



**NEW EFFICIENCY STANDARDS AND  
DIRECTIVES APPLICABLE TO  
THREE-PHASE CAGE INDUCTION MOTORS**

## PREFACE

*Numerous standards or regulations are currently used to define the efficiency of electric motors (NEMA, EPAct, NRCAN, CEMEP, COPANT, AS/NZS, etc), and others are in preparation.*

*It is becoming increasingly difficult for manufacturers to design motors for a global market and for users to understand the differences and similarities between standards in different countries.*

**Standard IEC 60034-30** defines the principle to be adopted and brings global harmonisation to energy efficiency classes for electric motors throughout the world.

**Directive 2005/32/EC** (6 July 2005) from the European Parliament has established a framework for setting the eco-design requirements to be applied to “energy-using products”.

*These products are grouped in lots. Motors come under lot 11 of the eco-design programme, as do pumps, fans and circulating pumps.*

**European directive EuP - lot 11** was voted on July 2009. It is based on standard IEC 60034-30 and defines the efficiency classes whose use will be mandatory in the future.

*It specifies the efficiency levels to be attained for machines sold in the European market and outlines the timetable for their implementation.*

## CONTENTS

■ New standard for measuring the efficiency of electric motors: IEC 60034-2-1 .....	5
■ New standard for efficiency classification of electric motors: IEC 60034-30 (September 2008) .....	6
■ EuP (Energy using Product) European directive (summer 2009) .....	8
■ Main standards throughout the world and ranges concerned .....	9
■ FAQ .....	10
■ Summary table of the scope of application for the standard and the directive .....	12
■ Table of Leroy-Somer series affected by the standard and the directive .....	13
■ Tables of rated efficiency values .....	14
■ Conclusion .....	16



## ■ New standard for measuring the efficiency of electric motors: IEC 60034-2-1 (September 2007)

### EXISTING STANDARD

IEC 60034-2 of 1972, still in use, applicable up to November 2010

- Direct method<sup>1</sup> for all single-phase and three-phase motors
  - fixed rate for additional losses = 0.5% Pab

### NEW STANDARD

IEC 60034-2-1 of September 2007 in widespread use since 2009

- SINGLE and THREE-PHASE  $\leq 1$  kW
  - preferred method<sup>2</sup> = direct method
- THREE-PHASE  $> 1$  kW
  - preferred method<sup>2</sup> = method which adds the losses to the total measured additional losses

### Comments:

- The new standard for efficiency measurement is not much used on the European market. It will start to be used more commonly during 2009. It is very similar to the IEEE 112-B method used in North America.
- Since the measurement standard is different, this means that for the same motor, the rated value will be different (usually lower) with IEC 60034-2-1. Example of a 22 kW 4P LSES motor:
  - in accordance with IEC 60034-2 = 92.6%
  - in accordance with IEC 60034-2-1 = 92.3%

<sup>1</sup> Method in which a machine's input kW is determined by measuring the torque on the shaft and the speed. The output kW is measured during the same test.

<sup>2</sup> As several methods are proposed, for reasons of simplicity, motors frame size 56-63-71 are measured with the direct method and larger frame sizes with the method where losses are added together.

## ■ New standard for efficiency classification of electric motors: IEC 60034-30 (September 2008)

**Concerns:** Induction motors, three-phase cage motors, single speed motors (this standard does not apply to motors with magnets).

- $U_n \leq 1000$  V
- $P_n$  from 0.75 to 375 kW
- 2, 4 and 6 poles
- S1 or S3 duty with  $OF \geq 80\%$
- 50 and 60 Hz frequency
- Networked
- All types of fixing, shaft extension, accessories
- All IP1x to 6x and IC0x to 4x

### **Not concerned:**

- Motors specifically designed for variable speed in accordance with IEC 60034-25 (essentially reinforced insulation)
- Motors which are fully integrated in a machine and cannot be tested separately (such as rotor/stator).

Three efficiency classes:

- IE1 = STANDARD efficiency level
- IE2 = HIGH efficiency level
- IE3 = PREMIUM efficiency level

Characteristics	Description	Definition
IE1	Standard	comparable to eff2
IE2	High	comparable to eff1 and EAct'92
IE3	Premium	comparable to EAct'05
IE4	Super premium	At draft stage

This standard only defines efficiency classes and their conditions. It is then up to each country to define the efficiency classes and the exact scope of application.

## Comments:

A fourth class is currently in preparation:

**IE4 = SUPER PREMIUM efficiency**

Technical specification IEC 60034-31 will set the efficiency levels for motors used in variable speed applications. The rated values will only apply to motors. The efficiency value will be set for a torque in a given speed range.

Once approved, it will integrate IEC 60034-30 which will be extended to permanent magnet synchronous motors (Dyneo).

The values indicated in the standard to define the efficiency class are minimum values. There is no tolerance on these.

The method for measuring the efficiency of a motor-drive (motor + drive) will be included in future standard IEC 60034-2-3.

IP 55 IK08		I cl. F		40 °C S1			
V	Hz	min-1	kW	A	Cos $\psi$	V	A
$\Delta$ 400	50	1482	45	83.1	0.83	380-420	85.5-80.1
Y690	50	1482	45	48.2	0.83	660-725	49.2-46.3
$\Delta$ 440	60	1776	52	84.2	0.86		

MOBIL UNIREX N3 75 g 8500 h

## ■ EuP European Directive

**Concerns:** Motors defined under standard IEC 60034-30.

Obligation to release high-efficiency motors:

Class IE 2 from 16 June 2011

Class IE 3<sup>1</sup> from 1 January 2015 for power ratings from 7.5 to 375 kW

Class IE 3<sup>1</sup> from 1 January 2017 for power ratings from 0.75 to 375 kW

The European Commission is currently working to define minimum efficiency values for drives.

In the second half of 2009, Leroy-Somer will start to affix nameplates to 1.1 to 90 kW motors in the 2 and 4-pole LS and LSES ranges in accordance with 60034-30. The FLS/FLES ranges will be the next in line.

Other power ratings in the LS and FLS ranges will be taken into account from the start of 2010, and 6 poles from 2011.

From January 2011, new high-efficiency motor ranges will gradually be introduced onto the market (IE2, then IE3).

*The following are not concerned:*

- Motors designed to operate when fully submerged in liquid
- Motors which are fully integrated in another product (rotor/stator)
- Motors designed to operate at
  - Altitude > 1000 m
  - Ambient air temperature > 40°C
  - Maximum operating temperature > 400°C
  - Ambient air temperature < -15°C or < 0°C for air-cooled motors
  - Cooling water temperature at product entry < 5°C or > 25°C
- Safety motors conforming to directive ATEX 94/9/EC
- Brake motors
- On-board motors (road, rail, water)

<sup>1</sup> or IE2 motor + drive



## ■ Main standards throughout the world and ranges concerned

COUNTRY/ZONE	STANDARD or REGULATION	NAME	LABEL	DATE	OBLIGATION	RANGES CONCERNED	PRODUCTS
Europe	IEC 60034-2	CEMEP	EFF 2/1	1 January 2008	no	2 & 4P 1.1 to 90 kW IP55	IE2 or IE1
	IEC 60034-2-1/IEC 60034-30	EuP	IE2	16 June 2011	yes	2, 4 & 6P 0.75 to 375 kW IP55 and IP23	IE2
			IE3	1 January 2015			IE2 + IE3*
Israel	IEC 60034-2		IE3	1 January 2017	yes	2, 4 & 6P 0.75 to 375 kW IP55 and IP23	IE3*
USA	IEEE 112- B	EPAct92	EFF1	1 January 2006	yes	2 & 4P 1.1 to 90 kW IP55	IE1 or IE2
		EPAct05	EPAct	1 January 1997	yes	2, 4, 6 & 8P 0.75 to 400 kW IP55 and 23	IE1 or IE2
		NEMA Premium	NEMA Premium	1 January 2011	yes	2, 4, 6 & 8P 0.75 to 350 kW IP55 and 23	IE3
Canada	CAN/CSA-C390-93	NRCan	EPAct	1 January 1997	yes	2, 4, 6 & 8P 0.75 to 150 kW IP55 and 23	IE1 or IE2
China	GB 18613-2005	GB/T 1032	NEMA Premium	1 January 2011	yes	2, 4, 6 & 8P 0.75 to 375 kW IP55 and 23	IE3
			Grade 3	1 October 2008	no	2, 4 & 6P 0.55 to 315 kW IP55	IE1
			Grade 2	1 July 2011	yes	2, 4 & 6P 0.55 to 315 kW IP55	IE2
Australia New Zealand	AS NZS 1359.5-2000 Method A (IEEE112-B) Method B (IEC 60034-2)	MEPS	Grade 1	1 October 2008	no	2, 4 & 6P 4 to 315 kW IP55	IE3
				1 April 2006	yes	2, 4, 6 & 8P 0.75 to 185 kW	IE1 or IE2
Korea	KS C IEC 61972 IEC 60034-2-1	MKE		1 July 2008	yes	2, 4 & 6P 45 to 200 kW IP55 and IP23	IE1 or IE2
Mexico	NOM 016 ENER 1977 NOM 016 ENER 2002		EPAct	1 January 2010	yes	2, 4 & 6P 0.75 to 200 kW IP55 and IP23	IE1 or IE2
			NEMA Premium	1 January 1997	yes	2, 4, 6 & 8P 0.75 to 400 kW IP55 and 23	IE1 or IE2
Brazil	NBR 5383-1 part 1		EPAct	1 January 2011	yes	2, 4, 6 & 8P 0.75 to 350 kW IP55 and 23	IE3
			NEMA Premium	1 January 1997	yes	2, 4, 6 & 8P 0.75 to 400 kW IP55 and 23	IE1 or IE2
			NEMA Premium	1 January 2011	yes	2, 4, 6 & 8P 0.75 to 350 kW IP55 and 23	IE3

\*IE3 or IE2 + drive

IE 1 = standard efficiency

IE 2 = high efficiency

IE 3 = premium efficiency

MEPS Minimum Efficiency Performance Standards

CEMEP European Committee of Manufacturers of Electrical Machines and Power Electronics

EuP Energy using Product

EPAct Energy Policy Act

NRCan Natural Resources Canada

MKE Ministry of Knowledge Economy

IEEE Institute of Electrical and Electronics Engineers

IEC International Electrotechnical Commission

CSA Canadian Standards Association

### **Will there be any change to the motor nameplates?**

The efficiency measurement standard does not require any change to the nameplate. However, application of the IEC 60034-30 standard involves some modifications. The two main ones are the efficiency value and the corresponding efficiency class (IE1, IE2, IE3) which must be indicated on the nameplate. The directive also requires the year of manufacture to be indicated on the nameplate (in plain text or as a code).

From September 2009, motors affected by the old CEMEP agreement (currently Eff1 and Eff2) will include the Eff level + the corresponding efficiency class on the nameplate.

### **Will there be a special "eff1" logo?**

Neither the standard nor the directive will have a special logo. However, the efficiency classes will be clearly specified on the nameplates of the motors concerned.

### **From 16 June 2011, manufacturers will have to offer class IE2 motors in Europe. Will we be ready?**

As of now, we are able to supply class IE2 IP55 motors from 0,75 to 375 kW, both 2 and 4-pole versions. These are LSES/FLSES motors developed for the "eff1" CEMEP agreement and for certain complementary markets such as "ECA" in England. 6P IP55 motors and also 2, 4 and 6P IP23 motors are already in preparation so as to be ready in accordance with the timetable.

**Are ATEX motors affected?**

Yes, by the IEC.

Not by the directive.

**Are smoke extraction motors affected?**

Yes, by the IEC, with some reservations.

Yes, by the directive for smoke extraction temperature  $\leq 400^{\circ}\text{C}$ .

**What services are associated?**

We will put in place services which correspond to the new "standards", namely GA/RAC/SCO.

**Can motors covered by IEC 60034-30 be used in variable speed applications?**

Yes, but in this application, the rated efficiency is assumed not to apply because the voltage and current waveforms created by the drive are not sinusoidal. Supplying power via a drive therefore results in additional losses in the motor. According to specification 60034-17, these are estimated at 20% of the total losses. These losses have a direct impact on the "displayed" efficiency of the motor.

Motors with magnets are not affected by the existing standard and the directive.

**■ Summary table of the scope of application for the IEC and the directive**

<b>Categories</b>	<b>Affected by IEC 60034-30</b>	<b>Affected by EuP</b>
2, 4, 6 P std motors 0.75...375 kW S1 IP1x, to 6x	yes	yes
Motors which are fully integrated and cannot be tested separately	no	no
ATEX, brake motors 2,4, 6 P 0.75...375 kW S1 IP4x, 5x, 6x	yes (measurements taken without accessory)	no
Std motors + accessories (gearbox, FV, encoder, etc)	yes (measurements taken without accessory)	yes (measurements taken without accessory)
High-temperature motors for smoke extraction $\leq 400^{\circ}\text{C}$	yes	yes
Motors in short-time duty S2, or intermittent duty S3, S4, S...	no	no
Other special motors for drives (PM, multi-speed, etc)	no	no
Motors for built-in cooling function	yes	no
Motors for gearboxes (MI or MU)	yes	yes

■ **Summary table of Leroy-Somer ranges affected by the IEC and the directive**

<b>Categories</b>	<b>Affected by IEC 60034-30</b>	<b>Affected by EuP</b>
(F)LS 2, 4 and 6P	yes	yes
(F)LS 8P and higher	no	no
(F)LS multi-speed	no	no
(F)LSES	yes	yes
(F)LSMV	yes	yes
PLS	yes	yes
FLSB and PB	no	no
CPLS	no	no
(F)LSE 2, 4 and 6P	yes	yes
(F)LSN 2, 4 and 6P	yes	no
FLSD	yes	no
(F)LSHT 2, 4 and 6P	yes	yes
(F)LSHT 8P and higher	no	no
(F)LSHT multi-speed	no	no
(F)LS 85°, 135°, 150°	no	no
LSMO	yes	yes
Motor + Varmeca option	yes	yes
Rotor/Stator	no	no
Brake motors	yes	no
LSRPM	no	no
HPM	no	no
LSK	no	no

## ■ Table of rated efficiency values (50 Hz)

50 Hz

kW	IE-1 "STANDARD" efficiency level			IE-2 "HIGH" efficiency level			IE-3 "PREMIUM" efficiency level		
	2 poles	4 poles	6 poles	2 poles	4 poles	6 poles	2 poles	4 poles	6 poles
0.75	72.1	72.1	70.0	77.4	79.6	75.9	80.7	82.5	78.9
1.1	75.0	75.0	72.9	79.6	81.4	78.1	82.7	84.1	81.0
1.5	77.2	77.2	75.2	81.3	82.8	79.8	84.2	85.3	82.5
2.2	79.7	79.7	77.7	83.2	84.3	81.8	85.9	86.7	84.3
3	81.5	81.5	79.7	84.6	85.5	83.3	87.1	87.7	85.6
4	83.1	83.1	81.4	85.8	86.6	84.6	88.1	88.6	86.8
5.5	84.7	84.7	83.1	87.0	87.7	86.0	89.2	89.6	88.0
7.5	86.0	86.0	84.7	88.1	88.7	87.2	90.1	90.4	89.1
11	87.6	87.6	86.4	89.4	89.8	88.7	91.2	91.4	90.3
15	88.7	88.7	87.7	90.3	90.6	89.7	91.9	92.1	91.2
18.5	89.3	89.3	88.6	90.9	91.2	90.4	92.4	92.6	91.7
22	89.9	89.9	89.2	91.3	91.6	90.9	92.7	93.0	92.2
30	90.7	90.7	90.2	92.0	92.3	91.7	93.3	93.6	92.9
37	91.2	91.2	90.8	92.5	92.7	92.2	93.7	93.9	93.3
45	91.7	91.7	91.4	92.9	93.1	92.7	94.0	94.2	93.7
55	92.1	92.1	91.9	93.2	93.5	93.1	94.3	94.6	94.1
75	92.7	92.7	92.6	93.8	94.0	93.7	94.7	95.0	94.6
90	93.0	93.0	92.9	94.1	94.2	94.0	95.0	95.2	94.9
110	93.3	93.3	93.3	94.3	94.5	94.3	95.2	95.4	95.1
132	93.5	93.5	93.5	94.6	94.7	94.6	95.4	95.6	95.4
160	93.8	93.8	93.8	94.8	94.9	94.8	95.6	95.8	95.6
200 to 375	94.0	94.0	94.0	95.0	95.1	95.0	95.8	96.0	95.8

■ Table of rated efficiency values (60 Hz)

60 Hz									
kW	IE-1 "STANDARD" efficiency level			IE-2 "HIGH" efficiency level			IE-3 "PREMIUM" efficiency level		
	2 poles	4 poles	6 poles	2 poles	4 poles	6 poles	2 poles	4 poles	6 poles
0.75	77.0	78.0	73.0	75.5	82.5	80.0	77.0	85.5	82.5
1.1	78.5	79.0	75.0	82.5	84.0	85.5	84.0	86.5	87.5
1.5	81.0	81.5	77.0	84.0	84.0	86.5	85.5	86.5	88.5
2.2	81.5	83.0	78.5	85.5	87.5	87.5	86.5	89.5	89.5
3.7	84.5	85.0	83.5	87.5	87.5	87.5	88.5	89.5	89.5
5.5	86.0	87.0	85.0	88.5	89.5	89.5	89.5	91.7	91.0
7.5	87.5	87.5	86.0	89.5	89.5	89.5	90.2	91.7	91.0
11	87.5	88.5	89.0	90.2	91.0	90.2	91.0	92.4	91.7
15	88.5	89.5	89.5	90.2	91.0	90.2	91.0	93.0	91.7
18.5	89.5	90.5	90.2	91.0	92.4	91.7	91.7	93.6	93.0
22	89.5	91.0	91.0	91.0	92.4	91.7	91.7	93.6	93.0
30	90.2	91.7	91.7	91.7	93.0	93.0	92.4	94.1	94.1
37	91.5	92.4	91.7	92.4	93.0	93.0	93.0	94.5	94.1
45	91.7	93.0	91.7	93.0	93.6	93.6	93.6	95.0	94.5
55	92.4	93.0	92.1	93.0	94.1	93.6	93.6	95.4	94.5
75	93.0	93.2	93.0	93.6	94.5	94.1	94.1	95.4	95.0
90	93.0	93.2	93.0	94.5	94.5	94.1	95.0	95.4	95.0
110	93.0	93.5	94.1	94.5	95.0	95.0	95.0	95.8	95.8
150	94.1	94.5	94.1	95.0	95.0	95.0	95.4	96.2	95.8
185 to 375	94.1	94.5	94.1	95.4	95.4	95.0	95.8	96.2	95.8

## CONCLUSION

*Leroy-Somer already has high-efficiency motor ranges, conforming to classes IE1 and IE2.*

*As far as class IE3 is concerned, developments are ongoing.*

*It is important to note that the greatest efficiency gains are obtained by analysing and optimising the whole system.*

*This systemic approach can achieve energy savings which are often in excess of 40%. In addition, Leroy-Somer already offers drives which are in an efficiency class that matches or exceeds the future IE4 (Dyneo range of motors with permanent magnets).*



## NOTES

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[www.leroy-somer.com](http://www.leroy-somer.com)