0,170	0,624	0,468	1,28	0,960
1,6	0,061	0,046	0,345	0,259	0,952	0,714	1,95	1,46
2,5	0,091	0,068	0,516	0,387	1,42	1,07	2,92	2,19
4,0	0,139	0,104	0,788	0,591	2,17	1,63	4,46	3,34
6,3	0,210	0,158	1,19	0,889	3,27	2,45	6,71	5,03
10	0,318	0,239	1,80	1,35	4,95	3,71	10,2	7,63
16	0,485	0,364	2,74	2,06	7,56	5,67	15,5	11,6
25	0,725	0,544	4,10	3,07	11,3	8,47	23,2	17,4
40	1,11	0,830	6,26	4,69	17,2	12,9	35,4	26,6
63	1,67	1,25	9,42	7,06	26,0	19,5	53,3	40,0
100	2,52	1,89	14,3	10,7	39,3	29,5	80,8	60,6
160	3,85	2,89	21,8	16,3	60,1	45,1	123	92,5
250	5,76	4,32	32,6	24,4	89,7	67,3	184	138
400	8,79	6,59	49,7	37,3	137	103	281	211
630	13,2	9,90	74,8	56,1	206	155	423	317
1 600	30,6	23	173	130	477	358	979	734

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 ~~31/3 1992, Number 3-7~~ 80000-4:2006, Number 4-7.

NOTE 3 For intermediate and higher values, external moments of inertia shall be calculated according to the following formula from which the values in the table have been calculated:

– for 50 Hz motors $J = 0{,}04P^{0{,}9}p^{2{,}5}$

– for 60 Hz motors $J = 0{,}03P^{0{,}9}p^{2{,}5}$

where: J is the external moment of inertia in kg m^2;

P is the output in kW;

p is the number of pairs of poles.

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Table 5 – Minimum values of torques for design H

Range of rated output kW	Number of poles								
	4			6			8		
	T_l	T_u	T_b	T_l	T_u	T_b	T_l	T_u	T_b
~~0,4~~ 0,12 ≤ P_N ≤ 0,63	3,0	2,1	2,1	2,55	1,8	1,9	2,25	1,65	1,9
0,63 < P_N ≤ 1,0	2,85	1,95	2,0	2,55	1,8	1,9	2,25	1,65	1,9
1,0 < P_N ≤ 1,6	2,85	1,95	2,0	2,4	1,65	1,9	2,1	1,5	1,9
1,6 < P_N ≤ 2,5	2,7	1,8	2,0	2,4	1,65	1,9	2,1	1,5	1,9
2,5 < P_N ≤ 4,0	2,55	1,8	2,0	2,25	1,65	1,9	2,0	1,5	1,9
4,0 < P_N ≤ 6,3	2,4	1,65	2,0	2,25	1,65	1,9	2,0	1,5	1,9
6,3 < P_N ≤ 10	2,4	1,65	2,0	2,25	1,65	1,9	2,0	1,5	1,9
10 < P_N ≤ 16	2,25	1,65	2,0	2,1	1,5	1,9	2,0	1,4	1,9
16 < P_N ≤ 25	2,1	1,5	1,9	2,1	1,5	1,9	2,0	1,4	1,9
25 < P_N ≤ 40	2,0	1,5	1,9	2,0	1,5	1,9	2,0	1,4	1,9
40 < P_N ≤ 160	2,0	1,4	1,9	2,0	1,4	1,9	2,0	1,4	1,9

NOTE 1 The values given are per unit T_N.

NOTE 2 The values of T_l are 1,5 times the corresponding values for design N, but are not less than 2,0.

NOTE 3 The values of T_u are 1,5 times the corresponding values for design N, but are not less than 1,4.

NOTE 4 The values of T_b are equal to the corresponding values for design N, but are not less than 1,9 and the values of T_u.

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Table 6 – Minimum values of torques for design N ~~e~~ motors with type of protection '~~e~~ Ex eb – increased safety'

Range of rated output kW	Number of poles											
	2			4			6			8		
	T_l	T_u	T_b	T_l	T_u	T_b	T_l	T_u	T_b	T_l	T_u	T_b
~~0,4~~ 0,12 ≤ P_N ≤ 0,63	1,7	1,1	1,8	1,8	1,2	1,8	1,5	1,1	1,6	1,4	1,0	1,6
0,63 < P_N ≤ 1,0	1,6	1,1	1,8	1,7	1,2	1,8	1,5	1,1	1,6	1,4	1,0	1,6
1,0 < P_N ≤ 1,6	1,6	1,1	1,8	1,7	1,2	1,8	1,4	1,0	1,7	1,3	1,0	1,6
1,6 < P_N ≤ 2,5	1,5	1,0	1,8	1,6	1,1	1,8	1,4	1,0	1,7	1,3	1,0	1,6
2,5 < P_N ≤ 4,0	1,4	1,0	1,8	1,5	1,1	1,8	1,4	1,0	1,7	1,2	0,9	1,6
4,0 < P_N ≤ 6,3	1,4	1,0	1,8	1,4	1,0	1,8	1,4	1,0	1,7	1,2	0,9	1,6
6,3 < P_N ≤ 10	1,4	1,0	1,8	1,4	1,0	1,8	1,4	1,0	1,6	1,2	0,9	1,6
10 < P_N ≤ 16	1,3	0,9	1,8	1,4	1,0	1,8	1,3	1,0	1,6	1,1	0,8	1,6
16 < P_N ≤ 25	1,2	0,9	1,7	1,3	1,0	1,7	1,3	1,0	1,6	1,1	0,8	1,6
25 < P_N ≤ 40	1,1	0,8	1,7	1,2	0,9	1,7	1,2	0,9	1,6	1,1	0,8	1,6
40 < P_N ≤ 63	1,0	0,7	1,6	1,1	0,8	1,6	1,1	0,8	1,6	1,0	0,7	1,6
63 < P_N ≤ 100	0,9	0,65	1,6	1,0	0,8	1,6	1,0	0,8	1,6	0,9	0,7	1,6
100 < P_N ≤ 160	0,8	0,6	1,6	0,9	0,7	1,6	0,9	0,7	1,6	0,8	0,6	1,6
160 < P_N ≤ 250	0,75	0,55	1,6	0,8	0,6	1,6	0,8	0,6	1,6	0,8	0,6	1,6
250 < P_N ≤ 400	0,7	0,55	1,6	0,7	0,55	1,6	0,7	0,55	1,6	0,7	0,55	1,6
400 < P_N ≤ 630	0,6	0,45	1,6	0,6	0,45	1,6	0,6	0,4	1,6	0,6	0,4	1,6
NOTE The values given are per unit T_N.												

~~**Table 6 – Maximum values of locked rotor apparent power for motors with type of protection 'e'**~~

~~Range of rated output kW~~	~~S_l~~
~~0,4 ≤ P_N ≤ 6,3~~	~~12~~
~~6,3 < P_N ≤ 63~~	~~11~~
~~63 < P_N ≤ 630~~	~~10~~
~~NOTE S_l is expressed as a per unit value of P_N (kVA/kW).~~	

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Table 7 – External moment of inertia (J) for motors with type of protection ~~'e'~~ 'Ex eb – increased safety'

Number of poles	2		4		6		8	
Frequency Hz	50	60	50	60	50	60	50	60
Rated output kW	Moment of inertia kg m^2							
0,12	0,006	0,005	0,037	0,027	0,101	0,076	0,207	0,155
0,25	0,012	0,009	0,066	0,050	0,183	0,137	0,375	0,281
0,4	0,017	0,013	0,097	0,073	0,267	0,200	0,548	0,411
0,63	0,025	0,019	0,140	0,105	0,386	0,289	0,792	0,594
1,0	0,036	0,027	0,204	0,153	0,561	0,421	1,15	0,864
1,6	0,053	0,040	0,298	0,223	0,821	0,616	1,69	1,26
2,5	0,076	0,057	0,428	0,321	1,18	0,884	2,42	1,81
4,0	0,110	0,083	0,626	0,469	1,72	1,29	3,54	2,66
6,3	0,160	0,120	0,904	0,678	2,49	1,87	5,12	3,84
10	0,232	0,174	1,31	0,986	3,62	2,72	7,44	5,58
16	0,340	0,255	1,92	1,44	5,30	3,98	10,9	8,16
25	0,488	0,366	2,76	2,07	7,61	5,71	15,6	11,7
40	0,714	0,536	4,04	3,03	11,1	8,35	22,9	17,1
63	1,03	0,774	5,84	4,38	16,1	12,1	33,0	24,8
100	1,50	1,13	8,49	6,37	23,4	17,5	48,0	36,0
160	2,20	1,65	12,4	9,32	34,2	25,7	70,3	52,7
250	3,15	2,36	17,8	13,4	49,1	36,9	101,0	75,7
400	4,61	3,46	26,1	19,6	71,9	53,9	148	111
630	6,66	5,00	37,7	28,3	104	77,9	213	160

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 ~~31/3 1992, Number 3-7~~ 80000-4:2006, Number 4-7.

NOTE 3 For intermediate and higher values, external moments of inertia shall be calculated according to the following formula from which the values in the table have been calculated:

– for 50 Hz motors $J = 0{,}036 P^{0{,}81} p^{2{,}5}$

– for 60 Hz motors $J = 0{,}027 P^{0{,}81} p^{2{,}5}$

where: J is the external moment of inertia in kg m^2;

P is the output in kW;

p is the number of pairs of poles.

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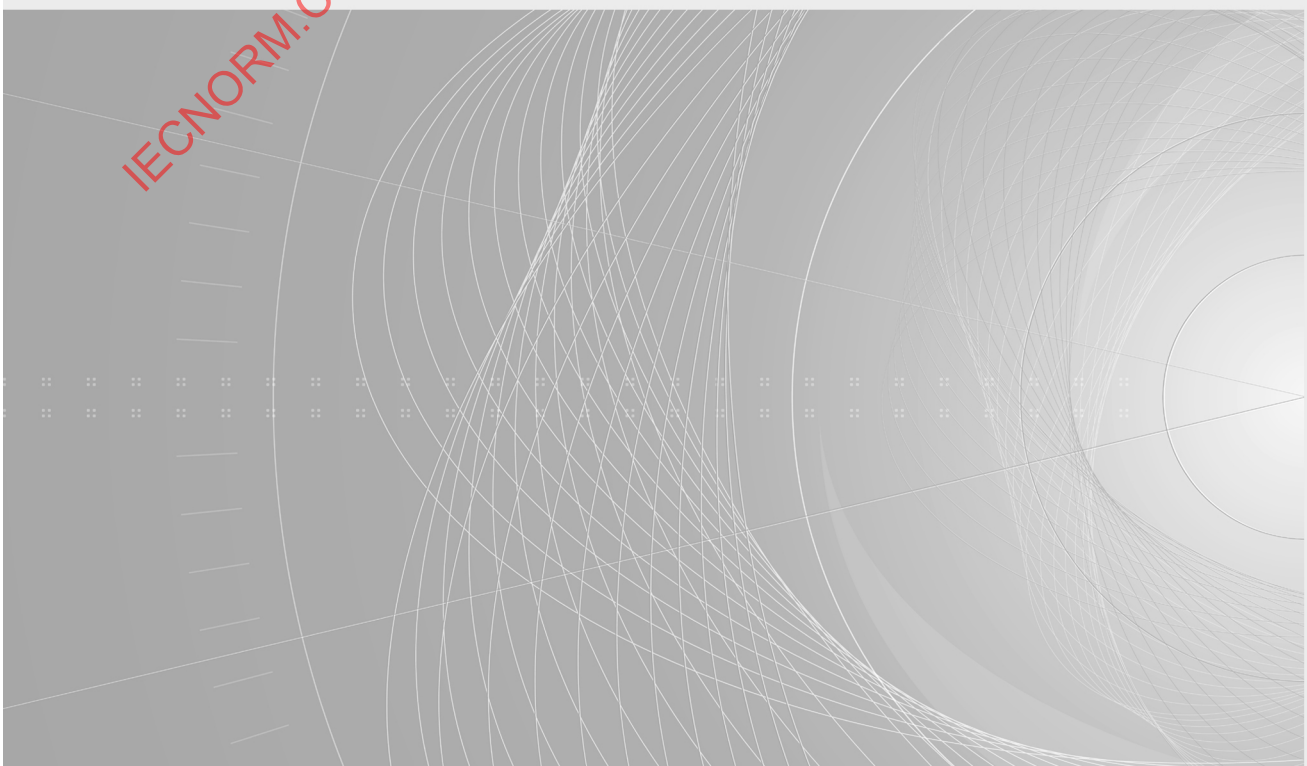
Rotating electrical machines – Part 12: Starting performance of single-speed three-phase cage induction motors

Machines électriques tournantes – Partie 12: Caractéristiques de démarrage des moteurs triphasés à induction à cage à une seule vitesse



IEC 60034-12:2016-11(en-fr)

CONTENTS

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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ROTATING ELECTRICAL MACHINES –

Part 12: Starting performance of single-speed three-phase cage induction motors

FOREWORD

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International Standard IEC 60034-12 has been prepared by IEC technical committee 2: Rotating machinery.

This third edition cancels and replaces the second edition, published in 2002, and its amendment 1, published in 2007. It constitutes a technical revision.

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The main technical changes with regard to the previous edition are as follows:

Clause or subclause	Change
1	Part of note 3 moved to the regular text
3	Definition of locked rotor current and of rated voltage added
5	New design letter E for extended efficiency motors, explanation of all design letters, and description of new designs NE, NEY, HE, and HEY
6.2 and 9.2	Limits for locked rotor apparent power for E(Ex)e motors replaced by a reference to IEC 60079-7
	Formula added to calculate locked rotor current from apparent power
7 and 10	Definition of new limits for locked rotor apparent power for extended efficiency motors (new table 3)
Tables	Tables 1 and 4 to 7 extended down to P_N = 120 W
	Name of type of protection updated according to IEC 60079-7 Ed. 5

The text of this standard is based on the following documents:

CDV	Report on voting
2/1789/CDV	2/1821A/RVC

Full information on the voting for the approval of this standard can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

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 in the IEC TC 2 dashboard on the IEC website.

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC website under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

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ROTATING ELECTRICAL MACHINES –

Part 12: Starting performance of single-speed three-phase cage induction motors

1 Scope

This part of IEC 60034 specifies the parameters for eight designs of starting performance of single-speed three-phase 50 Hz or 60 Hz cage induction motors in accordance with IEC 60034-1 that:

– have a rated voltage up to 1 000 V;
– are intended for direct-on-line or star-delta starting;
– are rated on the basis of duty type S1;
– are constructed to any degree of protection and explosion protection.

This document also applies to dual voltage motors provided that the flux saturation level is the same for both voltages.

The values of torque, apparent power and current given in this document are limiting values (that is, minimum or maximum without tolerance).

NOTE 1 It is not expected that all manufacturers will produce machines for all eight designs. The selection of any specific design in accordance with this document will be a matter of agreement between the manufacturer and the purchaser.

NOTE 2 Designs other than the eight specified may be necessary for particular applications.

NOTE 3 It should be noted that values given in manufacturers' catalogues may include tolerances in accordance with IEC 60034-1.

NOTE 4 The values tabled for locked rotor apparent power are based on r.m.s. symmetrical steady state locked rotor currents; at motor switch on there will be a one-half cycle asymmetrical instantaneous peak current which may range from 1,8 to 2,8 times the steady state locked rotor value. The current peak and decay time are a function of the motor design and switching angle.

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

IEC 60079-7:2015, *Explosive atmospheres – Part 7: Equipment protection by increased safety "e"*

3 Terms and definitions

For the purposes of this document, the following terms and definitions 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
rated torque
T_N
torque the motor develops at its shaft end at rated output and speed

[SOURCE: IEC 60050-411:1996, 411-48-05]

3.2
locked-rotor torque
T_l
smallest 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]

3.3
pull-up torque
T_u
smallest 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 motors whose 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. 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.

3.4
breakdown torque
T_b
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 those motors whose torque continually decreases with increase in speed.

3.5
rated output
P_N
value of the output included in the rating

3.6
rated voltage
U_N
value of the voltage included in the rating

3.7
locked rotor apparent power
S_l
apparent power input with the motor held at rest at rated voltage and frequency

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3.8
locked rotor current
I_l
steady state current with the motor held at rest at rated voltage and frequency

4 Symbols

Symbol	Quantity
J	External moment of inertia
p	Number of pole pairs
P_N	Rated output
S_l	Locked rotor apparent power
T_N	Rated torque
T_l	Locked rotor torque
T_u	Pull-up torque
T_b	Breakdown torque

5 Designation

5.1 General

Motors designed according to this document are classified according to 5.2 to 5.7. The letters used to specify the different designs stand for:

N: normal starting torque

H: high starting torque

Y: star-delta starting

E: motors utilizing extended / higher locked rotor apparent power and current to achieve a higher efficiency class according to IEC 60034-30-1

5.2 Design N

Normal starting torque three-phase cage induction motors, intended for direct-on-line starting, having 2, 4, 6 or 8 poles, rated from 0,12 kW to 1 600 kW.

5.3 Design NE

Normal starting torque three-phase cage induction motors having higher locked rotor apparent power than design N, intended for direct-on-line starting, having 2, 4, 6 or 8 poles, rated from 0,12 kW to 1 600 kW.

5.4 Designs NY and NEY

Motors similar to designs N or NE, respectively, but intended for star-delta starting. For these motors in star-connection, minimum values for T_l and T_u are 25 % of the values of design N or NE, respectively, see Table 1.

5.5 Design H

High starting torque three-phase cage induction motors with 4, 6 or 8 poles, intended for direct-online starting, rated from 0,12 kW to 160 kW at a frequency of 60 Hz.

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5.6 Design HE

High starting torque three-phase cage induction motors having higher locked rotor apparent power than design H, with 4, 6 or 8 poles, intended for direct-online starting, rated from 0,12 kW to 160 kW at a frequency of 60 Hz.

5.7 Designs HY and HEY

Motors similar to designs H or HE, respectively, but intended for star-delta starting. For these motors in star-connection, minimum values for T_l and T_u are 25 % of the values of design H or HE, respectively, see Table 5.

6 Design N requirements

6.1 Torque characteristics

The starting torque is represented by three characteristic features. These features shall be in accordance with the appropriate values given in Table 1 or Table 6. The values in Table 1 and Table 6 are minimum values at rated voltage. Higher values are allowed.

The motor torque at any speed between zero and that at which breakdown torque occurs shall be not less than 1,3 times the torque obtained from a curve varying as the square of the speed and being equal to rated torque at rated speed. However, for 2-pole motors with type of protection 'Ex eb – increased safety' having a rated output greater than 100 kW, the motor torque at any speed between zero and that at which breakdown torque occurs shall not be less than 1,3 times the torque obtained from a curve varying as the square of the speed and being equal to 70 % rated torque at rated speed. For motors with type of protection 'Ex eb', the three characteristic torques shall be in accordance with the appropriate values given in Table 6.

NOTE The factor 1,3 has been chosen with regard to an undervoltage of 10 % in relation to the rated voltage at the motor terminals during the acceleration period.

6.2 Locked rotor current and apparent power

The locked rotor apparent power shall be not greater than the appropriate value given in Table 2. The values given in Table 2 are independent of the number of poles and are maximum values at rated voltage. For motors with type of protection 'e', locked rotor apparent power shall be in accordance with the appropriate values specified in IEC 60079-7.

The locked rotor current is calculated from the locked rotor apparent power according to:

$$I_l = \frac{S_l}{P_N} \times \frac{P_N}{\sqrt{3} U_N}$$

NOTE The advantage of specifying S_l/P_N instead of I_l/I_N is that the locked rotor current can be calculated from rated power and rated voltage only, not requiring to know the rated current which depends on quantities such as power factor and efficiency that are usually not known in early stages of a project.

6.3 Starting requirements

Motors shall be capable of withstanding two starts in succession (coasting to rest between starts) from cold conditions and one start from hot after running at rated conditions. The retarding torque due to the driven load will be in each case proportional to the square of the speed and equal to the rated torque at rated speed with the external moment of inertia given in Table 4 or Table 7.

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In each case, a further start is permissible only if the motor temperature before starting does not exceed the steady temperature at rated load. However, for 2-pole motors with type of protection 'Ex eb – increased safety' having a rated output greater than 100 kW, the retarding torque due to the driven load is proportional to the square of the speed and equal to 70 % rated torque at rated speed, with the external moment of inertia given in Table 7. After this starting, load with rated torque is possible.

NOTE It should be recognized that the number of starts should be minimized since these affect the life of the motor.

7 Design NE starting requirements

The starting requirements are as for design N, except that the limits for locked rotor apparent power in Table 3 apply, as increasing efficiency values require physically increasing values for locked rotor apparent power.

8 Designs NY and NEY starting requirements

The starting requirements are as for designs N or NE, respectively. In addition, however, a reduced retarding torque is necessary as the starting torque in 'star connection' may be insufficient to accelerate some loads to an acceptable speed.

NOTE It should be recognized that the number of starts should be minimized since these affect the life of the motor.

9 Design H requirements

9.1 Starting torque

The starting torque is represented by three characteristic features. These features shall be in accordance with the appropriate values given in Table 5. These values are minimum values at rated voltage. Higher values are allowed.

9.2 Locked rotor current and apparent power

The locked rotor apparent power shall be not greater than the appropriate value given in Table 2. The values in Table 2 are independent of the number of poles and are maximum values at rated voltage.

The locked rotor current is calculated from the locked rotor apparent power according to the formula given in 6.2.

9.3 Starting requirements

Motors shall be capable of withstanding two starts in succession (coasting to rest between starts) from cold conditions, and one start from hot after running at rated conditions. The retarding torque due to the driven load is assumed to be constant and equal to rated torque, independent of speed, with an external moment of inertia of 50 % of the values given in Table 4.

In each case, a further start is permissible only if the motor temperature before starting does not exceed the steady temperature at rated load.

NOTE It should be recognized that the number of starts should be minimized since these affect the life of the motor.

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10 Design HE starting requirements

The starting requirements are as for design H, except that the limits for locked rotor apparent power in Table 3 apply, as increasing efficiency values require physically increasing values for locked rotor apparent power.

11 Designs HY and HEY starting requirements

The starting requirements are as for design H or HE, respectively. In addition, however, a reduced retarding torque is necessary as the starting torque in 'star connection' may be insufficient to accelerate some loads to an acceptable speed.

NOTE It should be recognized that the number of starts should be minimized since these affect the life of the motor.

Table 1 – Minimum values of torques for design N

Range of rated output kW	Number of poles											
	2			4			6			8		
	T_l	T_u	T_b	T_l	T_u	T_b	T_l	T_u	T_b	T_l	T_u	T_b
$0{,}12 \leq P_N \leq 0{,}63$	1,9	1,3	2,0	2,0	1,4	2,0	1,7	1,2	1,7	1,5	1,1	1,6
$0{,}63 < P_N \leq 1{,}0$	1,8	1,2	2,0	1,9	1,3	2,0	1,7	1,2	1,8	1,5	1,1	1,7
$1{,}0 < P_N \leq 1{,}6$	1,8	1,2	2,0	1,9	1,3	2,0	1,6	1,1	1,9	1,4	1,0	1,8
$1{,}6 < P_N \leq 2{,}5$	1,7	1,1	2,0	1,8	1,2	2,0	1,6	1,1	1,9	1,4	1,0	1,8
$2{,}5 < P_N \leq 4{,}0$	1,6	1,1	2,0	1,7	1,2	2,0	1,5	1,1	1,9	1,3	1,0	1,8
$4{,}0 < P_N \leq 6{,}3$	1,5	1,0	2,0	1,6	1,1	2,0	1,5	1,1	1,9	1,3	1,0	1,8
$6{,}3 < P_N \leq 10$	1,5	1,0	2,0	1,6	1,1	2,0	1,5	1,1	1,8	1,3	1,0	1,7
$10 < P_N \leq 16$	1,4	1,0	2,0	1,5	1,1	2,0	1,4	1,0	1,8	1,2	0,9	1,7
$16 < P_N \leq 25$	1,3	0,9	1,9	1,4	1,0	1,9	1,4	1,0	1,8	1,2	0,9	1,7
$25 < P_N \leq 40$	1,2	0,9	1,9	1,3	1,0	1,9	1,3	1,0	1,8	1,2	0,9	1,7
$40 < P_N \leq 63$	1,1	0,8	1,8	1,2	0,9	1,8	1,2	0,9	1,7	1,1	0,8	1,7
$63 < P_N \leq 100$	1,0	0,7	1,8	1,1	0,8	1,8	1,1	0,8	1,7	1,0	0,7	1,6
$100 < P_N \leq 160$	0,9	0,7	1,7	1,0	0,8	1,7	1,0	0,8	1,7	0,9	0,7	1,6
$160 < P_N \leq 250$	0,8	0,6	1,7	0,9	0,7	1,7	0,9	0,7	1,6	0,9	0,7	1,6
$250 < P_N \leq 400$	0,75	0,6	1,6	0,75	0,6	1,6	0,75	0,6	1,6	0,75	0,6	1,6
$400 < P_N \leq 630$	0,65	0,5	1,6	0,65	0,5	1,6	0,65	0,5	1,6	0,65	0,5	1,6
$630 < P_N \leq 1\,600$	0,5	0,3	1,6	0,5	0,3	1,6	0,5	0,3	1,6	0,5	0,3	1,6
NOTE The values given are per unit T_N.												

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Table 2 – Maximum values of locked rotor apparent power for designs N and H

Range of rated output kW	S_I/P_N
$P_N \leq 0,4$	22
$0,4 < P_N \leq 0,63$	19
$0,63 < P_N \leq 1,0$	17
$1,0 < P_N \leq 1,8$	15
$1,8 < P_N \leq 4,0$	14
$4,0 < P_N \leq 6,3$	13
$6,3 < P_N \leq 25$	12
$25 < P_N \leq 63$	11
$63 < P_N \leq 630$	10
$630 < P_N \leq 1\ 600$	9

Table 3 – Maximum values of locked rotor apparent power for designs NE and HE

Range of rated output kW	S_I/P_N
$P_N \leq 0,4$	22
$0,4 < P_N \leq 0,63$	19
$0,63 < P_N \leq 1,0$	17
$1,0 < P_N \leq 6,3$	15
$6,3 < P_N \leq 25$	14
$25 < P_N \leq 63$	13
$63 < P_N \leq 630$	12
$630 < P_N \leq 1\ 600$	11

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Table 4 – External moment of inertia (J)

Number of poles	2		4		6		8	
Frequency Hz	**50**	**60**	**50**	**60**	**50**	**60**	**50**	**60**
Rated output kW	**Moment of inertia** kg m^2							
0,12	0,006	0,004	0,034	0,025	0,092	0,069	0,190	0,142
0,25	0,011	0,009	0,065	0,049	0,179	0,134	0,368	0,276
0,4	0,018	0,014	0,099	0,074	0,273	0,205	0,561	0,421
0,63	0,026	0,020	0,149	0,112	0,411	0,308	0,845	0,634
1,0	0,040	0,030	0,226	0,170	0,624	0,468	1,28	0,960
1,6	0,061	0,046	0,345	0,259	0,952	0,714	1,95	1,46
2,5	0,091	0,068	0,516	0,387	1,42	1,07	2,92	2,19
4,0	0,139	0,104	0,788	0,591	2,17	1,63	4,46	3,34
6,3	0,210	0,158	1,19	0,889	3,27	2,45	6,71	5,03
10	0,318	0,239	1,80	1,35	4,95	3,71	10,2	7,63
16	0,485	0,364	2,74	2,06	7,56	5,67	15,5	11,6
25	0,725	0,544	4,10	3,07	11,3	8,47	23,2	17,4
40	1,11	0,830	6,26	4,69	17,2	12,9	35,4	26,6
63	1,67	1,25	9,42	7,06	26,0	19,5	53,3	40,0
100	2,52	1,89	14,3	10,7	39,3	29,5	80,8	60,6
160	3,85	2,89	21,8	16,3	60,1	45,1	123	92,5
250	5,76	4,32	32,6	24,4	89,7	67,3	184	138
400	8,79	6,59	49,7	37,3	137	103	281	211
630	13,2	9,90	74,8	56,1	206	155	423	317
1 600	30,6	23	173	130	477	358	979	734

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 80000-4:2006, Number 4-7.

NOTE 3 For intermediate and higher values, external moments of inertia shall be calculated according to the following formula from which the values in the table have been calculated:

– for 50 Hz motors $J = 0{,}04P^{0{,}9}p^{2{,}5}$

– for 60 Hz motors $J = 0{,}03P^{0{,}9}p^{2{,}5}$

where: J is the external moment of inertia in kg m^2;

P is the output in kW;

p is the number of pairs of poles.

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Table 5 – Minimum values of torques for design H

Range of rated output kW	Number of poles								
	4			6			8		
	T_l	T_u	T_b	T_l	T_u	T_b	T_l	T_u	T_b
$0,12 \le P_N \le 0,63$	3,0	2,1	2,1	2,55	1,8	1,9	2,25	1,65	1,9
$0,63 < P_N \le 1,0$	2,85	1,95	2,0	2,55	1,8	1,9	2,25	1,65	1,9
$1,0 < P_N \le 1,6$	2,85	1,95	2,0	2,4	1,65	1,9	2,1	1,5	1,9
$1,6 < P_N \le 2,5$	2,7	1,8	2,0	2,4	1,65	1,9	2,1	1,5	1,9
$2,5 < P_N \le 4,0$	2,55	1,8	2,0	2,25	1,65	1,9	2,0	1,5	1,9
$4,0 < P_N \le 6,3$	2,4	1,65	2,0	2,25	1,65	1,9	2,0	1,5	1,9
$6,3 < P_N \le 10$	2,4	1,65	2,0	2,25	1,65	1,9	2,0	1,5	1,9
$10 < P_N \le 16$	2,25	1,65	2,0	2,1	1,5	1,9	2,0	1,4	1,9
$16 < P_N \le 25$	2,1	1,5	1,9	2,1	1,5	1,9	2,0	1,4	1,9
$25 < P_N \le 40$	2,0	1,5	1,9	2,0	1,5	1,9	2,0	1,4	1,9
$40 < P_N \le 160$	2,0	1,4	1,9	2,0	1,4	1,9	2,0	1,4	1,9

NOTE 1 The values given are per unit T_N.

NOTE 2 The values of T_l are 1,5 times the corresponding values for design N, but are not less than 2,0.

NOTE 3 The values of T_u are 1,5 times the corresponding values for design N, but are not less than 1,4.

NOTE 4 The values of T_b are equal to the corresponding values for design N, but are not less than 1,9 and the values of T_u.

Table 6 – Minimum values of torques for design N motors with type of protection 'Ex eb – increased safety'

Range of rated output kW	Number of poles											
	2			4			6			8		
	T_l	T_u	T_b	T_l	T_u	T_b	T_l	T_u	T_b	T_l	T_u	T_b
$0,12 \le P_N \le 0,63$	1,7	1,1	1,8	1,8	1,2	1,8	1,5	1,1	1,6	1,4	1,0	1,6
$0,63 < P_N \le 1,0$	1,6	1,1	1,8	1,7	1,2	1,8	1,5	1,1	1,6	1,4	1,0	1,6
$1,0 < P_N \le 1,6$	1,6	1,1	1,8	1,7	1,2	1,8	1,4	1,0	1,7	1,3	1,0	1,6
$1,6 < P_N \le 2,5$	1,5	1,0	1,8	1,6	1,1	1,8	1,4	1,0	1,7	1,3	1,0	1,6
$2,5 < P_N \le 4,0$	1,4	1,0	1,8	1,5	1,1	1,8	1,4	1,0	1,7	1,2	0,9	1,6
$4,0 < P_N \le 6,3$	1,4	1,0	1,8	1,4	1,0	1,8	1,4	1,0	1,7	1,2	0,9	1,6
$6,3 < P_N \le 10$	1,4	1,0	1,8	1,4	1,0	1,8	1,4	1,0	1,6	1,2	0,9	1,6
$10 < P_N \le 16$	1,3	0,9	1,8	1,4	1,0	1,8	1,3	1,0	1,6	1,1	0,8	1,6
$16 < P_N \le 25$	1,2	0,9	1,7	1,3	1,0	1,7	1,3	1,0	1,6	1,1	0,8	1,6
$25 < P_N \le 40$	1,1	0,8	1,7	1,2	0,9	1,7	1,2	0,9	1,6	1,1	0,8	1,6
$40 < P_N \le 63$	1,0	0,7	1,6	1,1	0,8	1,6	1,1	0,8	1,6	1,0	0,7	1,6
$63 < P_N \le 100$	0,9	0,65	1,6	1,0	0,8	1,6	1,0	0,8	1,6	0,9	0,7	1,6
$100 < P_N \le 160$	0,8	0,6	1,6	0,9	0,7	1,6	0,9	0,7	1,6	0,8	0,6	1,6
$160 < P_N \le 250$	0,75	0,55	1,6	0,8	0,6	1,6	0,8	0,6	1,6	0,8	0,6	1,6
$250 < P_N \le 400$	0,7	0,55	1,6	0,7	0,55	1,6	0,7	0,55	1,6	0,7	0,55	1,6
$400 < P_N \le 630$	0,6	0,45	1,6	0,6	0,45	1,6	0,6	0,4	1,6	0,6	0,4	1,6

NOTE The values given are per unit T_N.

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Table 7 – External moment of inertia (J) for motors with type of protection 'Ex eb – increased safety'

Number of poles	2		4		6		8	
Frequency Hz	**50**	**60**	**50**	**60**	**50**	**60**	**50**	**60**
Rated output kW	**Moment of inertia** kg m^2							
0,12	0,006	0,005	0,037	0,027	0,101	0,076	0,207	0,155
0,25	0,012	0,009	0,066	0,050	0,183	0,137	0,375	0,281
0,4	0,017	0,013	0,097	0,073	0,267	0,200	0,548	0,411
0,63	0,025	0,019	0,140	0,105	0,386	0,289	0,792	0,594
1,0	0,036	0,027	0,204	0,153	0,561	0,421	1,15	0,864
1,6	0,053	0,040	0,298	0,223	0,821	0,616	1,69	1,26
2,5	0,076	0,057	0,428	0,321	1,18	0,884	2,42	1,81
4,0	0,110	0,083	0,626	0,469	1,72	1,29	3,54	2,66
6,3	0,160	0,120	0,904	0,678	2,49	1,87	5,12	3,84
10	0,232	0,174	1,31	0,986	3,62	2,72	7,44	5,58
16	0,340	0,255	1,92	1,44	5,30	3,98	10,9	8,16
25	0,488	0,366	2,76	2,07	7,61	5,71	15,6	11,7
40	0,714	0,536	4,04	3,03	11,1	8,35	22,9	17,1
63	1,03	0,774	5,84	4,38	16,1	12,1	33,0	24,8
100	1,50	1,13	8,49	6,37	23,4	17,5	48,0	36,0
160	2,20	1,65	12,4	9,32	34,2	25,7	70,3	52,7
250	3,15	2,36	17,8	13,4	49,1	36,9	101,0	75,7
400	4,61	3,46	26,1	19,6	71,9	53,9	148	111
630	6,66	5,00	37,7	28,3	104	77,9	213	160

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 80000-4:2006, Number 4-7.

NOTE 3 For intermediate and higher values, external moments of inertia shall be calculated according to the following formula from which the values in the table have been calculated:

– for 50 Hz motors $J = 0{,}036 P^{0{,}81} p^{2{,}5}$

– for 60 Hz motors $J = 0{,}027 P^{0{,}81} p^{2{,}5}$

where: J is the external moment of inertia in kg m^2;

P is the output in kW;

p is the number of pairs of poles.

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COMMISSION ÉLECTROTECHNIQUE INTERNATIONALE

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MACHINES ÉLECTRIQUES TOURNANTES –

Partie 12: Caractéristiques de démarrage des moteurs triphasés à induction à cage à une seule vitesse

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Cette troisième édition annule et remplace la deuxième édition, publiée en 2002, et son amendement 1, publié en 2007. Elle constitue une révision technique.

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Les modifications techniques majeures par rapport à l'édition précédente sont les suivantes:

Article ou paragraphe	Modification
1	Une partie de la NOTE 3 est déplacée dans le texte
3	Ajout des définitions du courant à rotor bloqué et de la tension assignée
5	Nouvelle lettre de conception E pour les moteurs de rendement amélioré, explication de toutes les lettres de conception, et description des nouvelles conceptions NE, NEY, HE, et HEY
6.2 et 9.2	Limites pour la puissance apparente à rotor bloqué pour les moteurs E(Ex)e remplacées par une référence à l'IEC 60079-7
	Formule ajoutée pour calculer le courant à rotor bloqué à partir de la puissance apparente
7 et 10	Définition de nouvelles limites de la puissance apparente à rotor bloqué pour les moteurs à rendement amélioré (nouveau Tableau 3)
Tableaux	Tableaux 1 et 4 à 7 étendus à P_N = 120 W
	Nom de type de protection mis à jour conformément à l'IEC 60079-7 édition 5

Le texte de cette norme est issu des documents suivants:

CDV	Rapport de vote
2/1789/CDV	2/1821A/RVC

Le rapport de vote indiqué dans le tableau ci-dessus donne toute information sur le vote ayant abouti à l'approbation de cette norme.

Cette publication a été rédigée selon les Directives ISO/IEC, Partie 2.

Une liste de toutes les parties de la série IEC 60034, publiées sous le titre général *Machines électriques tournantes,* peut être consultée sur le site web de l'IEC.

NOTE Un tableau de références croisées de toutes les publications de l'IEC TC 2 peut être consulté dans le tableau de bord de l'IEC TC 2 sur le site web de l'IEC.

Le comité a décidé que le contenu de cette publication ne sera pas modifié avant la date de stabilité indiquée sur le site web de l'IEC sous "http://webstore.iec.ch" dans les données relatives à la publication recherchée. A cette date, la publication sera

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MACHINES ÉLECTRIQUES TOURNANTES –

Partie 12: Caractéristiques de démarrage des moteurs triphasés à induction à cage à une seule vitesse

1 Domaine d'application

La présente partie de l'IEC 60034 spécifie les paramètres de huit conceptions de caractéristiques de démarrage de moteurs triphasés à induction à cage monovitesse fonctionnant à 50 Hz ou 60 Hz conformes à l'IEC 60034-1 qui:

– ont des tensions assignées jusqu'à 1 000 V;
– sont prévus pour démarrage direct ou étoile-triangle;
– sont dimensionnés pour le service type S1;
– peuvent avoir n'importe quel degré de protection incluant les protections contre les explosions.

Ce document s'applique également aux moteurs bitension à condition que le niveau de saturation du flux soit le même aux deux tensions.

Les valeurs de couple, de puissance apparente et de courant données dans le présent document sont des valeurs limites (c'est-à-dire minimales ou maximales sans tolérance).

NOTE 1 Les constructeurs ne sont pas tenus de fabriquer des machines correspondant à ces huit conceptions. Le choix d'une conception spécifique répondant au présent document fera l'objet d'un accord entre le constructeur et son client.

NOTE 2 Des conceptions autres que les huit spécifiées peuvent s'avérer nécessaires pour des applications particulières.

NOTE 3 Il convient de noter que les valeurs données dans les catalogues des constructeurs peuvent inclure des tolérances conformes à l'IEC 60034-1.

NOTE 4 Les valeurs calculées pour la puissance apparente à rotor bloqué sont fondées sur les courants à rotor bloqué en régime établi symétriques en valeur efficace; à la mise en marche du moteur, il y aura un courant de crête instantané asymétrique d'un demi-cycle qui peut fluctuer entre 1,8 et 2,8 fois la valeur à rotor bloqué en régime établi. La crête de courant et le temps de descente dépendent de la conception du moteur et de l'angle de commutation.

2 Références normatives

Les documents suivants cités dans le texte constituent, pour tout ou partie de leur contenu, des exigences du présent document. Pour les références datées, seule l'édition citée s'applique. Pour les références non datées, la dernière édition du document de référence s'applique (y compris les éventuels amendements).

IEC 60034-30-1, *Machines électriques tournantes – Partie 30-1: Classes de rendement pour les moteurs à courant alternatif alimentés par le réseau (code IE)*

IEC 60079-7:2015, *Atmosphères explosives – Partie 7: Protection du matériel par sécurité augmentée "e"*

3 Termes et définitions

Pour les besoins du présent document, les termes et les définitions suivantes s'appliquent.

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L'ISO et l'IEC tiennent à jour des bases de données terminologiques destinées à être utilisées en normalisation, consultables aux adresses suivantes:

- IEC Electropedia: disponible à l'adresse http://www.electropedia.org/
- ISO Online browsing platform: disponible à l'adresse http://www.iso.org/obp

3.1
couple assigné
T_N
couple que développe le moteur sur son bout d'arbre d'entraînement aux puissance et vitesse assignées

[SOURCE: IEC 60050-411:1996, 411-48-05]

3.2
couple à rotor bloqué
T_l
couple mesuré le plus faible que développe le moteur sur son bout d'arbre d'entraînement, quand son rotor est maintenu bloqué, quelle que soit sa position angulaire et qu'il est alimenté à tension et fréquence assignées

[SOURCE: IEC 60050-411:1996, 411-48-06]

3.3
couple minimal pendant le démarrage
T_u
valeur la plus faible du couple asynchrone en régime établi que le moteur développe entre la vitesse nulle et la vitesse qui correspond au couple de décrochage lorsque le moteur est alimenté à la tension et à la fréquence assignées

Note 1 à l'article: Cette définition ne s'applique pas aux moteurs dont le couple diminue de manière continue quand la vitesse augmente.

Note 2 à l'article: En plus des couples asynchrones en régime établi, les couples synchrones harmoniques, qui dépendent de l'angle de charge du rotor, seront présents à certaines vitesses. A de telles vitesses, le couple d'accélération peut être négatif pour certains angles de charge de rotor. L'expérience et les calculs montrent qu'il s'agit d'une condition de fonctionnement instable et c'est pourquoi les couples synchrones harmoniques n'empêchent pas l'accélération du moteur et qu'ils sont exclus de la présente définition.

3.4
couple de décrochage
T_b
valeur maximale du couple asynchrone en régime établi développé par le moteur sans chute brutale de la vitesse lorsque le moteur est alimenté à la tension et à la fréquence assignées

Note 1 à l'article: Cette définition ne s'applique pas aux moteurs dont le couple diminue de manière continue quand la vitesse augmente.

3.5
puissance de sortie assignée
P_N
valeur de la puissance de sortie incluse dans les caractéristiques assignées

3.6
tension assignée
U_N
valeur de la tension incluse dans les caractéristiques assignées

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3.7
puissance apparente à rotor bloqué
S_I
puissance apparente d'entrée, avec le moteur maintenu à l'arrêt à tension et fréquence assignées

3.8
courant à rotor bloqué
I_I
courant en régime établi, avec le moteur maintenu à l'arrêt à tension et fréquence assignées

4 Symboles

Symbole	Grandeur
J	Moment d'inertie extérieur
p	Nombre de paires de pôles
P_N	Puissance de sortie assignée
S_I	Puissance apparente à rotor bloqué
T_N	Couple assigné
T_I	Couple à rotor bloqué
T_u	Couple minimal pendant le démarrage
T_b	Couple de décrochage

5 Désignation

5.1 Généralités

Les moteurs conçus selon le présent document sont classés conformément à 5.2 à 5.7. Les lettres utilisées pour spécifier les différentes conceptions sont:

N: couple de démarrage normal

H: couple de démarrage élevé

Y: démarrage étoile-triangle

E: moteurs utilisant des valeurs étendues/supérieures de la puissance apparente et du courant à rotor bloqué pour obtenir un rendement supérieur conformément à l'IEC 60034-30-1

5.2 Moteurs de conception N

Moteurs triphasés à induction à cage à couple de démarrage normal prévus pour démarrage direct à 2, 4, 6 ou 8 pôles, avec des puissances assignées comprises entre 0,12 kW et 1 600 kW.

5.3 Moteurs de conception NE

Moteurs triphasés à induction à cage à couple de démarrage normal ayant une puissance apparente à rotor bloqué supérieure à celle des moteurs de conception N, prévus pour démarrage direct à 2, 4, 6 ou 8 pôles, avec des puissances assignées comprises entre 0,12 kW et 1 600 kW.

5.4 Moteurs de conception NY et NEY

Moteurs respectivement analogues à ceux de conception N et NE, mais qui sont prévus pour démarrage étoile-triangle. Pour ces moteurs en couplage étoile, les valeurs minimales de T_I et

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T_u sont respectivement égales à 25 % des valeurs indiquées pour la conception N et NE (voir Tableau 1).

5.5 Moteurs de conception H

Moteurs triphasés à induction à cage à couple de démarrage élevé à 4, 6 ou 8 pôles prévus pour démarrage direct, avec des puissances assignées comprises entre 0,12 kW et 160 kW à une fréquence de 60 Hz.

5.6 Moteurs de conception HE

Moteurs triphasés à induction à cage à couple de démarrage élevé ayant une puissance apparente à rotor bloqué supérieure à celle des moteurs de conception H, avec 4, 6 ou 8 pôles, prévus pour démarrage direct, avec des puissances assignées comprises entre 0,12 kW et 160 kW à une fréquence de 60 Hz.

5.7 Moteurs de conception HY et HEY

Moteurs respectivement analogues à ceux de conception H et HE, mais qui sont prévus pour démarrage étoile-triangle. Pour ces moteurs en couplage étoile, les valeurs minimales de T_l et T_u sont respectivement égales à 25 % des valeurs indiquées pour la conception H et HE (voir Tableau 5).

6 Exigences pour les moteurs de conception N

6.1 Caractéristiques de couple

Le couple de démarrage est représenté par trois caractéristiques. Ces caractéristiques doivent être conformes aux valeurs appropriées données dans le Tableau 1 ou le Tableau 6. Les valeurs données dans le Tableau 1 et le Tableau 6 sont des valeurs minimales à la tension assignée. Des valeurs plus élevées sont autorisées.

Le couple du moteur à n'importe quelle vitesse entre la vitesse nulle et celle pour laquelle le couple de décrochage se produit ne doit pas être inférieur à 1,3 fois le couple obtenu à partir d'une courbe variant avec le carré de la vitesse et étant égale au couple assigné à la vitesse assignée. Cependant, pour les moteurs à 2 pôles de mode de protection 'Ex eb – sécurité augmentée' ayant une puissance de sortie assignée supérieure à 100 kW, le couple du moteur à n'importe quelle vitesse entre la vitesse nulle et celle pour laquelle le couple de décrochage se produit ne doit pas être inférieur à 1,3 fois le couple obtenu à partir d'une courbe variant avec le carré de la vitesse et étant égale à 70 % du couple assigné à la vitesse assignée. Pour les moteurs à degré de protection 'Ex eb', les trois couples caractéristiques doivent être conformes aux valeurs données dans le Tableau 6.

NOTE Le facteur 1,3 a été choisi pour tenir compte d'une chute de tension de 10 % de la tension assignée aux bornes du moteur pendant la période d'accélération.

6.2 Courant et puissance apparente à rotor bloqué

La puissance apparente à rotor bloqué ne doit pas être supérieure à la valeur appropriée donnée dans le Tableau 2. Les valeurs données dans le Tableau 2 sont indépendantes du nombre de pôles et sont des valeurs maximales à la tension assignée. Pour les moteurs à mode de protection 'e', la puissance apparente à rotor bloqué doit être conforme aux valeurs appropriées spécifiées dans l'IEC 60079-7.

Le courant à rotor bloqué est calculé à partir de la puissance apparente à rotor bloqué conformément à:

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