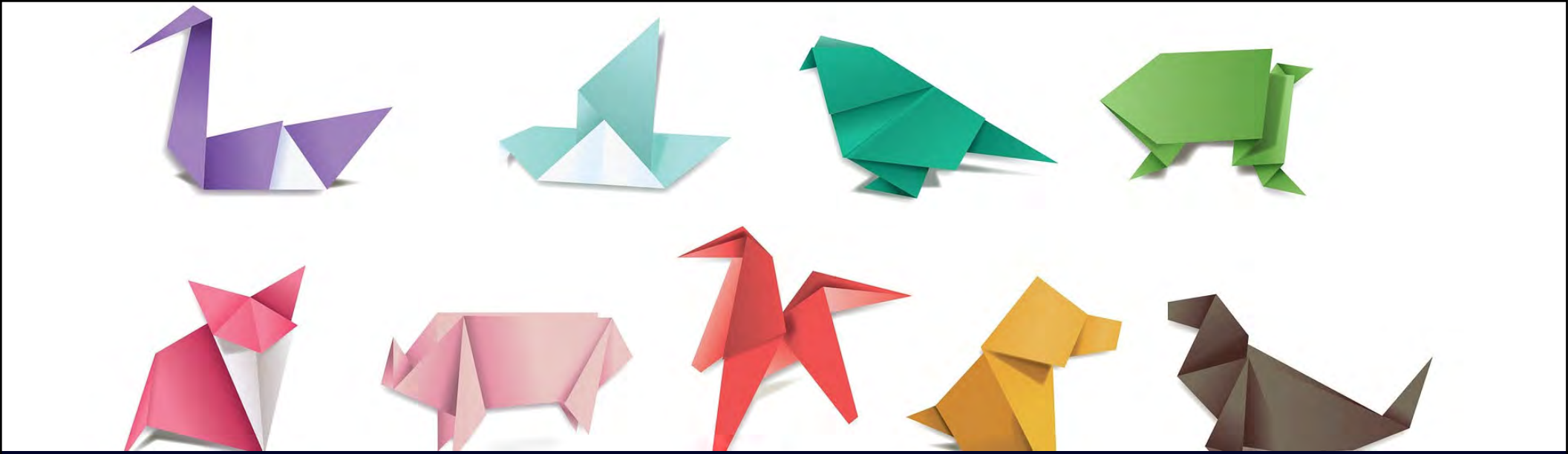


… then change the way you think!

SIEMENS

Change the way you think!
Why?

Why is it important to change the way you think?

What do you see?

A garbage-bin which is…

What you see is generally governed by your imagination.

"And sometimes, your beliefs prevent you from seeing the truth.

– Your own experience on the previous slide

7 thoughts that need an immediate change…

1. *Efficiency difference is the deciding factor.*
2. *The fine-print may be taken lightly.*
3. *CE Marking is applicable only in EU and EEA.*
4. *I have many pumps. Let me get new EEMs for these.*
5. *We have appointed a reputed consultant for the project.*
6. *“Think out of the box” – is just another trainer’s jargon.*
7. *Higher motor efficiencies is the best way towards energy conservation.*

Table of contents

Think not about efficiency difference…

Soch badlo; bahut kuchh badlega…

Ignore the fine print at your own peril

Foot-notes are the most ignored and cause the most harm

Act local; *…however, always think global.*

Think CE marked motors.

Think before you leap… …is a very old adage.

If we forget this….

Energy conservation is… … your responsibility

Not the Consultant's.

Think out of the box for unprecented energy savings

Let us give you some serious food for thought…

Jolly Roger

Does any of you know what this is?

Think not about efficiency difference…

Soch badlo; bahut kuchh badlega…

"

Think not about the efficiency difference …

… instead, think about difference in energy consumption.

The efficiency of a 75kW/4P motor as per IS 12615:2018

IS 12615 : 2018

Table 2 Values of Performance Characteristics of 4 Pole Line Operated a.c. Motors

(*Clauses* 1.2, 1.3, 1.6, 10.1, 10.2, 11, 14.1, 14.4, 15.4.1, 17.3.5)

	Rated Output	Frame Size	Full Load Speed	Full Load Current	Locked Torque in Terms of Full Load Torque	Locked Rotor Current in Terms of Full Load Current			Nominal Efficiency		
						IE2	IE3	IE4	IE2	IE3	IE4
				Max							
	kW		rev/ min	A	Percent	Percent	Percent	Percent	Percent	Percent	Percent
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
xix)	45.0	225M	1 460	84.0	160	700	750	830	93.1	94.2	95.4
xx)	55.0	250M	1 460	101.0	160	700	750	830	93.5	94.6	95.7
xxi)	75.0	280S	1 470	134.0	160	700	770	890	94.0	95.0	96.0
xxii)	90.0	280M	1 470	164.0	160	700	770	890	94.2	95.2	96.1

A 75kW, 4P motor has following efficiency values: 94%[*IE2*], 95%[*IE3*] and 96%[*IE4*].

The efficiency of a 75kW/4P motor increases from 94%[*IE2*] to 95%[*IE3*] to 96%[*IE4*]

Power input to an ***IE2***, 75kW, 4P motor would be

$$P_{in\_IE2} = \frac{P_{out}}{\eta_{IE2}}$$

$$P_{in\_IE2} = \frac{75}{94\%}$$

$$P_{in\_IE2} = 79.787\ kW$$

Power input to an ***IE3***, 75kW, 4P motor would be

$$P_{in\_IE3} = \frac{P_{out}}{\eta_{IE3}}$$

$$P_{in\_IE3} = \frac{75}{95\%}$$

$$P_{in\_IE3} = 78.947\ kW$$

Power input to an ***IE4***, 75kW, 4P motor would be

$$P_{in\_IE4} = \frac{P_{out}}{\eta_{IE4}}$$

$$P_{in\_IE4} = \frac{75}{96\%}$$

$$P_{in\_IE4} = 78.125\ kW$$

The difference in input power of ***IE2*** and ***IE3*** motor is 79.787 - 78.947 = **0.84kW**
The difference in input power of ***IE2*** and ***IE4*** motor is 79.787 - 78.125 = **1.66kW**

Let us see what this 0.84kW or 1.66kW reduction in power translates into…

Why an IE3 motor instead of an IE2 motor?

The difference in input power of ***IE2*** and ***IE3*** motor is **0.84kW**

If this 75kW, 4P motor operates for

- 360 days in a year (5 days of Diwali Holidays)
- 24 hours every day (process plant needs 24x7 operation)

Then, using an IE3 motor would cause a reduction in electricity consumption by…

$= \Delta input \times No.of\ days\ per\ year \times No.of\ hours\ per\ day$

$= 0.84kW \times 360 \times 24H$

= 7,258 kWH

7.3 MWH

5.3t CO_2 emission reduction$^{\$}$

$ - The average CO_2 emission factor for country **India in the year 2021 was 726.1 g/kWH** as per IEA 2021 report

Just a single 75kW, 4P *IE3* motor saves 7.3MWH in a year as compared to an *IE2* motor.

Why an IE4 motor instead of an IE2 motor?

Similarly, the difference in input power of ***IE2*** and ***IE4*** motor is **1.66kW**

If this 75kW, 4P motor operates for

- 360 days in a year (5 days of Diwali Holidays)
- 24 hours every day (process plant needs 24x7 operation)

Then, using an IE4 motor would cause a reduction in electricity consumption by…

$= \Delta input \times No.of\ days\ per\ year \times No.of\ hours\ per\ day$

$= 1.66kW \times 360 \times 24H$

= 14,360 kWH

14.4 MWH

10.5t CO_2 emission reduction$^{\$}$

$ - The average CO_2 emission factor for country **India in the year 2021 was 726.1 g/kWH** as per IEA 2021 report

Just a single 75kW, 4P *IE4* motor saves 14.4 MWH in a year as compared to an *IE2* motor.

Ignore the fine print at your own peril

Foot-notes are the most ignored and cause the most harm

"

Read the Standards carefully…

…these are meant to protect the users.

Now let us look at the efficiency of 75kW/4P & 90kW/4P IE2 motors

IS 12615 : 2018

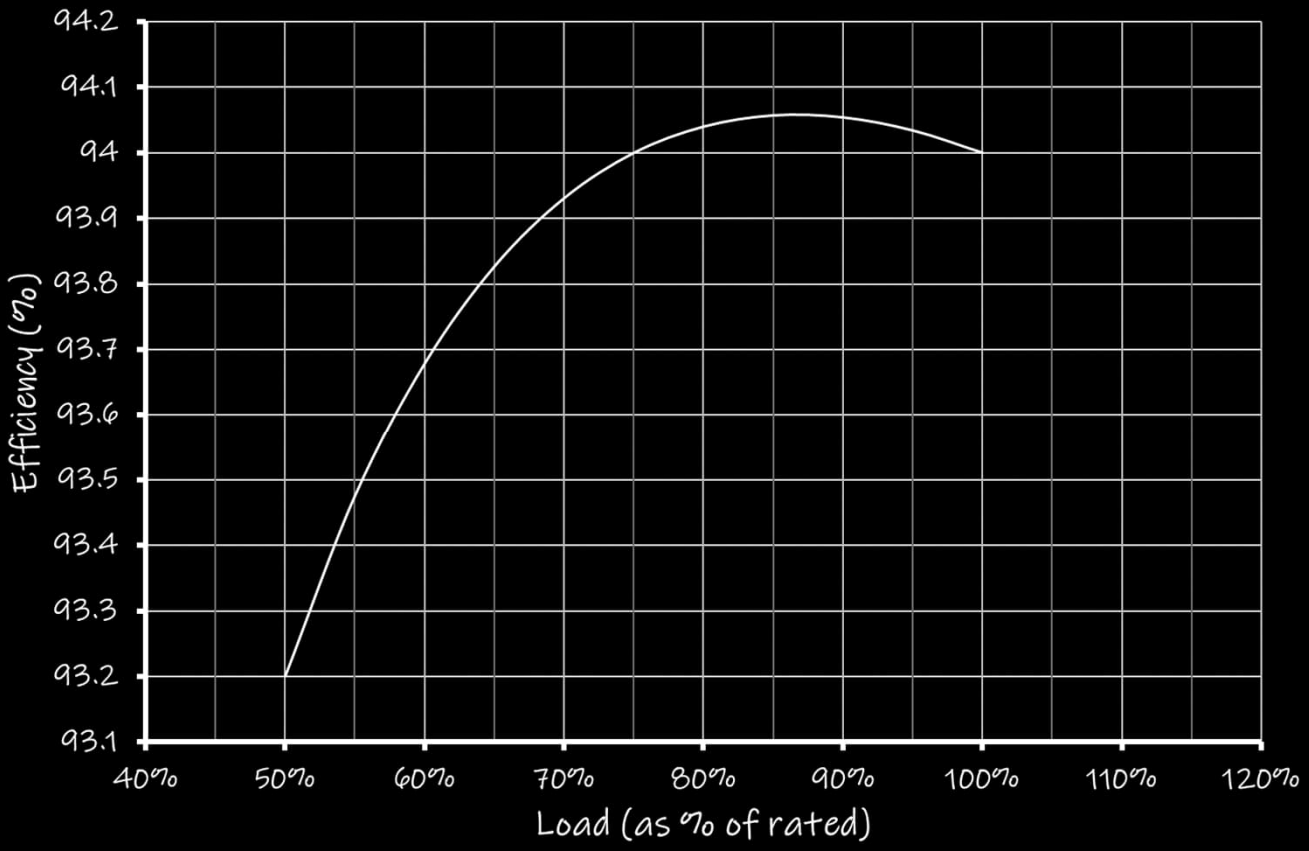
Table 2 Values of Performance Characteristics of 4 Pole Line Operated a.c. Motors

(*Clauses* 1.2, 1.3, 1.6, 10.1, 10.2, 11, 14.1, 14.4, 15.4.1, 17.3.5)

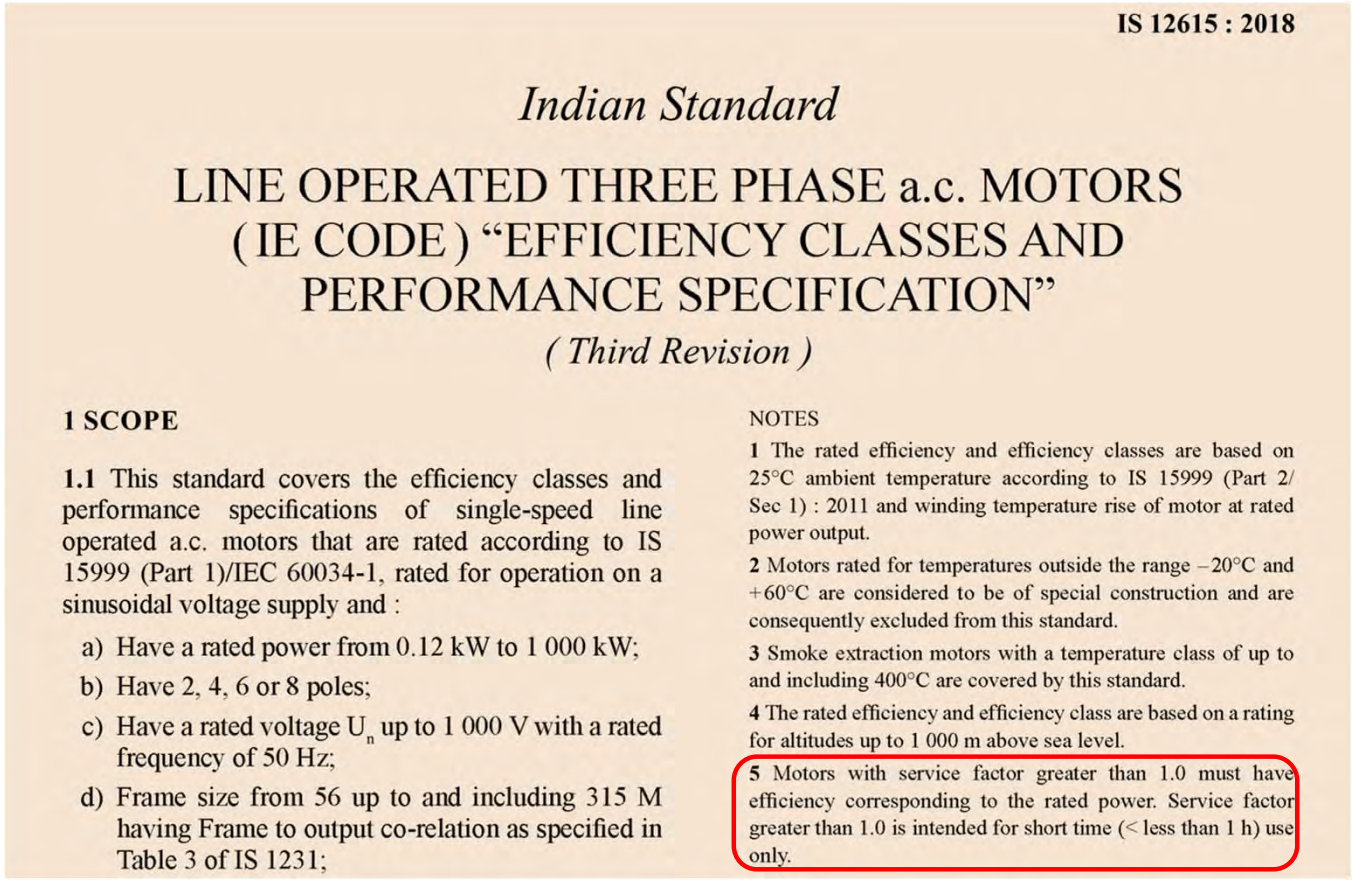
	Rated Output	Frame Size	Full Load Speed	Full Load Current	Locked Torque in Terms of Full Load Torque	Locked Rotor Current in Terms of Full Load Current			Nominal Efficiency		
						IE2	IE3	IE4	IE2	IE3	IE4
	kW		rev/ min	*Max* A	Percent	Percent	Percent	Percent	Percent	Percent	Percent
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
xix)	45.0	225M	1 460	84.0	160	700	750	830	93.1	94.2	95.4
xx)	55.0	250M	1 460	101.0	160	700	750	830	93.5	94.6	95.7
xxi)	75.0	280S	1 470	134.0	160	700	770	890	94.0	95.0	96.0
xxii)	90.0	280M	1 470	164.0	160	700	770	890	94.2	95.2	96.1

A 75kW, 4P motor has an efficiency of 94% while the 90kW, 4P motor has an efficiency of 94.2%.

Why is the maximum efficiency point between 80 to 90% loading?



The foot-note 5 of clause 1.1 of IS 12615:2018



IS 12615 : 2018

Indian Standard

LINE OPERATED THREE PHASE a.c. MOTORS (IE CODE) "EFFICIENCY CLASSES AND PERFORMANCE SPECIFICATION"

(Third Revision)

1 SCOPE

1.1 This standard covers the efficiency classes and performance specifications of single-speed line operated a.c. motors that are rated according to IS 15999 (Part 1)/IEC 60034-1, rated for operation on a sinusoidal voltage supply and :

a) Have a rated power from 0.12 kW to 1 000 kW;

b) Have 2, 4, 6 or 8 poles;

c) Have a rated voltage U_n up to 1 000 V with a rated frequency of 50 Hz;

d) Frame size from 56 up to and including 315 M having Frame to output co-relation as specified in Table 3 of IS 1231;

NOTES

1 The rated efficiency and efficiency classes are based on 25°C ambient temperature according to IS 15999 (Part 2/ Sec 1) : 2011 and winding temperature rise of motor at rated power output.

2 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 standard.

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

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

5 Motors with service factor greater than 1.0 must have efficiency corresponding to the rated power. Service factor greater than 1.0 is intended for short time (< less than 1 h) use only.

Ignoring the

fine-print

always causes the

greatest

harm.

The foot-note 5 of clause 1.1 of IS 12615:2018

NOTES

1 The rated efficiency and efficiency classes are based on 25°C ambient temperature according to IS 15999 (Part 2/ Sec 1) : 2011 and winding temperature rise of motor at rated power output.

2 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 standard.

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

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

5 Motors with service factor greater than 1.0 must have efficiency corresponding to the rated power. Service factor greater than 1.0 is intended for short time (< less than 1 h) use only.

When you go back to your plants check the compressor motor log…

You will be surprised that the motors operate on Service Factor Loading for a significantly higher duration.

Service Factor > 1.0 is intended for short time use only.

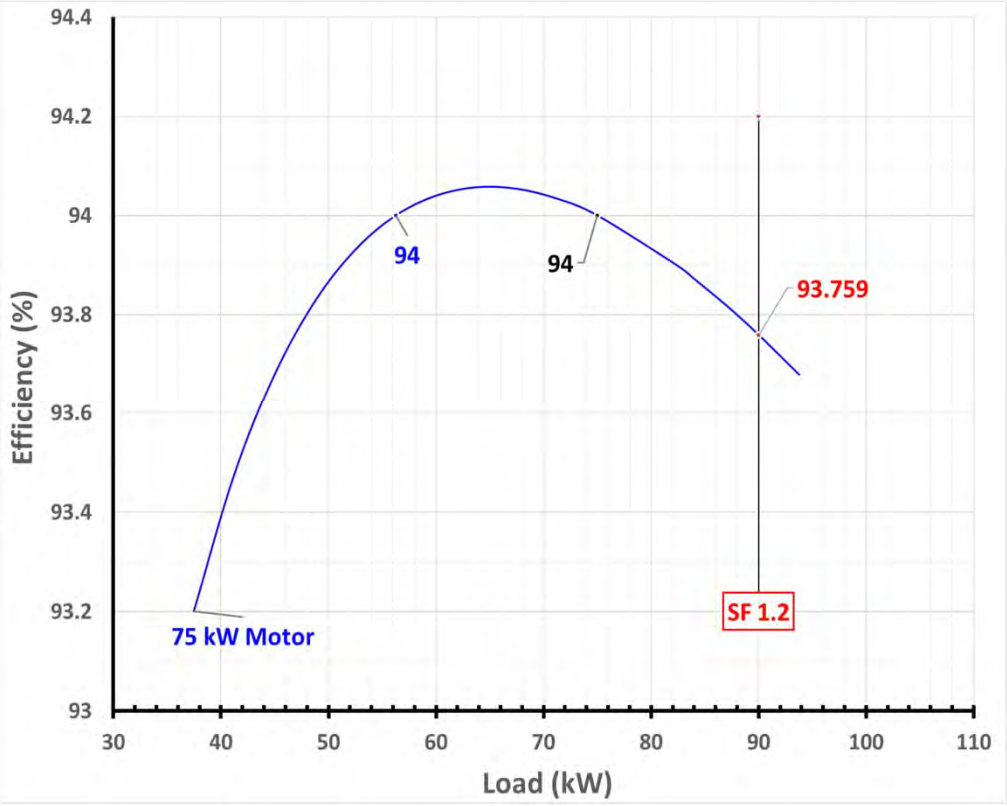
Compressor manufacturers all across the country use motors with SF…

A standard 75kW, 4P, IE2 motor operating at a service factor of 1.2 (i.e. 90kW) has an efficiency of 93.76%.

The input to this motor operating at SF (1.2) load is

$$P_{in} = \frac{P_{out}}{\eta_{SFLoad}} = \frac{90}{0.9376} = 95.99kW$$

instead of 75.8kW which is the rated input to a 75kW motor.



A 75kW, SF 1.2 motor designed for 75kW o/p efficiency operates inefficiently and consumes 95.99kW.

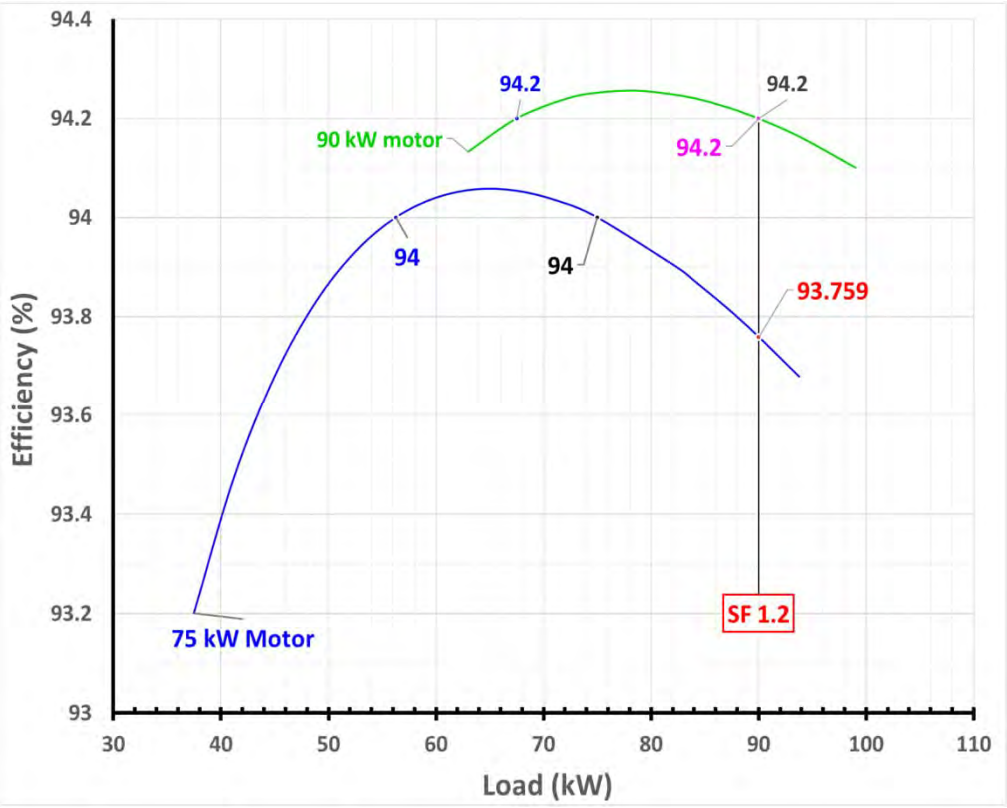
Motor operating at SF loads tend to lose out on efficiency …

Instead, a 90kW motor operating at its rated load efficiency of 94.2% will cause the input to drop.

The input to this 90kW motor operating at 90kW is

$$P_{in} = \frac{P_{out}}{\eta_{90}} = \frac{90}{0.942} = 95.54kW$$

instead of 95.99kW which was the input to 75kW motor operating at an SF of 1.2.



Using a 90kW motor at its rated loading, consumption drops by 95.99 - 95.54 = 0.45kW.

Savings possible from just one properly sized motor instead of one operating at Service Factor

95.99 - 95.54 = 0.45kW may not seem a lot.

However, if this motor operates for

- 24 hours a day
- 360 days a year

This amounts to 0.45 x 24 x 360 = 3,888 kWH.

3.9 MWH

2.8t CO_2 emission reduction$^{\$}$

$ - The average CO_2 emission factor for country **India in the year 2021 was 726.1 g/kWH** as per IEA 2021 report

How many compressors are there in a paper plant which use motors operating at SF loading?

Act local;
…however, always think global.

Think CE marked motors.

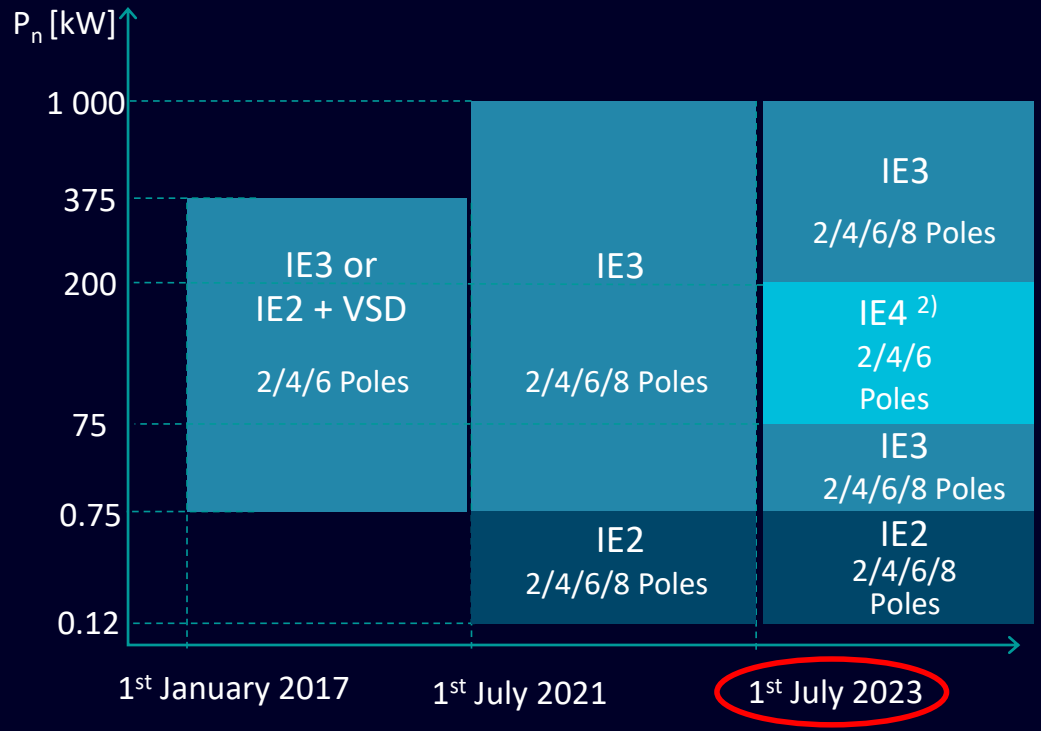
To CE or not to CE?
That is the question.

CE marking is mandatory only in the EU or the EEA…

… but it can benefit you in a very big way!

SIEMENS

Regulation (EU) 2019/1781 - Step 2 (Current)



Applies to

- Induction motors, single speed, 2-8 pole
- 3-phase, 50 Hz, 60Hz or 50/60 Hz, up to 1000V
- Motors for continuous duty S1, S3>80%, S6>80%
- Motors for explosive atmosphere Ex ec, Ex tb, Ex tc, and Ex db
- Brake motors
- Total Enclosed Air Over (TEAO) motors

Major exemptions from the requirements

- High voltage motors
- Total Enclosed Non-Ventilated (TENV) motors
- Submersible motors

2) IE4 exemptions = ATEX motors, brake motors, 8-pole

The step 2 of regulation (EU) 2019/1781 has come into force effective 1st July 2023.

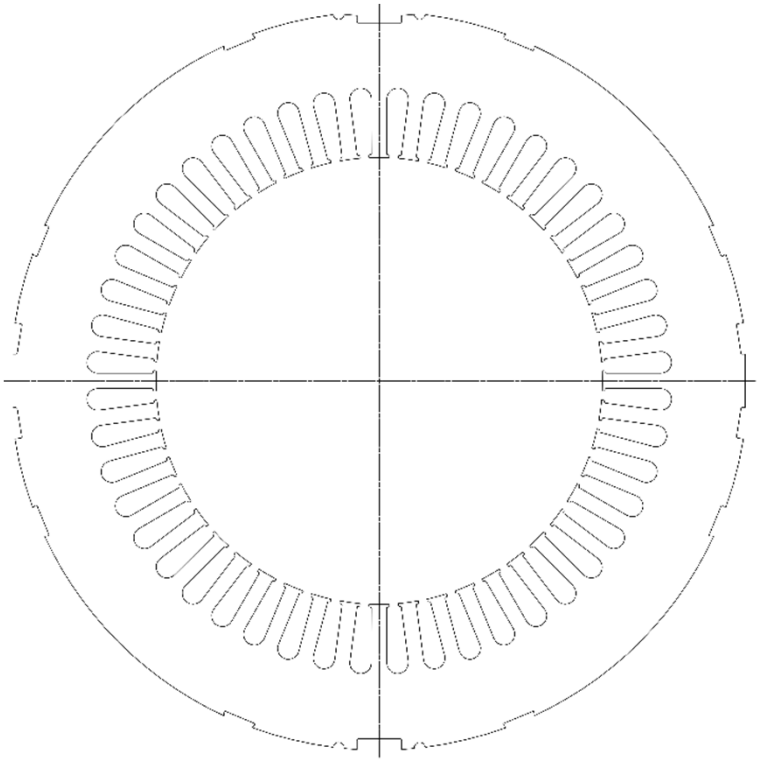
European Union has the most stringent of MEPS

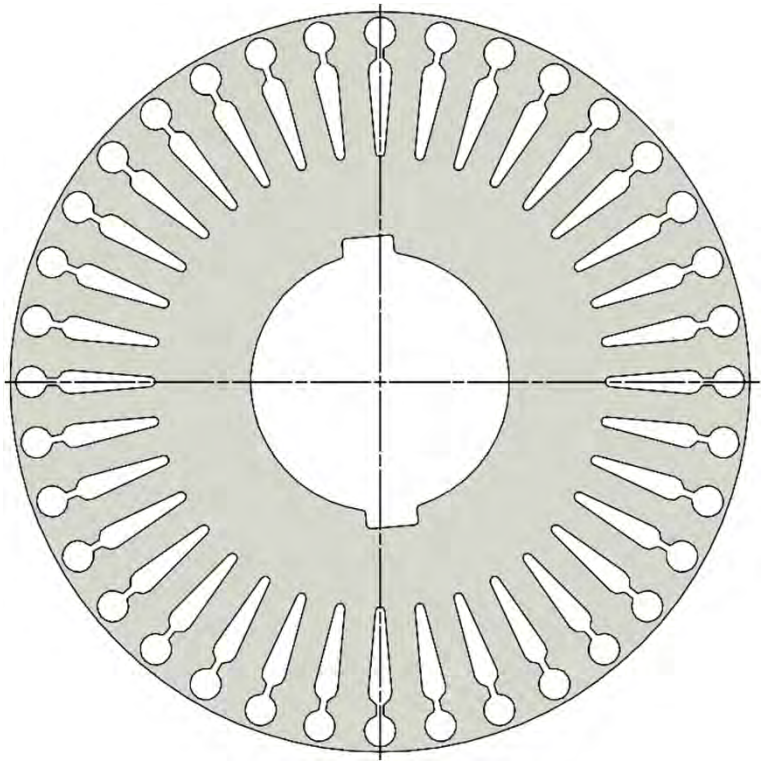
Area	Power range	Pole numbers	Minimum efficiency
Safe area — non explosion proof	≥ 0.12 - < 0.75 kW	2, 4, 6, 8	IE2
	≥ 0.75 - < 75 kW	2, 4, 6, 8	IE3
	≥ 75 - ≤ 200 kW	2, 4, 6	IE4
	≥ 75 - ≤ 200 kW	8	IE3
	> 200 - ≤ 1000 kW	2, 4, 6, 8	IE3

However, the very same CE regulation does not prevent European Manufacturers from manufacturing IE1& IE2 efficiency class motors for export to other countries.

The European Union does not really care about us. We have to care for ourselves.

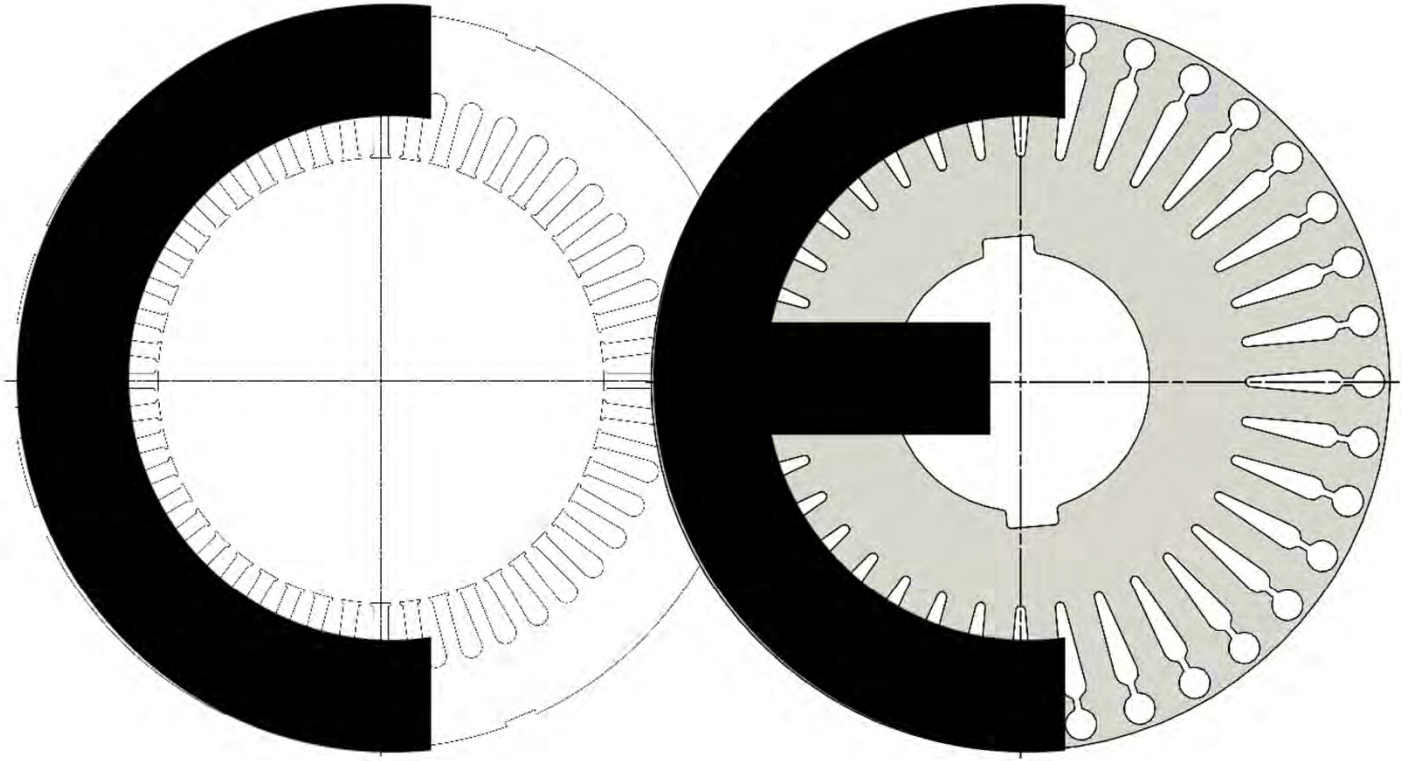
To mark a motor CE, one has to begin right at the design stage…





very serious commitment

CE mark is a ~~commitment~~ towards declared efficiency values…



Always insist for CE Marked motors.

Conformance to the new CE Regulation

'The verification tolerances defined in this Annex relate only to the verification by Member State authorities of the declared values and shall not be used by the manufacturer, importer or authorised representative as an allowed tolerance to establish the values in the technical documentation or in interpreting these values with a view to achieving compliance or to communicate better performance by any means.';

The new CE Regulation EU 2019/1781 requires that *only such values* of efficiency can be declared *as are measured at the test bed and reported in available Type Test report*.

The manufacturer (or importer or authorized representative) **shall not** use the tolerance for…

- declaring the values in the catalogue or any technical documentation
- or declaring conformance to the EU regulation qualifying criteria
- or declaring or communicating better performance

We are proud to confirm that the efficiency values declared by us are in conformance with the EU regulation (and its amendment) and therefore our 1LE7504 IE4 motors will carry the CE mark on the nameplate.

Note: *EU Regulation **does** however **permit** the use of tolerances as a conformance verification criteria.*

Why should you insist for a CE Marked motor?

Table 21 – Schedule of tolerances on values of quantities

Item	Quantity	Tolerance
1	Efficiency η	
	– machines up to and including 150 kW (or kVA)	–15 % of (1 – η)
	– machines above 150 kW (or kVA)	–10 % of (1 – η)

As per IS 12615:2018 / IEC 60034-30-1, for a 75kW, 4P, 50Hz motor, the qualifying value of efficiency for IE4 is 96%. After subtracting the tolerance, this value reduces to 95.4%. Depending on the test realised value….

Case No.	Max value in an available Type Test report	Required to qualify for IE4	Can motor be called IE4?	Can the motor be marked CE?	
1	95.4% ≤ η < 96%	96%	Yes	No	**Motors w/o CE mark**
2	η ≥ 96%		Yes	Yes	**Motors with CE Mark**

CE mark is much more than “just another nameplate marking”.

How does having a CE marked motor benefit the user?

Motors which <u>are</u> marked CE

1. Motors are “designed” for nominal efficiency value - meaning tolerance is not considered when designing the motors
2. Declared efficiency **MUST** have been recorded at the test field for the same design as was offered to the market (else it cannot be declared)
3. From any given random sample, **a lesser %age** of motors will need the “full permissible tolerance” to meet the declared efficiency.

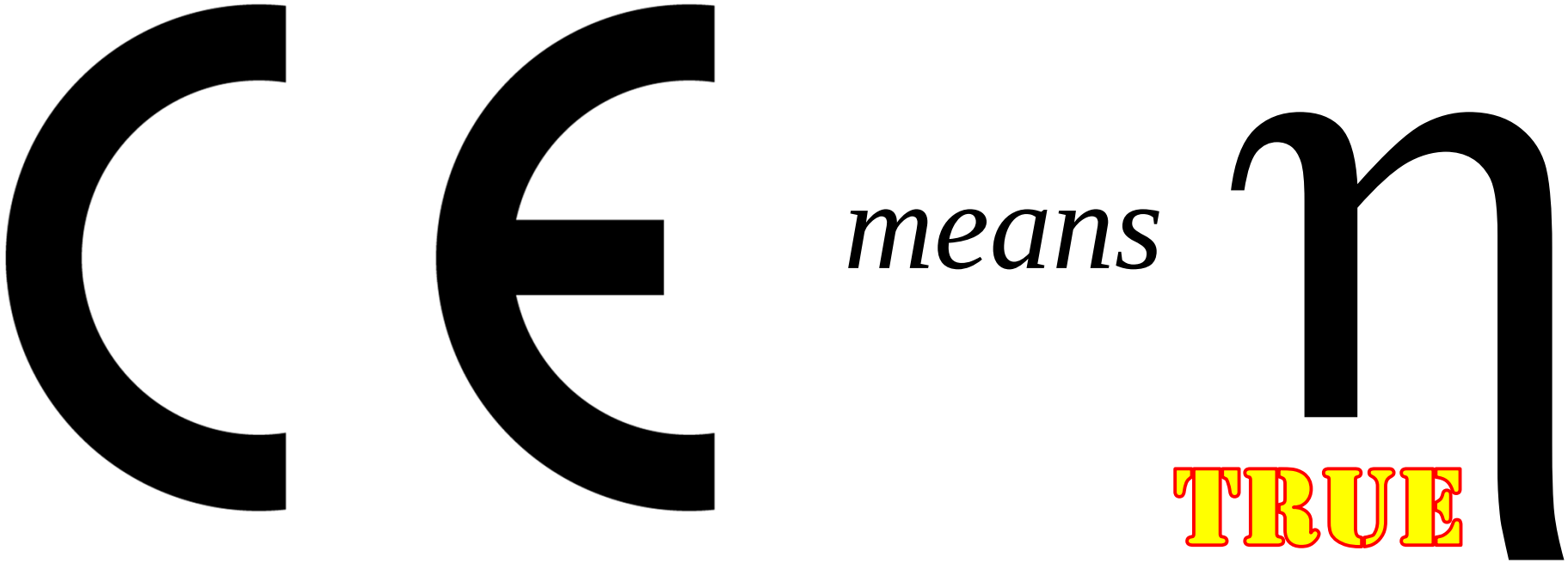
Motors which <u>are not</u> marked CE

1. Motors may be designed for lower efficiency value (within the permissible tolerance of the nominal value)
2. Declared efficiency **need not have been ever recorded** at the test field for the same design as is being offered to the market
3. From any given random sample, **a higher %age** of motors will meet the declared after utilizing the “full permissible tolerance”.

CE is not just another mark on the name-plate - CE indirectly means a truly efficient motor!

Why CE?

Because CE stands for Efficiency!



Think before you leap…

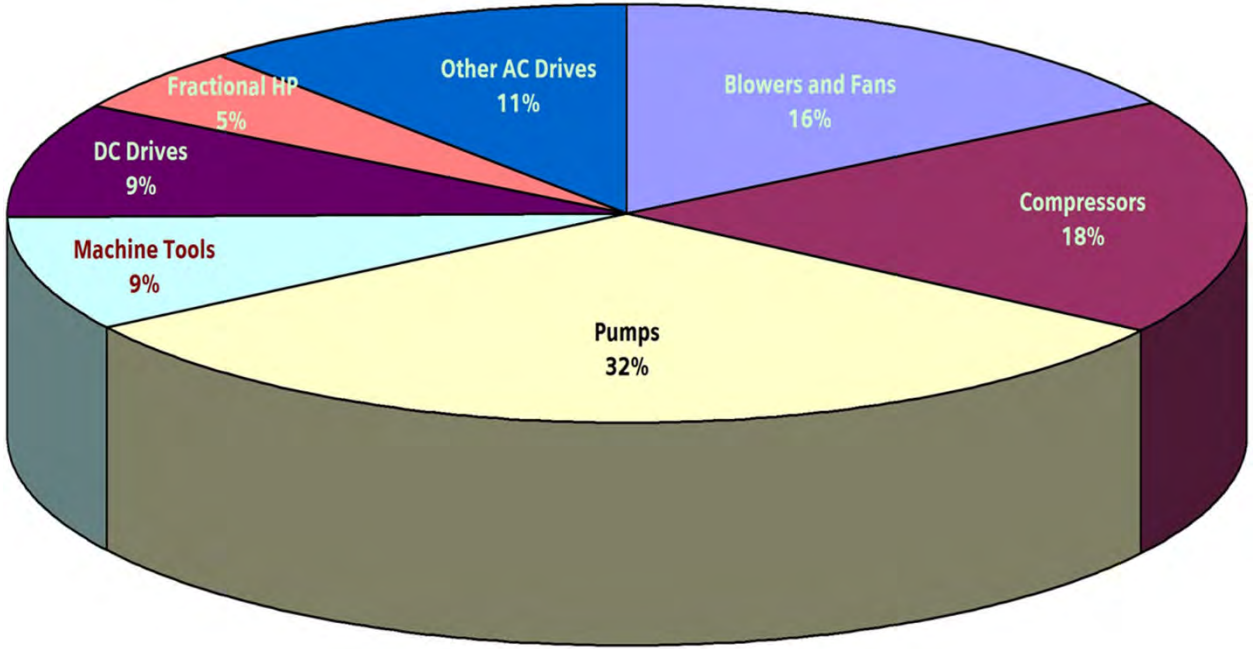
…is a very old adage.

If we forget this….

Think before you replace…

… existing motors blindly (specially for pumps)

Fans, pumps & compressors…



Blowers & Fans	16%
Compressors	18%
Pumps	32%
	66%

66% of motor driven applications!

… constitute almost ⅔ of the total motor driven applications!

The IEC TS 60034-31

This IEC document brings to the attention one very important phenomenon.

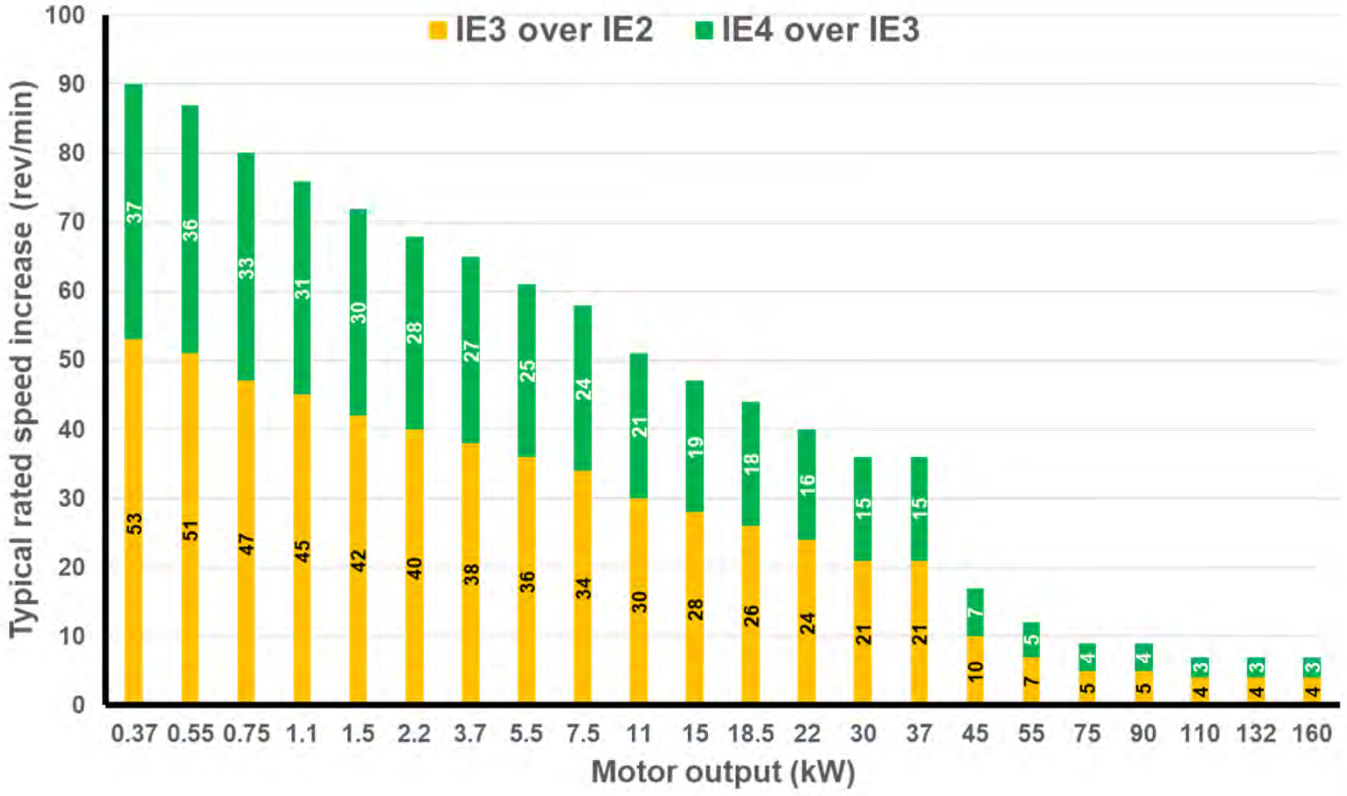
High efficiency motors have lower slip…

7.4 Operating speed and slip

In general, motors with higher efficiency have a higher operating speed, i.e. a reduced slip compared to motors of lower efficiency. On average, the slip is reduced by some 20 % to 30 % per next higher efficiency class for motors of the same rated output power.

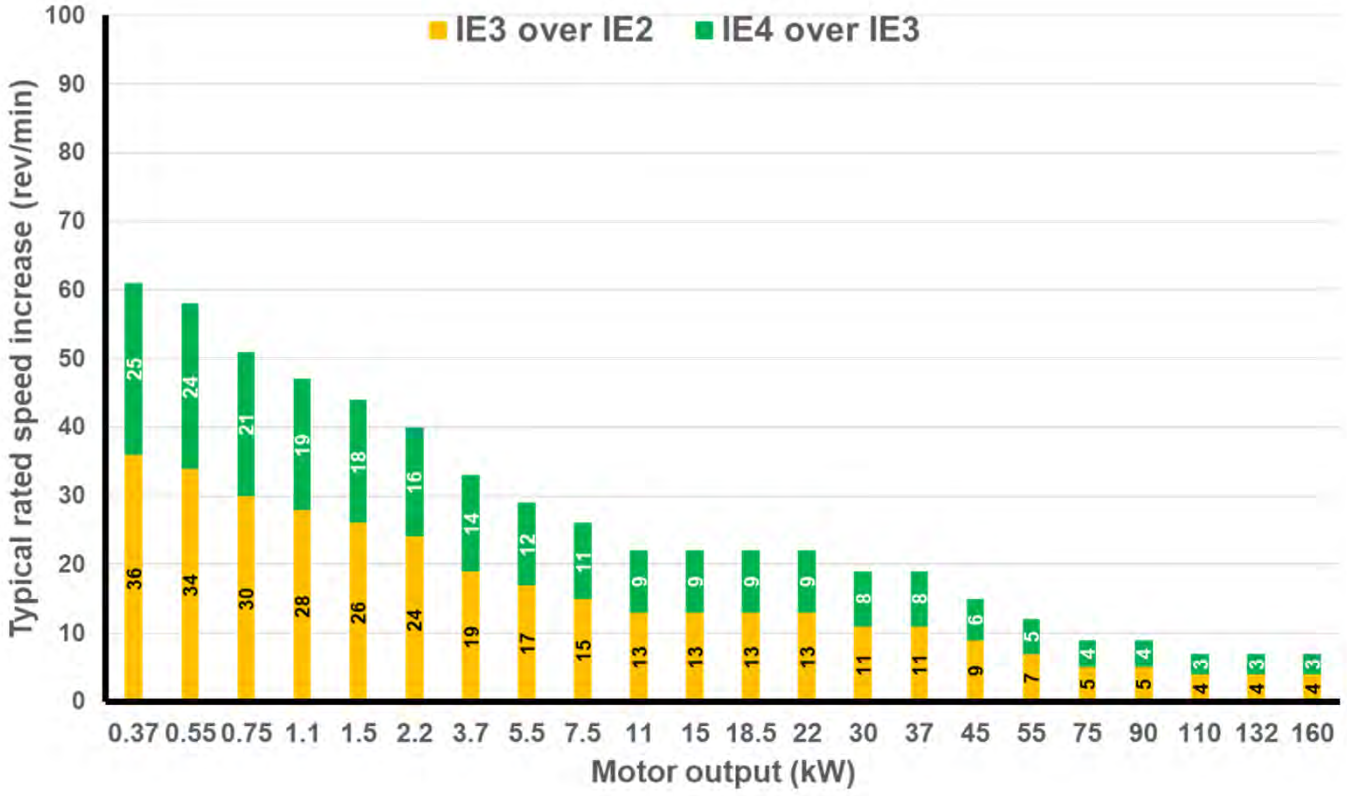
What does 20 to 30% slip reduction mean?

Typical expectable speed increase from one IE class to the next - 2P



2 Pole, 50Hz Induction motors			
Output	Typical Rated Speed (rev/min)		
kW	IE2	IE3	IE4
0.37	2825	2878	2915
0.55	2832	2883	2919
0.75	2846	2893	2926
1.1	2853	2898	2929
1.5	2860	2902	2932
2.2	2867	2907	2935
3.7	2874	2912	2939
5.5	2881	2917	2942
7.5	2888	2922	2946
11	2902	2932	2953
15	2909	2937	2956
18.5	2916	2942	2960
22	2923	2947	2963
30	2930	2951	2966
37	2930	2951	2966
45	2969	2979	2986
55	2968	2975	2980
75	2976	2981	2985
90	2976	2981	2985
110	2984	2988	2991
132	2984	2988	2991
160	2984	2988	2991

Typical expectable speed increase from one IE class to the next - 4P



4 Pole, 50Hz Induction motors			
Output	Typical Rated Speed (rev/min)		
kW	IE2	IE3	IE4
0.37	1381	1417	1442
0.55	1388	1422	1446
0.75	1402	1432	1453
1.1	1409	1437	1456
1.5	1416	1442	1460
2.2	1423	1447	1463
3.7	1437	1456	1470
5.5	1444	1461	1473
7.5	1451	1466	1477
11	1458	1471	1480
15	1458	1471	1480
18.5	1458	1471	1480
22	1458	1471	1480
30	1465	1476	1484
37	1465	1476	1484
45	1472	1481	1487
55	1468	1475	1480
75	1476	1481	1485
90	1476	1481	1485
110	1484	1488	1491
132	1484	1488	1491
160	1484	1488	1491

High efficiency motors have lower slip…

7.4 Operating speed and slip

In general, motors with higher efficiency have a higher operating speed, i.e. a reduced slip compared to motors of lower efficiency. On average, the slip is reduced by some 20 % to 30 % per next higher efficiency class for motors of the same rated output power.

If an existing motor is replaced with a more efficient motor, the higher speed may put more demand on the motor and as a result could draw more energy than the existing less efficient motor. This is sometimes referred to as a rebound effect. Care should be taken to avoid this

The standard warns against possible increased energy consumption.

What happens in case of centrifugal pumps & fans?

These equipment have square law torque characteristic and follow affinity laws.

- Flow α Speed
- Torque (Head) α Speed^2
- Power α Speed^3

$$P = \frac{2\pi \cdot N \cdot T}{60} \rightarrow P \propto N \cdot T$$

$$T \propto N^2 \rightarrow P \propto N \cdot N^2$$

$$P \propto N^3$$

What difference can a little increase in the motor speed really make?

Energy savings when going from IE2 to IE3 - Speed assumed same

Energy savings potential in a typical automobile plant.
Only the motors for exhaust and ventilation (basically fans) considered.

Sr. No.	Output	Poles	Frame Size	Qty	Speed of IE2 motor	IE2		IE3		Efficiency difference in %age points	Input in kW		Speed of IE3 motor considered to be		Energy Savings per motor	Total Energy Savings
	kW				rev / min	Effy (%)	LF	Effy (%)	LF		IE2	IE3	rev / min	Diff	kWH	kWH
1	15	4	160L	20	1458	91	0.85	92.4	0.850	1.4	14.011	13.799	1458	0	1,577.28	31,546
2	18.5	4	180M	4	1458	91.3	0.85	92.7	0.850	1.4	17.223	16.963	1458	0	1,934.40	7,738
3	22	4	180L	2	1458	91.7	0.85	93.1	0.850	1.4	20.393	20.086	1458	0	2,284.08	4,568
4	30	4	200L	2	1465	92.4	0.85	93.7	0.850	1.3	27.597	27.215	1465	0	2,842.08	5,684
5	30	6	225M	7	962	91.8	0.85	93	0.850	1.2	27.778	27.419	962	0	2,670.96	18,697
6	37	4	225S	3	1465	92.8	0.85	94	0.850	1.2	33.890	33.457	1465	0	3,221.52	9,665
7	45	4	225M	3	1472	93.2	0.85	94.3	0.850	1.1	41.041	40.562	1472	0	3,563.76	10,691
8	45	6	280S	1	972	92.8	0.85	93.8	0.850	1	41.218	40.778	972	0	3,273.60	3,274
9	55	4	250M	22	1468	93.6	0.85	94.7	0.850	1.1	49.947	49.366	1468	0	4,322.64	95,098
10	75	4	280S	1	1476	94.1	0.85	95	0.850	0.9	67.747	67.105	1476	0	4,776.48	4,776
11	90	4	280M	4	1476	94.3	0.85	95.2	0.850	0.9	81.124	80.357	1476	0	5,706.48	22,826
12	110	4	315S	8	1484	94.6	0.85	95.4	0.850	0.8	98.837	98.008	1484	0	6,167.76	49,342
13	132	4	315M	4	1484	94.8	0.85	95.6	0.850	0.8	118.354	117.364	1484	0	7,365.60	29,462
14	132	6	315L	15	984	94.7	0.85	95.4	0.850	0.7	118.479	117.610	984	0	6,465.36	96,980
15	160	4	315L	7	1484	94.9	0.85	95.8	0.850	0.9	143.309	141.962	1484	0	10,021.68	70,152
Total energy savings of the paint booth (in MWH)																**460**

Assumptions

1 IE2 Motors operate at 85% loading for 24 hours/day, 310 days/year.

2 Efficiency at LF (Load Factor) loading arrived at by formula as given in IEC TS 60034-31.

3 Speed of IE3 motor assumed to be same as that of IE2 motor.

Energy savings when going from IE2 to IE3 - Speed increase considered

Energy savings potential in a typical automobile plant.
Only the motors for exhaust and ventilation (basically fans) considered.

Sr. No.	Output	Poles	Frame Size	Qty	Speed of IE2 motor	IE2		IE3		Efficiency difference in %age points	Input in kW		Speed of IE3 motor considered to be		Energy Savings per motor	Total Energy Savings
	kW				rev / min	Effy (%)	LF	Effy (%)	LF		IE2	IE3	rev / min	Diff	kWH	kWH
1	15	4	160L	20	1458	91	0.85	92.4	0.870	1.4	14.011	14.123	1471	13	-833.28	-16,666
2	18.5	4	180M	4	1458	91.3	0.85	92.7	0.873	1.4	17.223	17.422	1471	13	-1,480.56	-5,922
3	22	4	180L	2	1458	91.7	0.85	93.1	0.873	1.4	20.393	20.629	1471	13	-1,755.84	-3,512
4	30	4	200L	2	1465	92.4	0.85	93.7	0.869	1.3	27.597	27.823	1476	11	-1,681.44	-3,363
5	30	6	225M	7	962	91.8	0.85	93	0.879	1.2	27.778	28.355	973	11	-4,292.88	-30,050
6	37	4	225S	3	1465	92.8	0.85	94	0.869	1.2	33.890	34.205	1476	11	-2,343.60	-7,031
7	45	4	225M	3	1472	93.2	0.85	94.3	0.864	1.1	41.041	41.230	1480	8	-1,406.16	-4,218
8	45	6	280S	1	972	92.8	0.85	93.8	0.871	1	41.218	41.786	980	8	-4,225.92	-4,226
9	55	4	250M	22	1468	93.6	0.85	94.7	0.860	1.1	49.947	49.947	1474	6	0.00	0
10	75	4	280S	1	1476	94.1	0.85	95	0.859	0.9	67.747	67.816	1481	5	-513.36	-513
11	90	4	280M	4	1476	94.3	0.85	95.2	0.859	0.9	81.124	81.208	1481	5	-624.96	-2,500
12	110	4	315S	8	1484	94.6	0.85	95.4	0.855	0.8	98.837	98.585	1487	3	1,874.88	14,999
13	132	4	315M	4	1484	94.8	0.85	95.6	0.855	0.8	118.354	118.054	1487	3	2,232.00	8,928
14	132	6	315L	15	984	94.7	0.85	95.4	0.858	0.7	118.479	118.717	987	3	-1,770.72	-26,561
15	160	4	315L	7	1484	94.9	0.85	95.8	0.855	0.9	143.309	142.797	1487	3	3,809.28	26,665
Total energy savings of the paint booth (in MWH)																**-54**

Assumptions

1 IE2 Motors operate at 85% loading for 24 hours/day, 310 days/year.

2 Efficiency at LF (Load Factor) loading arrived at by formula as given in IEC TS 60034-31.

3 Speed of IE3 motor assumed to be higher than that of IE2 motor as indicated in IEC TS 60034-31.

Blind replacement of IE2 motors with IE3 on the same equipment can give unpleasant surprises.

Does it mean one should never replace old motors with High Efficiency ones?

We never said that. However extra care needs to be taken…

For pumps (generally directly coupled)

- If the application permits, trim the impeller to a smaller diameter to account for higher speed of the high efficiency motors. This helps keeping the power demand same and thus achieve energy savings.

For fans (generally driven through a belt-pulley drive)

- Change the pulley ratio so that the fan still runs at the original speed (before motor replacement). This helps keep power demand same and thus achieve energy savings.

For pumps & fans replacing existing motors with high efficiency ones needs extra care!

High efficiency motors have lower slip…

7.4 Operating speed and slip

In general, motors with higher efficiency have a higher operating speed, i.e. a reduced slip compared to motors of lower efficiency. On average, the slip is reduced by some 20 % to 30 % per next higher efficiency class for motors of the same rated output power.

If an existing motor is replaced with a more efficient motor, the higher speed may put more demand on the motor and as a result could draw more energy than the existing less efficient motor. This is sometimes referred to as a rebound effect. Care should be taken to avoid this concern by adjusting the driven equipment accordingly, for instance by selecting a fan with a smaller diameter in order to achieve the same flow as before. In a new application the driven load would naturally be sized for the increased speed. The common error is illustrated in

What is the possible solution to this?

Even the IEC standards recommend a similar thing…

The example illustrates the importance of knowing the exact working conditions when comparing different motors. A practical solution in this case could be to adjust the impeller diameter of the fan in order to get the same power and flow at the higher speed, or to adjust the speed in a case when a variable frequency drive is used.

Basically, blind replacement of existing motors by EEMs is counter productive without proper care.

Energy conservation is…
… your responsibility

Not the Consultant’s.

"You could be buying energy inefficient motors…

…without even knowing it.

Interesting vacancy notification

- **Photocopy Machine Operator**

  Experience: Fresher or max 1 year of experience. Qualification: B.Tech with Distinction in Computer Science from IIT Kanpur or IIT Delhi. ***Candidates from any other universities need not apply.*** *IIT Madras and IIT Bombay pass outs may be considered only if IIT Kanpur or IIT Delhi candidates refuse to take up the job.*

We are sure you do not do such a hiring. However, when it comes to motors the story is different!

Inefficient operation of motors

Experience shows that most significant cause for in-efficient operation of motors in the Indian Industry is…

OVER-SIZING

The slides displayed here are based on factual observations.

The opinions expressed are purely personal.

Any resemblance to reality is purely coincidental and ~~unintentional~~. *actually it is intentional.*

The major causes for oversizing

1. Stringent (and uncalled for) restrictions on starting current
2. Specifying motors be suitable for very high voltage variations
3. Misconceptions about Locked Rotor Withstand Time and resulting clauses in consultant specifications
4. Our habit of never challenging our ancestors

We are obsessed with specifying $I_A/I_N \leq 6$

The following are typical clauses from the LV Motor Specifications of reputed consultants.

The starting current (as % rated current) at 100 % rated voltage shall not exceed **600%** for all motors

Unless otherwise specified, the starting current (as % rated current) shall not exceed 600% subject to tolerance.

Starting current of the motors, when started on direct-on-line mode, shall not exceed 6 times the rated current.

Insisting for lower starting current amounts to specifying low efficiency motors.

The IS 12615:2018 also stipulates higher I_A/I_N

IS 12615 : 2018

Table 1 Values of Performance Characteristics of 2 Pole Line Operated a.c. Motors

(*Clauses* 1.2, 1.3, 1.6, 10.1, 10.2, 11, 14.1, 14.4, 15.4.1, 17.3.5)

Sl. No.	Rated Output	Frame Size	Full Load Speed	Full Load Current	Locked Torque in Terms of Full Load Torque	Locked Rotor Current in Terms of Full Load Current			Nominal Efficiency		
						IE2	IE3	IE4	IE2	IE3	IE4
	kW		rev/ min	*Max* A	Percent	Percent	Percent	Percent	Percent	Percent	Percent
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
xiii)	11.0	160M	2 860	21.5	160	700	770	890	89.4	91.2	92.6
xiv)	15.0	160M	2 870	29.0	160	700	770	890	90.3	91.9	93.3
xv)	18.5	160L	2 880	35.0	160	700	770	890	90.9	92.4	93.7
xvi)	22.0	180M	2 890	41.5	160	700	770	890	91.3	92.7	94.0
xvii)	30.0	200L	2 900	55.0	160	700	770	890	92.0	93.3	94.5
xviii)	37.0	200L	2 900	67.0	160	700	770	890	92.5	93.7	94.8
xix)	45.0	225M	2 955	80.0	160	700	770	890	92.9	94.0	95.0
xx)	55.0	250M	2 960	95.0	160	700	770	890	93.2	94.3	95.3
xxi)	75.0	280S	2 970	130.0	160	700	770	890	93.8	94.7	95.6
xxii)	90.0	280M	2 970	150.0	160	700	770	890	94.1	95.0	95.8
xxiii)	110.0	315S	2 980	185.0	160	700	770	890	94.3	95.2	96.0
xxiv)	132.0	315M[1)]	2 980	220.0	160	700	770	890	94.6	95.4	96.2
xxv)	160.0	315L[1)]	2 980	265.0	160	700	770	890	94.8	95.6	96.3

The IS 12615:2018 also stipulates higher I_A/I_N

IS 12615 : 2018

Table 2 Values of Performance Characteristics of 4 Pole Line Operated a.c. Motors

(*Clauses* 1.2, 1.3, 1.6, 10.1, 10.2, 11, 14.1, 14.4, 15.4.1, 17.3.5)

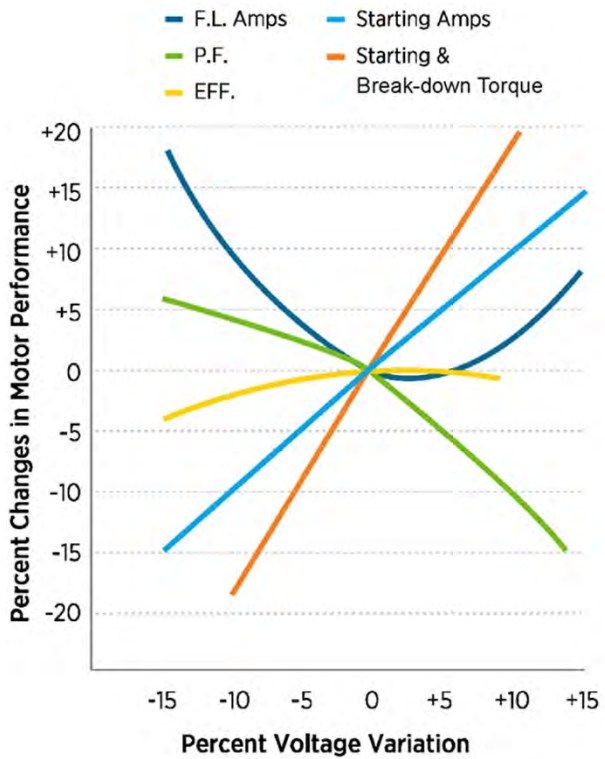
	Rated Output	Frame Size	Full Load Speed	Full Load Current	Locked Torque in Terms of Full Load Torque	Locked Rotor Current in Terms of Full Load Current			Nominal Efficiency		
						IE2	IE3	IE4	IE2	IE3	IE4
				Max							
	kW		rev/ min	A	Percent	Percent	Percent	Percent	Percent	Percent	Percent
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
xiii)	11.0	160M	1 440	22.0	160	700	750	830	89.8	91.4	93.3
xiv)	15.0	160L	1 440	30.0	160	700	750	830	90.6	92.1	93.9
xv)	18.5	180M	1 440	36.0	160	700	750	830	91.2	92.6	94.2
xvi)	22.0	180L	1 440	43.0	160	700	750	830	91.6	93.0	94.5
xvii)	30.0	200L	1 450	57.0	160	700	750	830	92.3	93.6	94.9
xviii)	37.0	225S	1 450	69.0	160	700	750	830	92.7	93.9	95.2
xix)	45.0	225M	1 460	84.0	160	700	750	830	93.1	94.2	95.4
xx)	55.0	250M	1 460	101.0	160	700	750	830	93.5	94.6	95.7
xxi)	75.0	280S	1 470	134.0	160	700	770	890	94.0	95.0	96.0
xxii)	90.0	280M	1 470	164.0	160	700	770	890	94.2	95.2	96.1
xxiii)	110.0	315S	1 480	204.0	160	700	770	890	94.5	95.4	96.3
xxiv)	132.0	315M[1)]	1 480	247.0	160	700	770	890	94.7	95.6	96.4
xxv)	160.0	315L[1)]	1 480	288.0	160	700	770	890	94.9	95.8	96.6

We like to specify wide voltage and frequency variation

415V±15%, 50Hz±5%

415V $^{+10\%}_{-15\%}$, 50Hz $^{+3\%}_{-6\%}$

1. Do not specify a wide voltage band
2. Instead, specify the voltage at which the motor will operate for major part of the day



The declared motor performance is binding if the motor operates…

1. at rated load
2. at rated frequency
3. with rated voltage

at its terminals.

Efficiency is the only parameter which deteriorates on either side of voltage deviation.

The IS 12615:2018 states that motors may not meet efficiency expectations

4.3 Voltage and Frequency Variation

Motors shall be capable of delivering rated output with:

a) Terminal voltage differing from its rated value by not more than ± 10 percent,

b) Frequency differing from its rated value by not more than ± 5 percent, or

c) Combined variation — The sum of absolute percent variations of (a) and (b) not exceeding 10 percent.

NOTE — In the case of continuous operation at the extreme voltage limits specified at **4.3 (a) and (b),** the temperature rise limits of the winding specified in IS 15999 (Part 1)/IEC 60034-1 shall not exceed by more than 20 K. In such cases, motor may be designed with higher class of insulation. Motors operated under the extreme conditions of voltage and/or frequency specified in **4.3 (a) and (b),** the performance values given in Table 1 to Table 4 may not necessarily comply with this standard.

The Indian Standard clearly allows 20K of higher temperature rise.

What about international standards?

IEC 60034-30-1:2014 © IEC 2014 – 11 –

The following motors may not be able to reach the higher efficiency classes specifications (IE3 and above):

- Motors specifically built for operation in explosive environments according to IEC 60079-0 (due to safety requirements and possible design constraints of explosion proof motors such as increased air-gap, reduced starting current, enhanced sealing);
- Motors for special requirements of the driven machine beyond the requirements of the IEC 60034 series of standards (such as motors for heavy starting duty, special torque stiffness and/or breakdown torque characteristics, large number of start/stop cycles, very low rotor inertia);
- Motors for special characteristics of the grid supply beyond the requirements of the IEC 60034 series of standards (such as motors with limited starting current, increased tolerances of voltage and/or frequency);

The IEC 60034-30-1 states that limiting the starting current means specifying lower efficiency.

What about international standards?

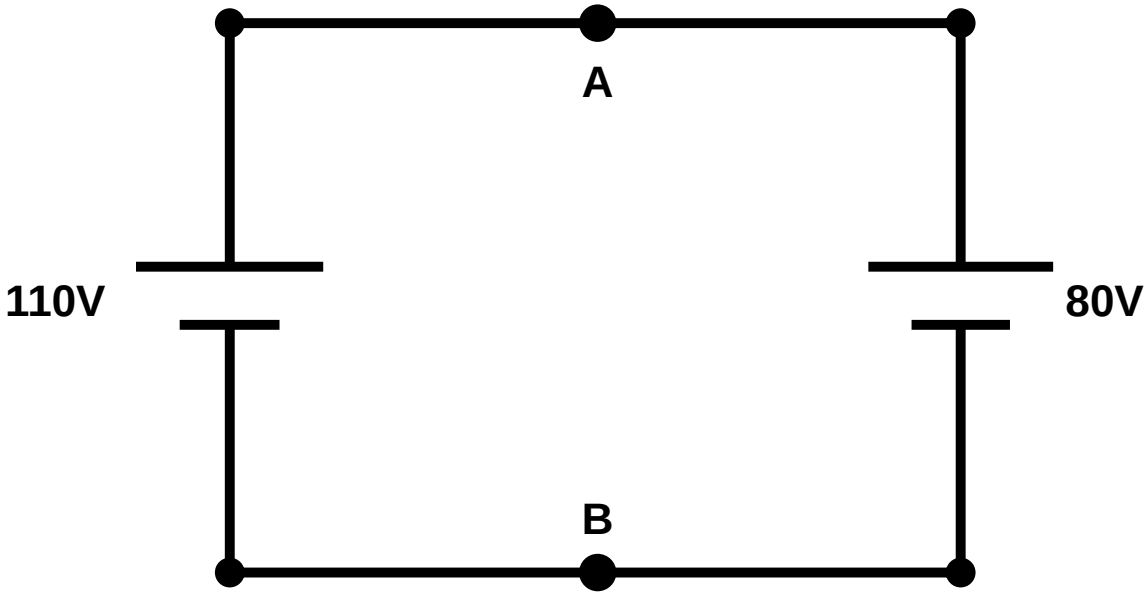
IEC 60034-30-1:2014 © IEC 2014 – 11 –

The following motors may not be able to reach the higher efficiency classes specifications (IE3 and above):

- Motors specifically built for operation in explosive environments according to IEC 60079-0 (due to safety requirements and possible design constraints of explosion proof motors such as increased air-gap, reduced starting current, enhanced sealing);
- Motors for special requirements of the driven machine beyond the requirements of the IEC 60034 series of standards (such as motors for heavy starting duty, special torque stiffness and/or breakdown torque characteristics, large number of start/stop cycles, very low rotor inertia);
- Motors for special characteristics of the grid supply beyond the requirements of the IEC 60034 series of standards (such as motors with limited starting current, increased tolerances of voltage and/or frequency);

The IEC 60034-30-1 also indicates specifying higher supply variations means lower efficiency.

Can you tell, what is the voltage across points A & B?



Consider that impedances of both the sources are identical.

Many a consultant’s most favourite clause…

Starting condtions:

For motors rated 55kW and above the Locked Rotor Withstand Time under Hot condition at 110%Vr should be at least 5s more than the starting time at 80%Vr.

Note:

This is a typical clause. Not necessary that all consultants have this. Also, the rating may change from consultant to consultant.

What could be the intent behind such a clause? And what could be the implications?

Many consultant’s most favourite clause…

Starting condtions:

For motors rated 55kW and above the Locked Rotor Withstand Time under Hot condition at 110%Vr should be at least 5s more than the starting time at 80%Vr.

Example:

An ID Fan directly coupled to a 6P motor has a BkW (absorbed power) of 45kW and its GD² referred to motor shaft is 250 kgf.m². Recommended motor rating is 55kW/6P in Frame Size 280M. Please confirm if the motor meets the above detailed consultant requirement. If not please select an appropriate motor.

To conform to this clause the condition to be met is….

$$t_{Start\_0.8U_N} = LRWT_{1.1U_N} - 5$$

Let us look at the implications of this seemingly innocent clause

Many consultant's most favourite clause…

$$t_{Start\_0.8U_N} = LRWT_{1.1U_N} - 5$$

Motor Data							Load Data		Starting Time (s)		Difference between LRWT Hot at 110% Vr and Starting time at 80% Vr
Output	Frame Size	GD²	I_A/I_N	LRWT Hot (s)			Absorbed Power	GD²			
kW		kgf.m²		at 100% Vr	at 80% Vr	at 110% Vr	kW	kgf.m²	at 100% Vr	at 80% Vr	s
55	280M	6	6	8	12	6	45	250	7	15	-9
75	315S	9.6	6	12	18	9	45	250	5	11	-2
90	315M	11.6	6	12	18	9	45	250	5	10	-1
110	315L	15	6	12	18	9	45	250	3	6	3
132	315L	19.8	5.5	12	18	9	45	250	4	8	1
160	355L	24	6	20	31	16	45	250	3	6	10

The requirement of the clause can be met …

- neither by motors rated 55kW, 75kW and 90kW
- nor by motors rated 110kW and 132kW

One needs 160kW/6P motor to satisfy this specific clause.

Motor rated 160kW needs to be offered for a BkW of only 45kW. Is there any merit in such clauses?

Insulation “F” but utilized to “B” limits

Insisting that a Class F insulated motor (145˚C temperature class) is used only till Class B (120˚C) coupled with previously discussed requirement causes the motors to be offered in higher frame size.

* Unless otherwise specified, the motors shall have class ‘F’ insulation utilized to class B temperature rise (i.e. temperature over an ambient of 40° C. as measured by the resistance of the windings when the altitude

Unless otherwise specified in the data sheet, motors shall be provided with class ’F’ type insulation. The permissible temperature rise as measured by resistance method, shall be limited to those specified in the applicable Indian standards for class ‘B’ insulation.

Unless otherwise specified in the motor data sheet, motors shall be provided with class ‘B’ insulation as a minimum. In case of motors with class ‘F’ insulation the permissible temperature rise above the specified ambient temperature shall be limited to those specified in the applicable Indian standards for class ‘B’ insulation.

All Motors shall be with class ‘F’ insulation with temperature rise limited to class ‘B’.

There is always a margin planned for P_{out} over the BkW of the Driven Machine. Why F to B then?

Too generic and stone-age specifications…

CODES AND STANDARDS

The squirrel cage induction motors and their components shall comply with the latest editions of following standards issued by BIS (Bureau of Indian Standards) unless otherwise specified:

IS - 5	Colours for ready mixed paints and enamels.
IS - 325	Three phase induction motors.
IS - 1076	Preferred numbers.
IS - 1231	Dimensions of three phase foot mounted induction motors.
IS - 1271	Thermal evaluation and classification of electrical insulation.
IS - 2148	Flame proof enclosures of electrical apparatus.
IS - 2223	Dimensions of flange mounted AC Induction motors.
IS - 2253	Designation for type of construction and mounting arrangement of rotating electrical machines.
IS - 2254	Dimensions of vertical shaft motors for pumps.
IS - 2968	Dimensions of slide rails for electric motors.
IS - 4029	Guide for testing three phase induction motors.
IS - 4691	Degrees of protection provided by enclosure for rotating electrical machinery.
IS - 4722	Rotating electrical machines.

Withdrawn in 2001

Is your consultant specification really updated? Or is it “out-dated”?

Too generic and stone-age specifications…

IS - 4722	Rotating electrical machines.
IS - 4728	Terminal marking and direction of rotation for rotating electrical machinery.
IS - 4889	Method of determination of efficiency of rotating electrical machines.
IS - 6362	Designation of methods of cooling of rotating electrical machines.
IS - 6381	Construction and testing of electric apparatus with type of protection 'e'.
IS - 7389	Pressurized enclosure of electrical equipment for use in hazardous area.
IS - 7816	Guide for testing insulation resistance of rotating machines.
IS - 8223	Dimensions and output series for rotating electrical machines.
IS - 8289	Electrical equipment with type of protection 'n'.
IS - 8789	Values of performance characteristics for three phase induction motors.
IS - 9283	Motors for submersible pump sets.
IS - 9628	Three phase induction motors with type of protection 'n'.
IS - 12065	Permissible limits of noise level for rotating electrical machines.
IS - 12075	Mechanical vibration of rotating Electrical Machines with shaft heights 56 mm and higher - measurement, evaluation and limits of vibration severity.

Withdrawn in 2002

Withdrawn in 2006

Withdrawn in 2006

Is your consultant specification really updated? Or is it "out-dated"?

Too generic and stone-age specifications…

IS - 9628	Three phase induction motors with type of protection 'n'.
IS - 12065	Permissible limits of noise level for rotating electrical machines.
IS - 12075	Mechanical vibration of rotating Electrical Machines with shaft heights 56 mm and higher - measurement, evaluation and limits of vibration severity.
IS - 12802	Temperature rise measurement of rotating electrical machines.
IS - 12824	Type of duty and classes of rating assigned to rotating electrical machines.
IS - 13408	Code of practice for the selection, installation and maintenance of electrical apparatus for use in potentially explosive atmospheres.
IS - 13529	Guide on effects of unbalanced voltages on the performance of three phase cage induction motors.
IS - 13555	Guide for selection and application of three phase induction motors for different types of driven equipment.
IS - 14568	Dimensions and output series for rotating electrical machines, frame numbers 355 to 1000 and flange numbers 1180 to 2360.

If the IS 12615 itself is not mentioned, how does one hope to be supplied an IE2, IE3 or an IE4 motor in the first place?

Is your consultant specification really updated? Or is it "out-dated"?

Yes, we do indeed buy the bus instead of the car…

When?

- When we specify a reduced starting current for thousands of motors in a steel plant because there are always around 35-50 motors which need to be started with power from DG - Set and these few need to have $I_A/I_N < 5.0$.
- When we specify all motors for a greatly reduced voltage starting to account for a voltage drop when “all the motors in the plant are started at the same instant” - something that will never occur.
- When we insist for a VFD Fed fan motor to be capable of Y-Δ starting for that once in a blue moon scenario.
- When we insist for class F utilized to B to account for over-loads, when motor ratings are already arrived at after considering margins on shaft power demand.
- When we stop using our engineering sense and simply trust the consultant.

Can we please stop buying the bus instead of the car?

Consultant specification should ensure trouble free operation…

…but not at the cost of oversizing and resulting inefficiencies.

Think out of the box
for unprecented energy savings

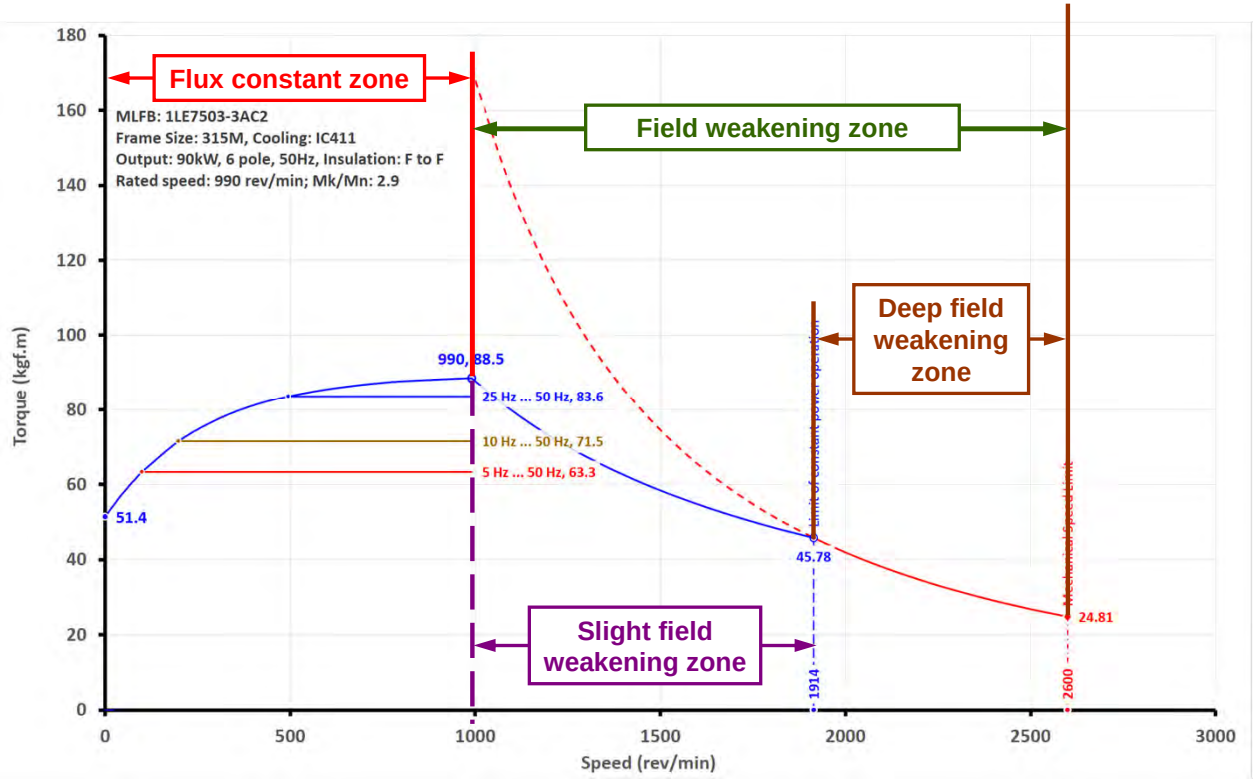
Let us give you some **serious** food for thought…

"

Pole optimized motor selection…

…a new idea which can do wonders.

Zones of operation of a converter fed induction motor



Operating on a VFD a motor may operate into 3 zones

1. Flux constant zone - 0Hz to f_{Rated} (the constant torque zone)
2. Field weakening zone - slight (the constant power zone)
3. Field weakening zone - deep (the reducing power zone)

A VFD fed motor can operate in Flux Constant Zone or the Field Weakening Zone

Introduction to pole-optimized motor selection

When the torque demand of the driven machine can be described by either of the two characteristics shown besides,

1. DC Motor characteristics or
2. Constant torque characteristics

then pole-optimized motor selection is possible.

What does pole optimization really mean?

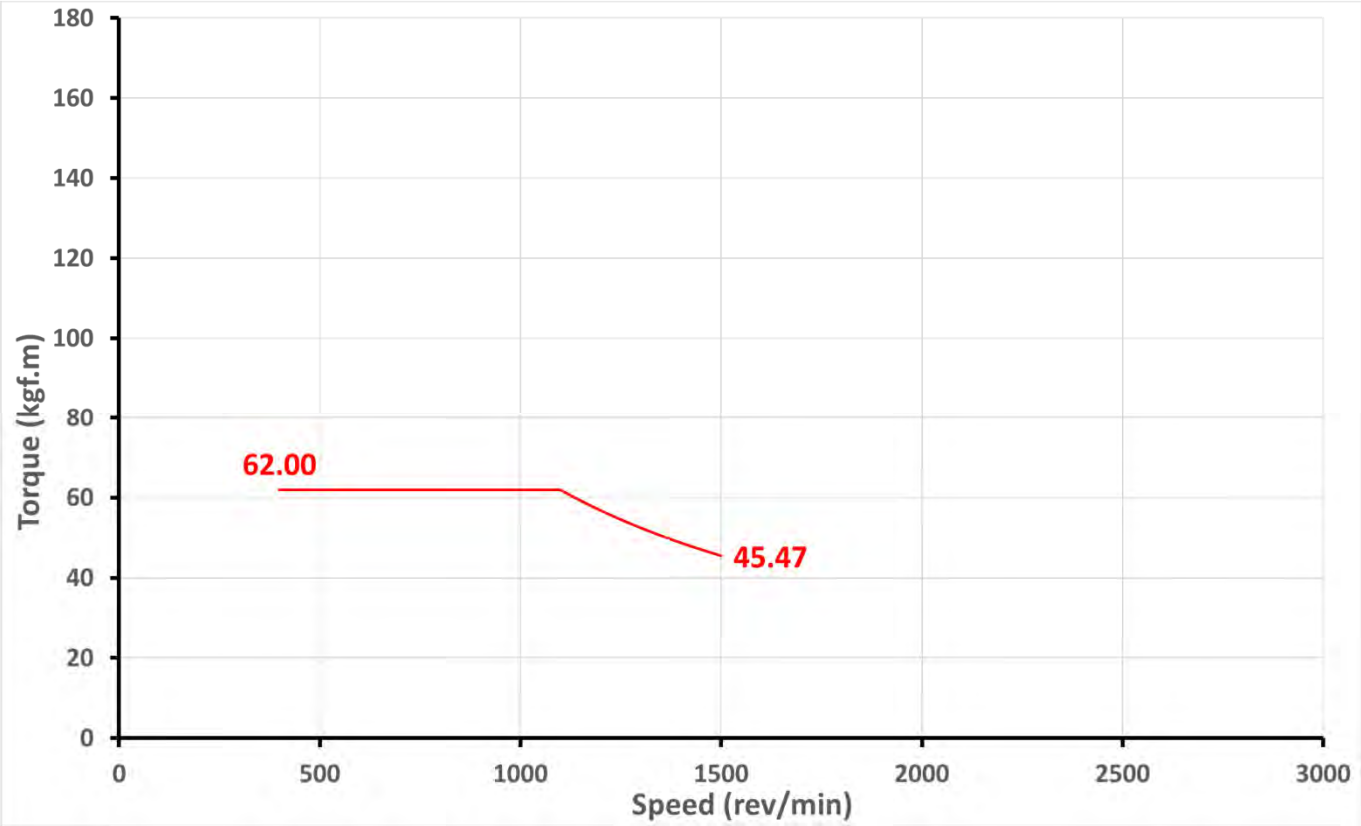
Pole optimization - What exactly is it?

Pole-optimized motor selection means …

- **Instead of selecting a 4P motor operating in Constant-Flux mode,**
- **selecting a 6P motor which operates in a slight field-weakening mode**

can result in a smaller output or a reduced converter current rating!

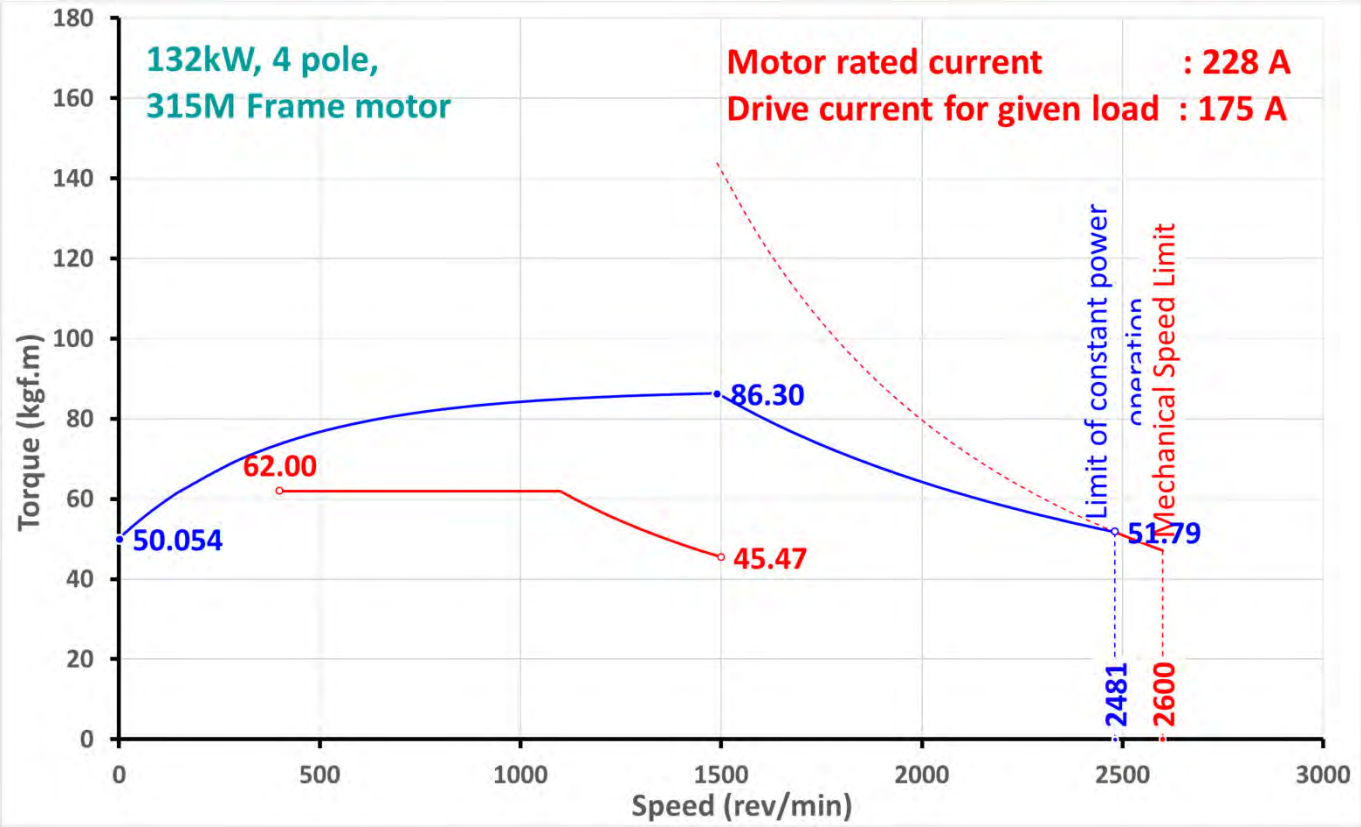
A typical application in paper industry



This is a typical application which needs

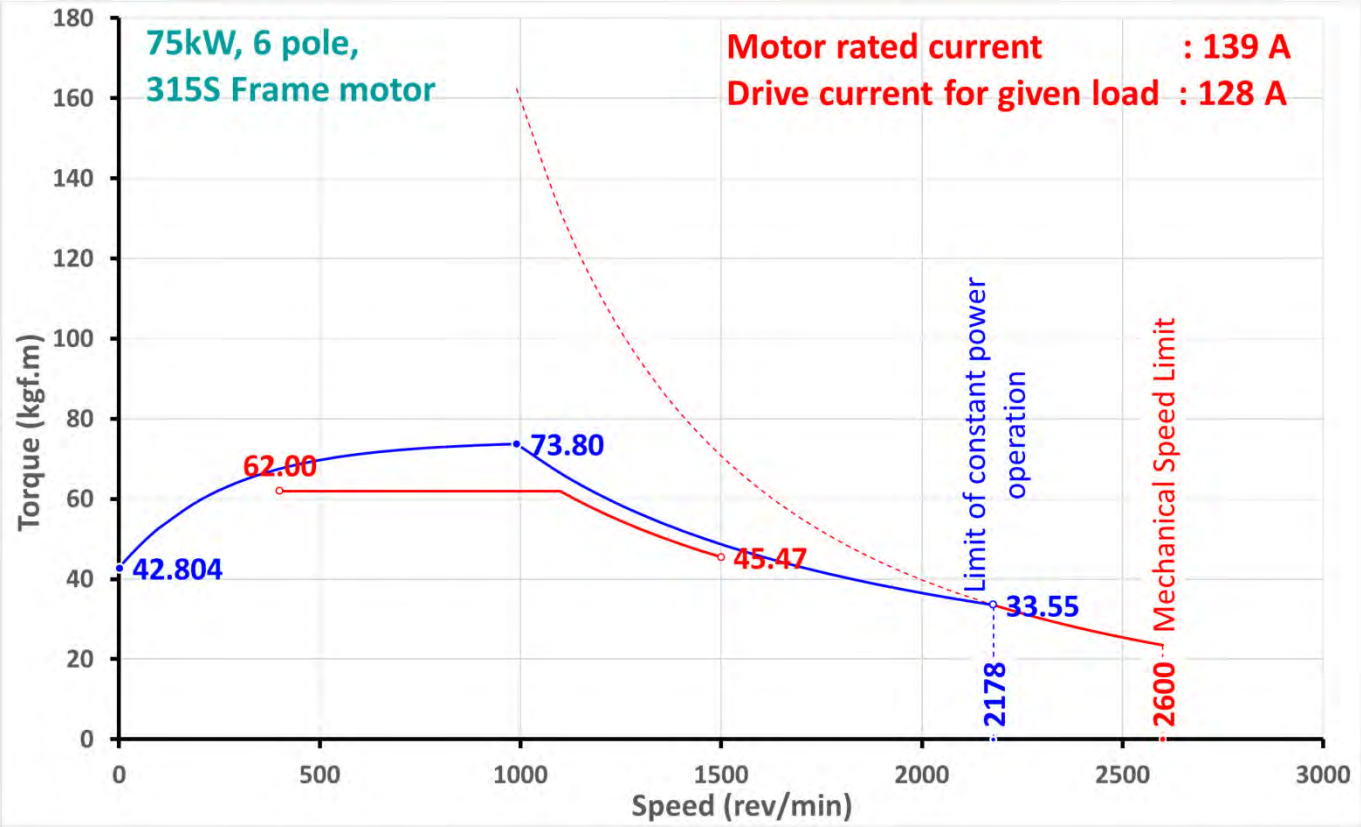
- constant torque of 62 kgf.m over 400 - 1100 rev/min and
- constant power over 1100 - 1500 rev/min

A typical application in paper industry - with 132kW/4P, IC411 motor



A 132kW, 4P, IC411 motor runs in constant flux zone (Zone A) only.

A typical application in paper industry - with 75kW/6P, IC411 motor

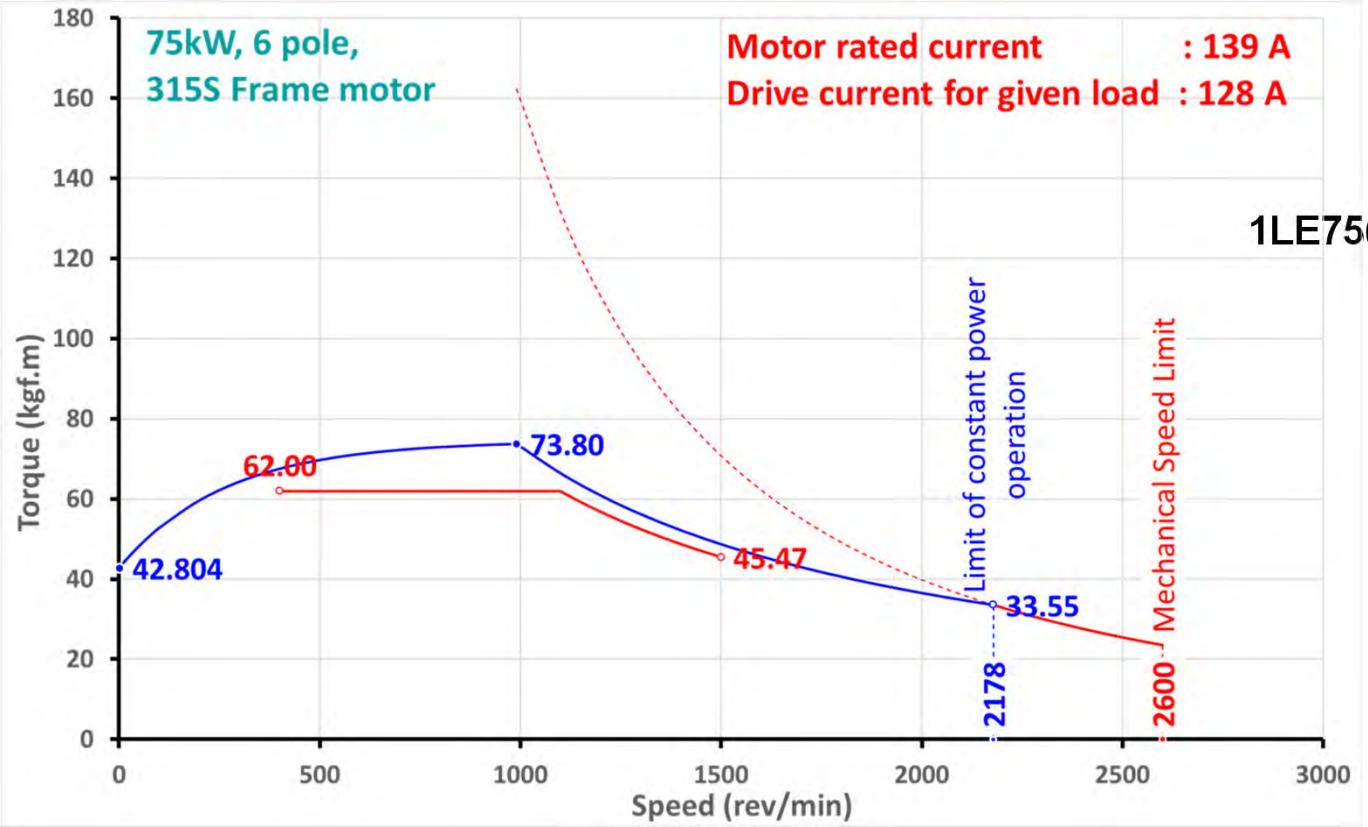


A 75kW, 6P IC411 motor runs in Zone A as well as Zone B.

The reduction of rating from 132kW to 75kW would mean a significantly lesser converter current.

It does sometimes make sense to let the motor operate in field weakening zone.

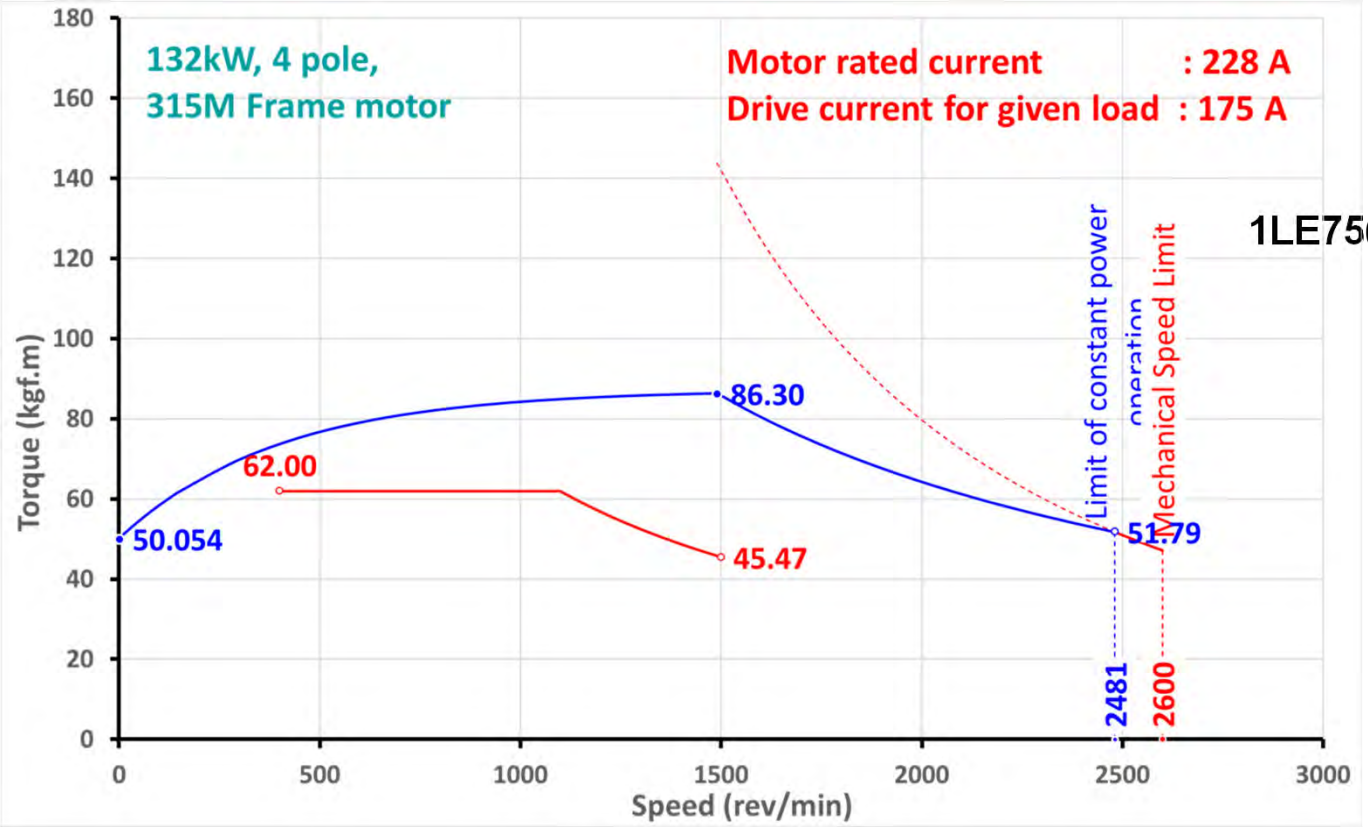
How do you benefit from Pole Optimization?



1LE7501-3AC0, 315S, 75kW/6P, 50Hz

Motor rated current : 139A
Drive current for given load : 128A

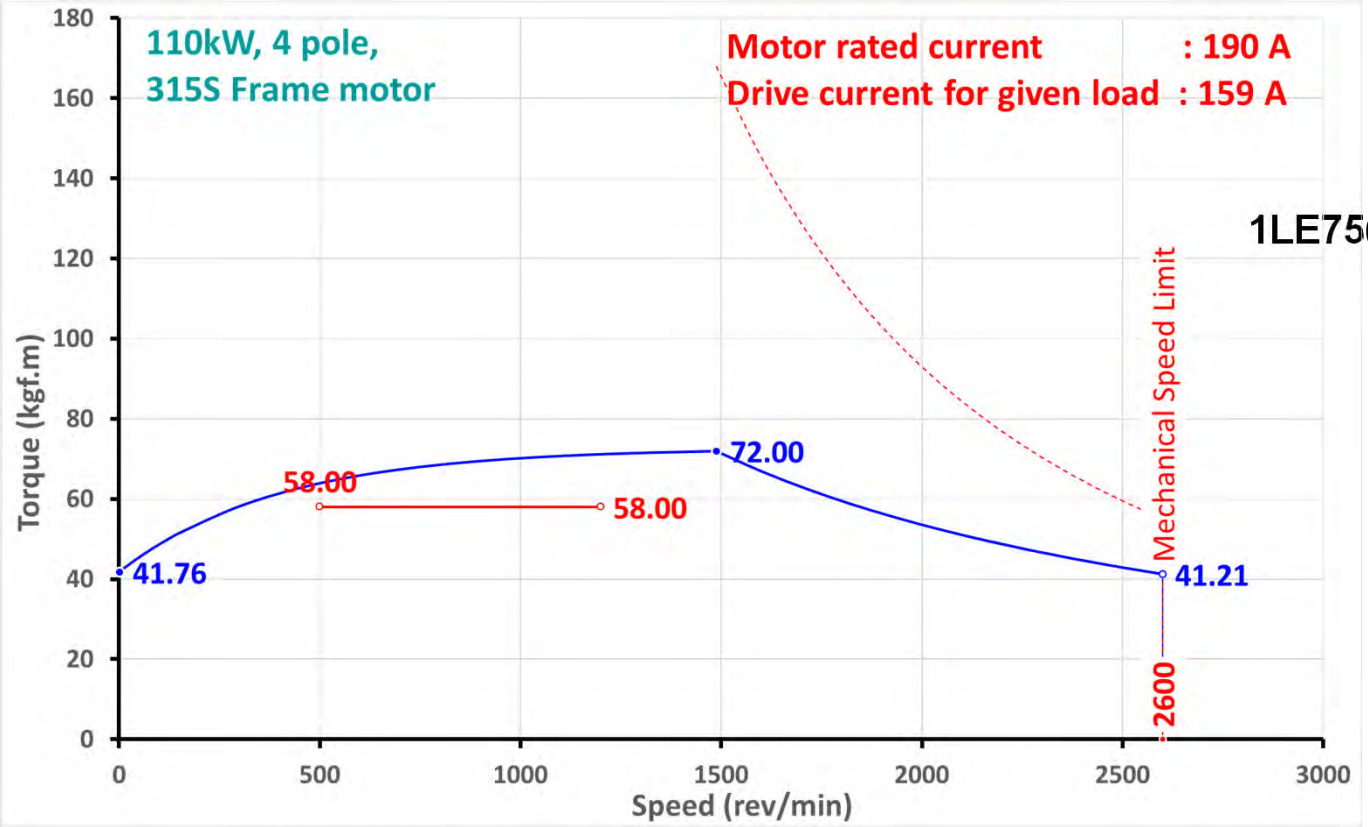
How do you benefit from Pole Optimization?



1LE7501-3AB2, 315M, 132kW/4P, 50Hz

Motor rated current : 228A
Drive current for given load : 175A

How do you benefit from Pole Optimization?

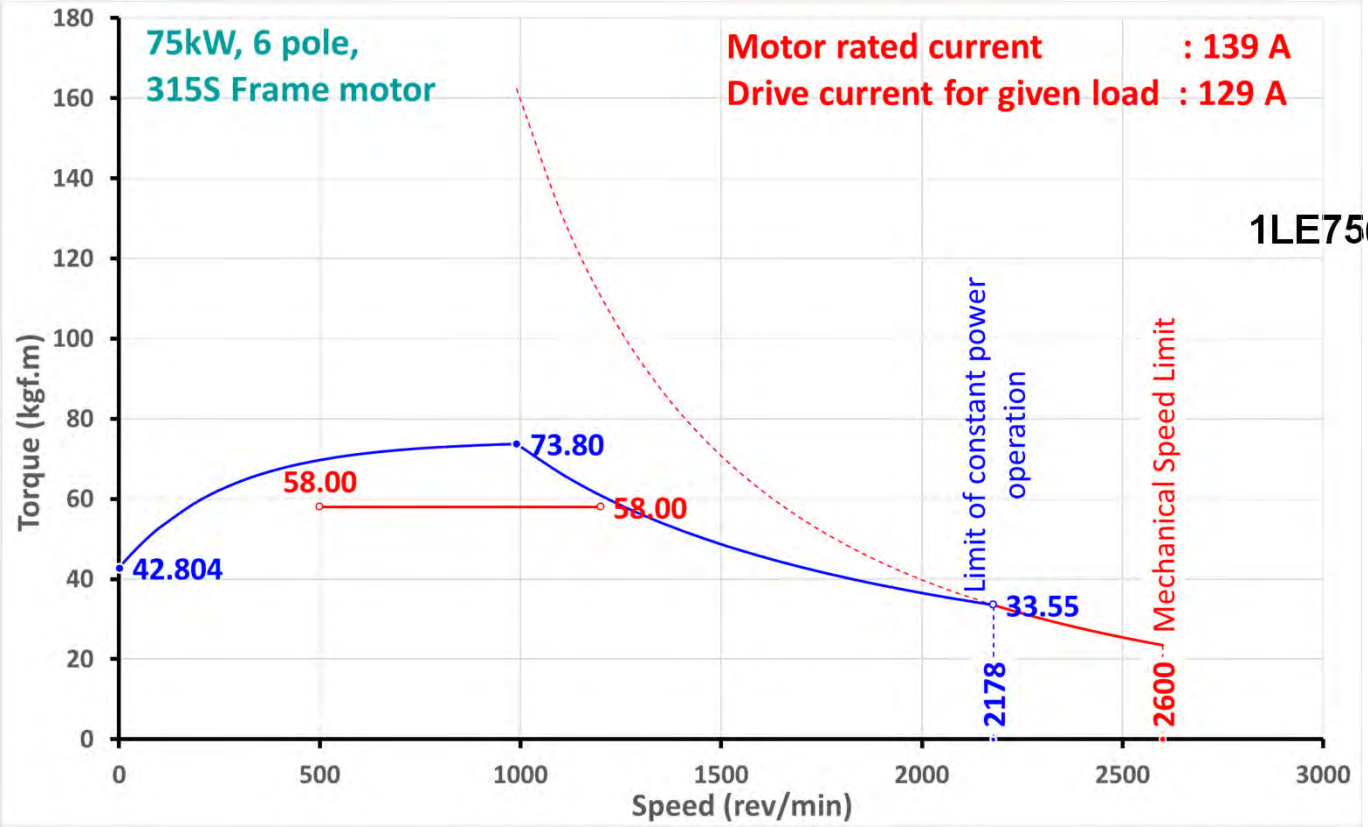


For a conveyor demanding 58 kgf.m of constant torque over 500 - 1200 rev/min as well….

1LE7501-3AB0, 315S, 110kW/4P, 50Hz

Motor rated current : 190A
Drive current for given load : 159A

How do you benefit from Pole Optimization?



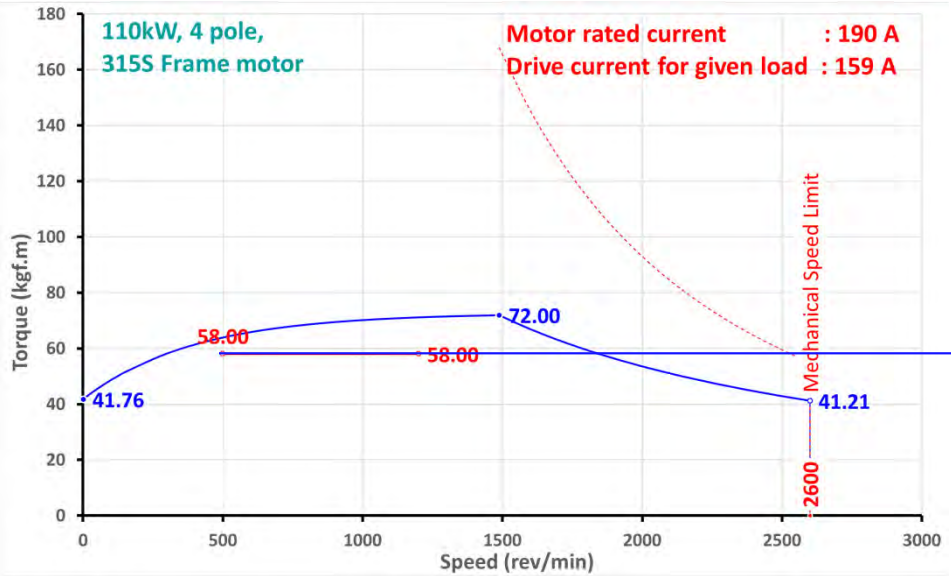
For a conveyor demanding 58 kgf.m of constant torque over 500 - 1200 rev/min as well….

1LE7501-3AC0, 315S, 75kW/6P, 50Hz

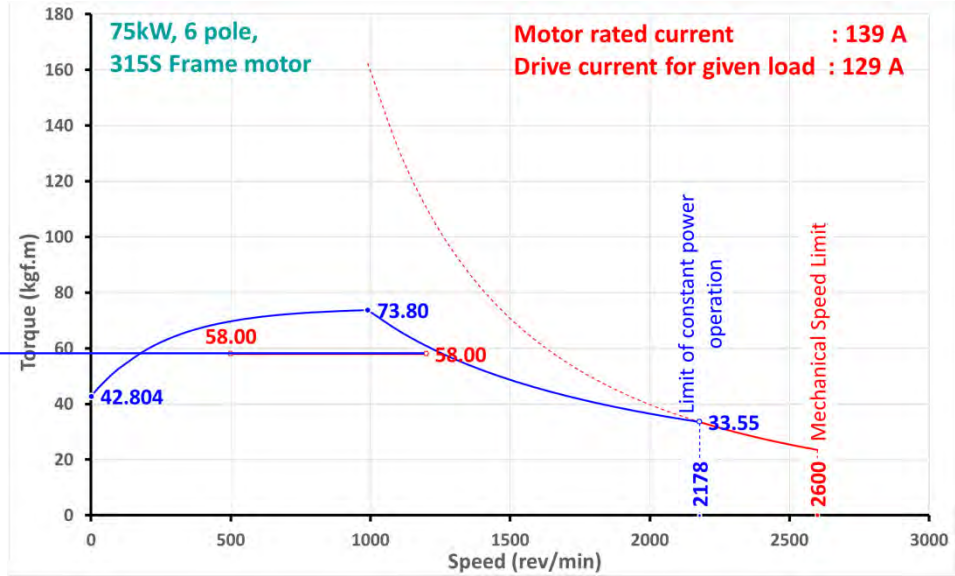
Motor rated current : 139A
Drive current for given load : 129A

How do you benefit from Pole Optimization?

1LE7501-3AB0, 315S, 110kW/4P, 50Hz



1LE7501-3AC0, 315S, 75kW/6P, 50Hz



Even for a constant torque load, which is ideally suited for flux constant zone (**Zone A**), pole optimization does give an advantage of reduction in rating of the motor and thereby reduction in converter current.

Be open to the concept and benefit from reduced motor and VFD sizing.

Jolly Roger

Does any of you know what this is?

"

The greater danger to furthering your energy conservation effort comes…

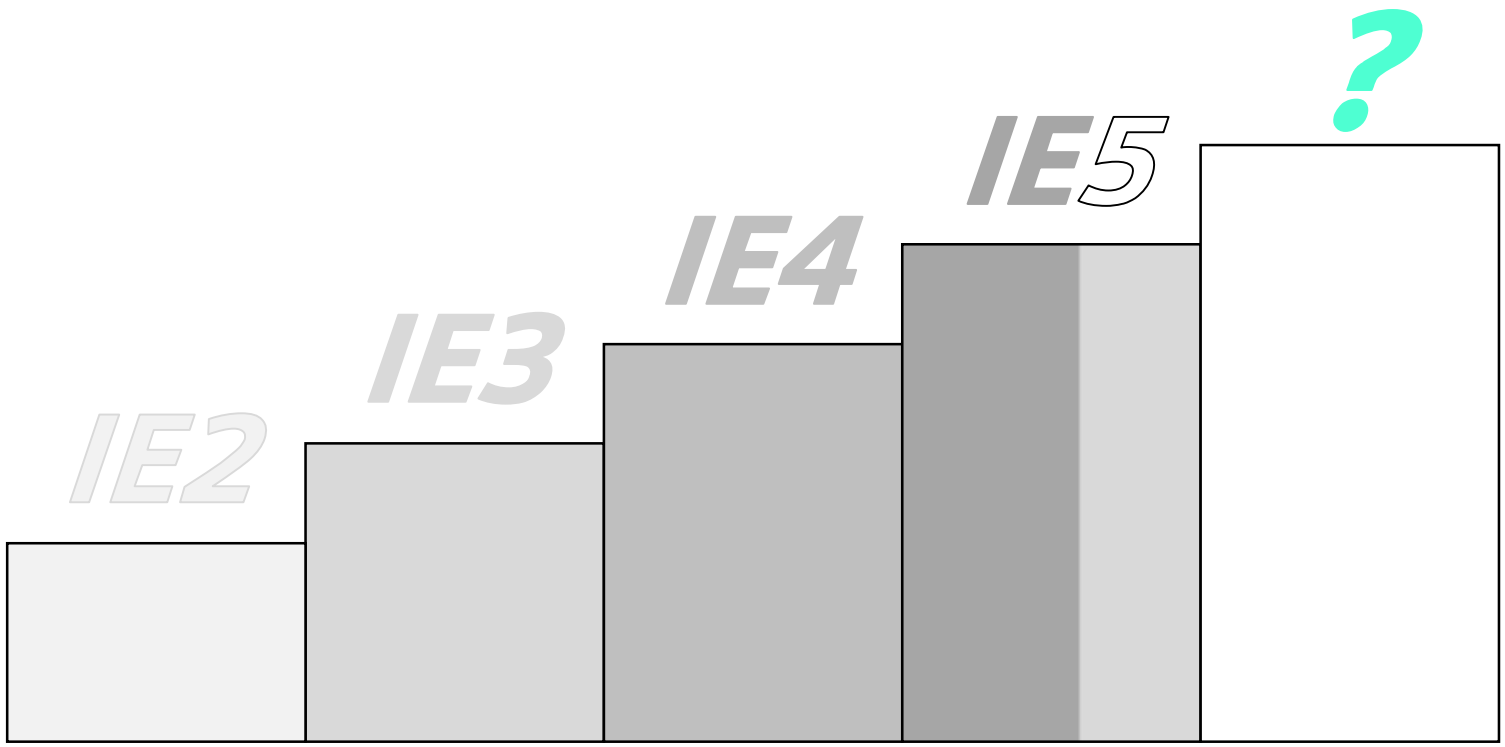
The IEC 60034-30-1 states regarding IE5 as…

Annex A
(informative)

Nominal limits for efficiency class IE5

The levels of the IE5 efficiency class are envisaged to be incorporated into the next edition of this standard and/or in part two of this standard series. It is the goal to reduce the losses of IE5 by some 20 % relative to IE4. Motor technologies for IE5 are currently not well developed and not commercially available.

To further the energy conservation drive…



Case study - 30kW centrifugal pump, 75kW/2P motor

Centrifugal Pump (M ~ N^2 load characteristics)		
Output	kW	30
Efficiency	%	55%
Input	kW	54.55
Margin considered	%	15%
Calculated Motor Rating	kW	62.73
Motor Details		
Next Standard Motor rating	kW	75
Type of Motor		Induction
Type of operation		Line Fed
Efficiency class		IE2
Poles		2
Speed		2976
Power demand at motor shaft (Corrected for the actual speed of the motor)	kW	54.55
Motor Loading (as ratio to the rated)		0.727
Efficiency at the load point	%	93.8%
Input to the motor	kW	58.17
No. of Days of operation per year		360
No. of hours of operation per day	h	24
Annual energy consumption	MWH	502.57
Savings from one class to other	MWH	

For a centrifugal pump with an output of 30kW and efficiency of 55%...

- The input required to the pump will be 54.55kW
- With a 15% margin over this, calculated motor rating is 62.73kW
- Next standard motor rating is 75kW

A 75kW, 2P, IE2, 2976 rev/min motor operating at load point of 54.55kW will have an annual power consumption of …

502.57 MWH

Case study - 30kW centrifugal pump, 75kW/2P motor

Centrifugal Pump (M ~ N^2 load characteristics)			
Output	kW	30	30
Efficiency	%	55%	55%
Input	kW	54.55	54.55
Margin considered	%	15%	
Calculated Motor Rating	kW	62.73	62.73
Motor Details			
Next Standard Motor rating	kW	75	75
Type of Motor		Induction	Induction
Type of operation		Line Fed	Line Fed
Efficiency class		IE2	IE3
Poles		2	2
Speed		2976	2981
Power demand at motor shaft (Corrected for the actual speed of the motor)	kW	54.55	54.82
Motor Loading (as ratio to the rated)		0.727	0.731
Efficiency at the load point	%	93.8%	94.7%
Input to the motor	kW	58.17	57.90
No. of Days of operation per year		360	360
No. of hours of operation per day	h	24	24
Annual energy consumption	MWH	502.57	500.26
Savings from one class to other	MWH		2.31

Using a 75kW, 2P, IE3 motor instead of the existing 75kW, 2P, IE2 motor…

- Higher speed of IE3 motor (2981 rev/min) as compared to the IE2 motor (2976 rev/min), causes motor loading to increase from 54.55kW to 54.82kW
- However, better efficiency of IE3 as compared to IE2 results in an annual energy saving of…

2.31 MWH

1.68t CO_2 emission reduction$

$ - The average CO_2 emission factor for country **India in the year 2021 was 726.1 g/kWH** as per IEA 2021 report

Case study - 30kW centrifugal pump, 75kW/2P motor

Centrifugal Pump (M ~ N^2 load characteristics)			
Output	kW	30	30
Efficiency	%	55%	55%
Input	kW	54.55	54.55
Margin considered	%		
Calculated Motor Rating	kW	62.73	62.73
Motor Details			
Next Standard Motor rating	kW	75	75
Type of Motor		Induction	Induction
Type of operation		Line Fed	Line Fed
Efficiency class		IE3	IE4
Poles		2	2
Speed		2981	2985
Power demand at motor shaft (Corrected for the actual speed of the motor)	kW	54.82	55.04
Motor Loading (as ratio to the rated)		0.731	0.734
Efficiency at the load point	%	94.7%	95.6%
Input to the motor	kW	57.90	57.58
No. of Days of operation per year		360	360
No. of hours of operation per day	h	24	24
Annual energy consumption	MWH	500.26	497.51
Savings from one class to other	MWH		2.75

Using a 75kW, 2P, IE4 motor instead of the existing 75kW, 2P, IE3 motor…

- Higher speed of IE4 motor (2985 rev/min) as compared to the IE3 motor (2981 rev/min), causes motor loading to increase from 54.82kW to 55.04kW
- However, better efficiency of IE4 as compared to IE3 results in an annual energy saving of…

2.75 MWH

2.0t CO_2 emission reduction$^{\$}$

$ - The average CO_2 emission factor for country **India in the year 2021 was 726.1 g/kWH** as per IEA 2021 report

Case study - 30kW centrifugal pump, 75kW/2P motor

Centrifugal Pump (M ~ N^2 load characteristics)			
Output	kW	30	30
Efficiency	%	55%	55%
Input	kW	54.55	54.55
Margin considered	%	15%	
Calculated Motor Rating	kW	62.73	62.73
Motor Details			
Next Standard Motor rating	kW	75	75
Type of Motor		Induction	Induction
Type of operation		Line Fed	Line Fed
Efficiency class		IE2	IE4
Poles		2	2
Speed		2976	2985
Power demand at motor shaft (Corrected for the actual speed of the motor)	kW	54.55	55.04
Motor Loading (as ratio to the rated)		0.727	0.734
Efficiency at the load point	%	93.8%	95.6%
Input to the motor	kW	58.17	57.58
No. of Days of operation per year		360	360
No. of hours of operation per day	h	24	24
Annual energy consumption	MWH	502.57	497.51
Savings from one class to other	MWH		5.06

Using a 75kW, 2P, IE4 motor instead of the existing 75kW, 2P, IE2 motor…

- Higher speed of IE4 motor (2985 rev/min) as compared to the IE2 motor (2976 rev/min), causes motor loading to increase from 54.55kW to 55.04kW
- However, better efficiency of IE4 as compared to IE2 results in an annual energy saving of…

5.06 MWH

3.68t CO_2 emission reduction$

$ - The average CO_2 emission factor for country **India in the year 2021 was 726.1 g/kWH** as per IEA 2021 report

Case study - 30kW centrifugal pump, 55kW/2P motor

Centrifugal Pump (M ~ N^2 load characteristics)			
Output	kW	30	30
Efficiency	%	55%	65%
Input	kW	54.55	46.15
Margin considered	%	15%	
Calculated Motor Rating	kW	62.73	53.08
Motor Details			
Next Standard Motor rating	kW	75	55
Type of Motor		Induction	Induction
Type of operation		Line Fed	Line Fed
Efficiency class		IE2	IE2
Poles		2	2
Speed		2976	2968
Power demand at motor shaft (Corrected for the actual speed of the motor)	kW	54.55	46.15
Motor Loading (as ratio to the rated)		0.727	0.839
Efficiency at the load point	%	93.8%	93.3%
Input to the motor	kW	58.17	49.49
No. of Days of operation per year		360	360
No. of hours of operation per day	h	24	24
Annual energy consumption	MWH	502.57	427.58
Savings from one class to other	MWH		75.00

However, with a pump with just **10%age points higher** efficiency…

- The BkW and therefore the motor rating reduces to 55kW
- And, using a 55kW, IE2 motor instead of 75kW, IE2 motor results into annual saving of

75 MWH

54.46t CO_2 emission reduction$

Much higher energy reductions can result from mechanical equipment efficiency improvements.

$ - The average CO_2 emission factor for country **India in the year 2021 was 726.1 g/kWH** as per IEA 2021 report

The IEC 60034-30-1 states …

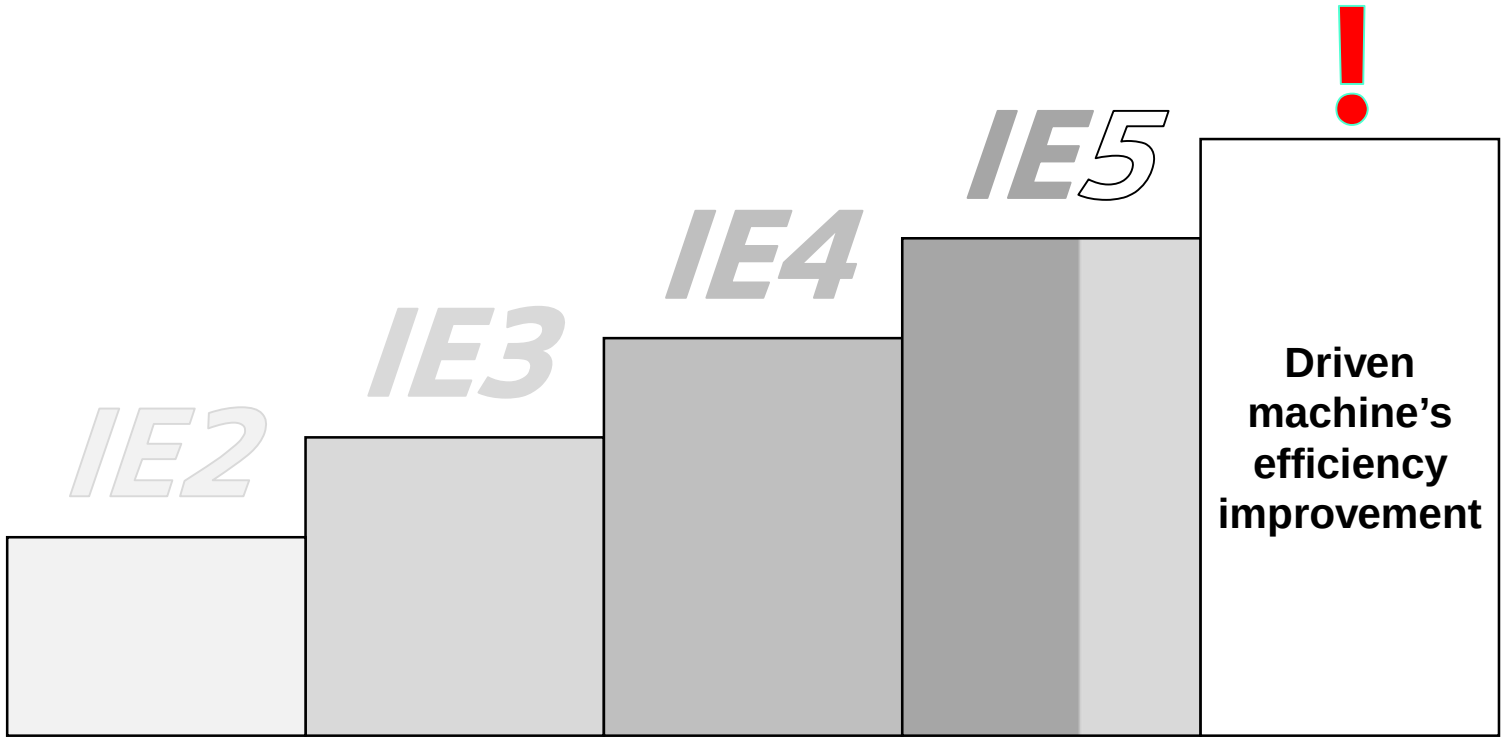
Annex A
(informative)

Nominal limits for efficiency class IE5

The levels of the IE5 efficiency class are envisaged to be incorporated into the next edition of this standard and/or in part two of this standard series. It is the goal to reduce the losses of IE5 by some 20 % relative to IE4. Motor technologies for IE5 are currently not well developed and not commercially available.

Further energy-efficiency optimizations will have to focus on improved system efficiency throughout the entire operating load cycle including all system-losses (converter, filter, cables, motor, etc.), see EN 52800.

To further the energy conservation drive…



"

For further & significantly greater reduction in Energy-use and Carbon Footprint …

… start looking beyond the motor!!!

Summarising the key points

We feel you should note these…

SIEMENS

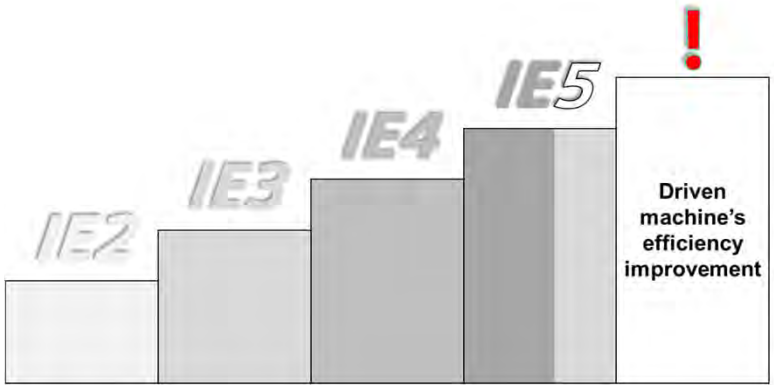
Summary

1. It is the energy saving that matters and not the efficiency difference
2. A properly sized motor is more efficient than one operating at service factor
3. Insisting for CE marked motors always works to your advantage
4. Blind replacement of existing motors with EEMs can be counter-productive
5. Check if the consultant specification is resulting in **criminal oversizing**
6. Sometimes operating a motor in field-weakening can be beneficial
7. Further energy conservation efforts should concentrate on driven mechanical equipment rather than motors

ΔkWH more important than Δη

SF1 better than SF1.x

CE better than 



We hope we have given you something to seriously think about…

Contact

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