Motor MEPS Guide

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Electric Motor MEPS Guide

Information on the introduction of new testing standards, efficiency classes, labels and minimum energy performance standards MEPS for electric motors in global markets.

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Table of contents

Summary

Why this guide?

The purpose of this guide is to inform on new standards for electric motors that will facilitate trade of high efficient motors across the globe. Roughly 30 million new electric motors are sold each year for industrial purposes, some 300 million motors are in use in industry, infrastructure and large buildings. These electric motors are responsible for 40 % of global electricity used to drive pumps, fans, compressors and other mechanical traction equipment. Motor technology has evolved in the last decades. Superior so called «premium» products are now available, ready to change the market toward energy efficiency and to contribute in lowering greenhouse gas emissions worldwide.

Until recently diverging regional or national standards for efficiency and energy classifications have been in use. They are a source of misunderstanding between manufacturer and user and are responsible for trade barriers between national markets. In order to clarify the situation the International Electrotechnical Commission IEC has worked together with NEMA, CEMEP, JEMA, IEEE and other international organizations to harmonize testing standards, efficiency classes and subsequent labels necessary to recognize high efficient products in the market. Many nations have already based their minimum energy performance standards MEPS on these standards because they have experienced very slow market transformation towards more efficient motors with voluntary labels only. Many other countries are likely to follow suit in the next years.

The intention of this guide is to form the prerequisite for market transformation towards energy efficient electric motors. Our hope is that this guide will help engineers, motor users and manufacturers and also regulators to use the transition period between old and new standards intensively. The guide follows a sequence of steps to be taken: To define the product, the classification, the test methods and labels. Only then national regulators can step in and set MEPS and identify testing labs, monitor compliance and set the necessary timeline for enactment. We think that this guide could eventually help to speed up the process of implementation of the new standards and to harvest the large benefits from energy efficiency improvement through MEPS more rapidly and more effectively.

What products will be covered?

AC, three-phase, induction motors constitute the large majority of motors over 0.75 kW (1 Hp) sold worldwide (well over 80 %) and are responsible for most of the motor electricity use. Therefore, Minimum Efficiency Performance Standards and Voluntary Agreements worldwide have focused on this type of motor technology.

The recent standard IEC 60034-30 defines energy efficiency classes for single-speed, three-phase, 50 Hz and 60 Hz, cage-induction motors.

Although this classification standard applies to a wide variety of 3-phase induction motors, MEPS apply only to general purpose motors because motor efficiency is sometimes compromised by design restrictions imposed by special working requirements (e.g. motors built for use in high ambient temperatures or in hazardous areas/Hazloc in US).

What efficiency level and class will be used?

Electric motor technology has advanced over the last two decades continuously. AC induction motors are still the main stream products sold in the industrial market. Their energy performance has been improved through better design, more precise production and use of more conductive material. In order to inform buyers transparently on the different aspects of motor quality a number of standards are in use. For energy efficiency only recently a global standardization has been issued. This new IEC classification will harmonize regional and national standards that have been in use so far.

Three commercial levels of energy efficiency are defined in IEC 60034-30 (2008):

Premium Efficiency	IE3	(NEMA Premium)
High Efficiency	IE2	(EPAct, Eff1)
Standard efficiency	IE1	(Eff2)

The standard also mentions a future level above IE3 to be called IE4 Super Premium Efficiency although these products are not commercially available yet and might go beyond AC induction motor technology. There are still lower efficiency motors in use now (i.e. Eff3), but they will not be used anymore in the new classification.

The efficiency class and motor efficiency, tested according to IEC 60034-2-1 at nominal load, will be printed by the manufacturer on the rating plate as shown in the following example and stated in the written product documentation and catalogue:

IE3 94.5 %

It is recommended to report also the efficiencies at 50 % and 75 % of nominal load in the product documentation as these will be required to calculate the energy demand when the motor is operated in part load.

What performance test method will be required?

Already very early in the last century the IEC standard 34-2 was established and included the «summation of losses» test procedure with the additional load losses assumed to be 0.5 % of full-load input power. This test formed the basis for indirect loss determination in most countries with 50 Hz power supply frequency until just recently. For example, all efficiency values according to the European CEMEP-EU agreement (Eff1, Eff2, and Eff3) are based on this test procedure. However IEC 34-2 (or IEC 60034-2:1996 as it is called today) has some drawbacks which are not so important when testing low-efficient motors but which have a great influence on the testing of high-efficient motors. In general, IEC 34-2 has a clear tendency to overestimate efficiency and it does not allow a fair comparison of motor efficiencies.

In North-America and some other countries with 60 Hz power supply frequency the harmonized test standards IEEE 112 and CSA 390 have been used since more than 20 years instead of IEC 34-2. The standard contains several test procedures but for high efficient induction motors procedure B is usually used (IEEE 112B). Both procedures are recognized by Canadian, Mexican and US regulations.
In 2007, IEC published the improved testing standard 60034-2-1 which supersedes the old IEC 34-2 and also the intermediate publication IEC 61972. The new IEC 60034-2-1 contains a test procedure «Indirect loss determination with PLL determined from residual loss» similar to IEEE 112B with some further improvements especially for smaller motors (1 kW and below). This test is now the standard procedure for efficiency classifications IE2 and IE3 according to the new international standard IEC 60034-30. The test results are largely compatible with those obtained by IEEE 112B or CSA C390.

What label requirement will be used?

It is very important that motor efficiency labeling be handled in a consistent way. Motors are built and distributed globally. Individual markets including countries will be advised to utilize global MEPS as a way to assure availability of the most efficient motor products for their users. Two dominant labeling schemes have emerged for polyphase electrical motor efficiency in the world today, IEC and NEMA. As the result of work done to harmonize test methods, lab accreditation and efficiency levels the individual motor efficiency label has become a relatively simple task.

Motors of the covered type always include a permanently attached durable nameplate. The nameplate includes the necessary information to correctly install and use the motor. This may include connections, horsepower or kW, design code, power supply, amps and nominal motor efficiency expressed as a percentage of 100 %.

In addition to the nominal efficiency motors will include the efficiency class expressed as IE1, IE2 or IE3. Motors sold under the NEMA scheme will also include nominal efficiency plus a unique manufactures' compliance number issued to the manufacturer by the US Department of Energy. NEMA motors that meet NEMA Premium (IE3) efficiency levels will also include the NEMA Premium logo licensed by NEMA to qualifying motor manufacturers. By treating both NEMA and IEC with equal for 60 Hz motors regard the selection of the motor user maintains the broadest product selection meeting the desired efficiency levels.

In Europe, mandatory minimum efficiency levels and label requirements are going to be implemented in the context of the introduction of the EuP directive 2005/32/EC (Ecodesign Requirements for Energy-Using Products).

How will test labs be evaluated and accredited?

The test methods predominantly used in the world today are IEC 60034-2-1, IEEE 112B and CSA390. All of these methods utilize similar equipment and lab procedures to test motor efficiency. A motor efficiency test takes several hours and requires a great deal of resources. In North America usually only a sample of a motor family are completely tested. The efficiency of the production units is then correlated to the sample results. The efficiencies of the untested members of the motor family are derived from calculations.

In other countries, usually at least one sample of every member of a motor family is completely tested. Motor users expect the nominal efficiency provided on the motor nameplate to be accurate within the standards set for in either NEMA or IEC.

NEMA name-plated motors follow NVLAP (National Voluntary Lab Accreditation Program) accreditation regulations as set forth in US federal code (CFR10 part 431). As of this writing IEC name-plated motors are not governed by any specific lab accreditation standard.

The NVLAP motors reference is «NIST Handbook 150-10 Checklist Efficiency of Electric Motors Program». This document may be obtained online from the NIST (National Institute of Standards) website. To have a lab accredited NIST will provide personnel to inspect labs and certify policy and procedures. In addition to the NIST program both CSA and Underwriter Laboratories UL provide product certification programs that are accepted in the US, Canada and Mexico.

How will compliance be enforced?

Individual stakeholders including regulators, manufacturers or users may from time to time determine a need to verify a product's efficiency.

North American motor regulations include a methodology under which a sample is to be tested and the performance that must be met to be considered passing.

In Europe, such a methodology is currently under development and will be included in an European directive.

Other countries, like Brazil and Australia, usually include appropriate compliance enforcement procedures in their national energy efficiency regulations as well.

How much time will be allowed from enactment to implementation?

Successful MEPS rely on an adequate supply of compliant product reaching users to meet their operating needs. MEPS programs that utilize existing NEMA and IEC product, labeling, testing and compliance schemes should not require more than one year to establish. Good communication of MEPS being of primary concern of a successful program.

If existing MEPS components are not followed there will need to be ample time for suppliers to design and produce products that meet unique MEPS requirements. Depending on the variation from the existing MEPS standards this could require anywhere from three to five years before implementation.

1. What products will be covered according to IEC 60034-30?

AC, three-phase, cage-induction motors constitute the large majority of motors over 0.75 kW (1 HP) sold worldwide (well over 80 %) and are responsible for most of the motor electricity use. Therefore, Minimum Efficiency Performance Standards and Voluntary Agreements worldwide have focused on this type of motor technology. Although smaller motors (below 0.75 kW or 1 HP) also present significant energy savings potential, they are mostly customized designs, generally incorporated into appliances and equipment (e.g. refrigerators, air conditioners, air handling units) whose minimum efficiency performance can be regulated addressing the whole appliance.

The recent IEC 60034-30:2008 standard defines energy efficiency classes for single-speed, three-phase, 50 Hz and 60 Hz, cage-induction motors that:

- have a rated voltage U_N up to 1000 V;
- have a rated output P_N between 0.75 kW and 375 kW;
- have either 2, 4 or 6 poles;
- are rated on the basis of duty type S1 (continuous duty) or S3 (intermittent periodic duty) with an operation time of 80 % or more;
- are capable of operating direct on-line;
- are rated for operating conditions according to IEC 60034-1, clause 6.

The only exclusions to this classification standard are:

- Motors exclusively built for converter operation in accordance with IEC 60034-25
- Motors completely integrated into a machine (for example pump, fan and compressor) that can not be tested separately from the machine

All other motors are covered by the standard including geared motors and brake motors or special purpose motors such as flameproof motors. This is very helpful for consumers that can benefit from a market where energy efficiency information is clear and universal.

However, national MEPS only apply to general purpose motors because motor efficiency is sometimes compromised by design restrictions imposed by special working requirements such as motor specifically designed for:

- special requirements of the driven machine (e.g. heavy starting duty, special torque stiffness and/or breakdown torque characteristics, large number of start/stop cycles, very low rotor inertia);
- special characteristics of the grid supply (e.g. limited starting current, high tolerances of voltage and/or frequency);
- special ambient conditions (e.g. very high or very low ambient temperature; smoke extraction motors, high altitudes of installation);
- operation in hazardous area according to IEC 60079-0;

The General Purpose definition of a Alternating-Current motor in NEMA MG 1 is somewhat different:

General-Purpose
A general-purpose alternating-current motor is an induction motor, rated 500 (375 kW) horsepower and less, which incorporates all of the following:

a. Open or enclosed construction
b. Rated continuous duty
c. Service factor in accordance with 12.51 (1:15 SF)
d. Class A or higher rated insulation system with a temperature rise not exceeding that specified in 12.42 for Class A insulation for small motors or Class B or higher rated insulation system with a temperature rise not exceeding that specified in 12.43 for Class B insulation for medium motors.

It is designed in standard ratings with standard operating characteristics and mechanical construction for use under usual service conditions without restriction to a particular application or type of application.

Motor product category not covered by North American regulations

Definite-Purpose Motor
A definite-purpose motor is any motor designed in standard ratings with standard operating characteristics or mechanical construction for use under service conditions other than usual or for use on a particular type of application.

Special-Purpose Motor
A special-purpose motor is a motor with special operating characteristics or special mechanical construction, or both, designed for a particular application and not falling within the definition of a general purpose or definite-purpose motor.

It must also be noted that when used in variable-speed drive applications the rated efficiency of the motor should not be assumed to apply due to increased losses from the harmonic-voltage content of the power supply.

The power range of existing MEPS and Voluntary Agreements around the world also varies significantly. For example, in the USA NEMA Premium scheme cover motors in the 0.75 – 375 kW (1 – 500 HP) power range; in Australia MEPS apply to motors in the 0.73 – 185 kW power range; In China MEPS cover motors with rated power between 0.55 kW and 315 kW. Because of the new IEC Standard it is desirable to standardize MEPS to cover the entire range of 0.75 – 375 kW (1 – 500 HP).

2. What efficiency level and class will be used?

Electric motor technology has advanced over the last two decades continuously. AC induction motors are still main stream products sold on the market. Their performance has been improved through better design, more precise production and the use of more conductive material. In order to inform buyers transparently on the motor quality a number of standards are in use.

For the purpose of energy efficiency different classification schemes have been used so far:

CEMEP-EU 1999	Eff1 / Eff2 / Eff3 (based on IEC 60034-2:1996)
USA	EPAct / NEMA Premium (based on IEEE 112B)
Australia	Minimum Efficiency/High Efficiency (based on IEC 60034-2:1996 or IEEE 112B)
China	Grade 1, 2 and 3 (based on GB/T 1032 which is similar to IEC 60034-2:1996)

In 2007 a project for a new harmonized global standard for energy classes for electric motors has been initiated by IEC. The IEC 60034-30 (Ed.1.0): 2008-10 has been published in October 2008. The new classification scheme will harmonize the regional and national standards that have been used so far.

Three commercial levels of energy efficiency are defined in IEC 60034-30:

Premium Efficiency	IE3	NEMA Premium
High Efficiency	IE2	EPAct, Eff1
Standard efficiency	IE1	Eff2

The standard also reserves IE4 (Super Premium Efficiency), a future level above IE3. These products are not yet commercially available and might need to go beyond AC induction motor technology to reach the necessary values. There are also lower efficient motors still in use now (i.e. Eff3) but they will not be used anymore in the new classification.

The efficiency limits of the existing CEMEP-EU classes Eff1 and Eff2 have to be recalibrated according to the new testing standard IEC 60034-2-1 that includes a more accurate account of additional stray load losses in order to qualify for the IE2 and IE3 class respectively.

The efficiency class and motor efficiency, tested according to IEC 60034-2-1 at nominal load, using a low uncertainty test method will be printed as shown in the following example on the rating plate and stated in the written product documentation and catalogue:

IE3 94.5 %

Motors produced and operated in dual frequency zones (i.e. Japan) will have a rating plate with one or more efficiency level and class.

The limit values for the motor efficiency classes are given in separate form for 2-pole, 4-pole and 6-pole motors between 0.75 and 375 kW (see Annex 1). Two sets of data are provided (graphs for 4-pole only):

- For 50 Hz motors (Figure 1)
- For 60 Hz motors (Figure 2).

The 50 Hz values are given also in mathematical form in a smooth curve between 0.75 and 200 kW (from 200 to 375 kW the efficiencies are constant). This allows also to use the classification for intermediate motor output sizes not given in the tables. Although there is no standard for a strict relationship between motor output and motor geometric dimensions in IEC, the data allows existing EN 50347 frame sizes to be used for the new classes, also in Premium Efficiency IE3 motors that tend to have a more tight load of material in the frame.

The 60 Hz values are given in data points derived from existing EPAct and NEMA Premium values. They form a stepped curve based on existing distinct NEMA frame sizes.

For both 50 Hz and 60 Hz frequencies the data are given in tables in Annex 1 in kW (60 Hz in kW and hp).

3. What performance test method will be required?

In order to calculate motor efficiency the losses must be determined first since all other electric energy is being transformed into mechanical energy by the motor.

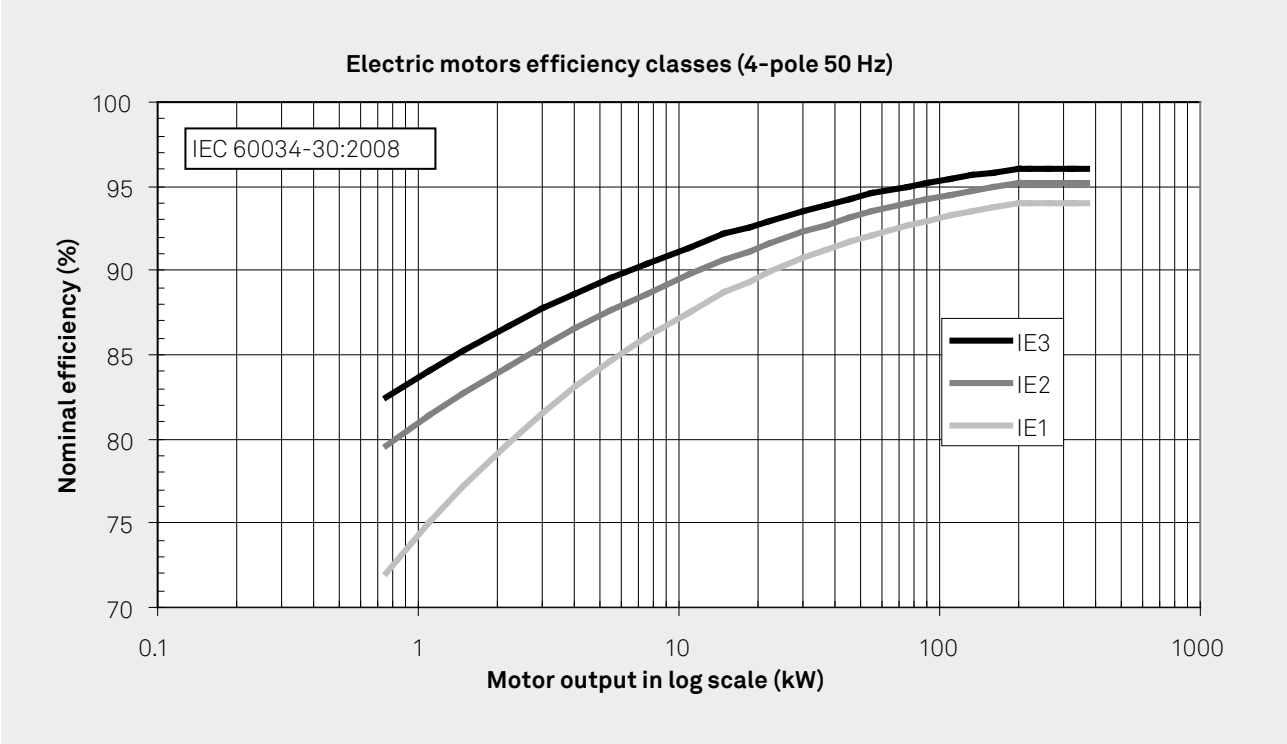

Figure 1: Efficiency classes for 50 Hz 4-pole motors (IEC 60034-30:2008)

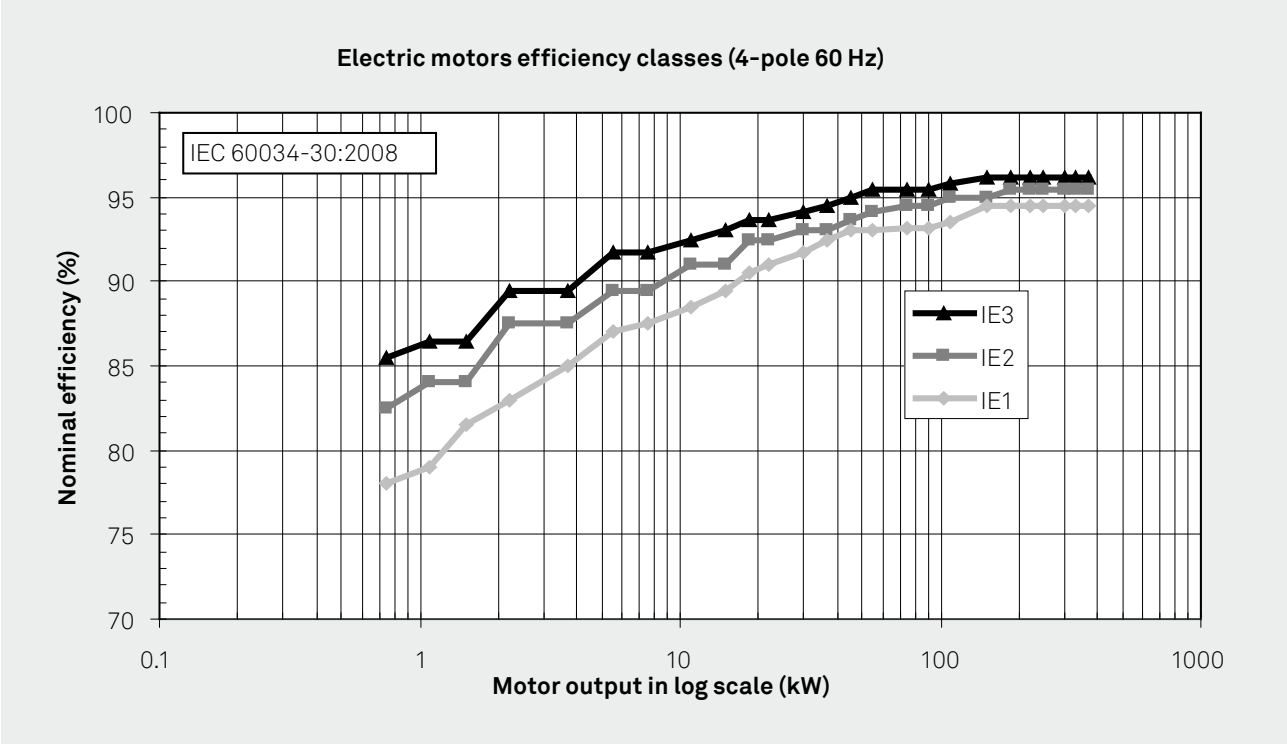

Figure 2: Efficiency classes for 60 Hz 4-pole motors (IEC 60034-30:2008)

In induction motors there are five main sources for losses:

- Stator and rotor winding losses (I^2R),
- Mechanical losses (friction in the bearings and shaft-seals plus air ventilation),
- Losses in the iron lamination (hysteresis and eddy currents),
- Additional load losses resulting from various parasitic currents in the stator and rotor iron lamination, housing, shaft and end shields.

Basically the motor efficiency can be determined by measuring output and input. The simplistic approach to determine efficiency directly by measuring electrical input power with a wattmeter and mechanical output power with a torque sensor plus tachometer can lead to big errors especially for high efficient motors where both powers are large compared to their difference (i.e. the motor losses).

Therefore, total losses are usually determined indirectly by determining the five components independently and summing them up. Each of the components are determined by performing various tests under load and no-load conditions.

Already early in the last century the IEC standard 34-2 was established and included the «summation of losses» test procedure with the additional load losses assumed to be 0.5 % of full-load input power. In 1972, the third edition of this standard was released and subsequently formed the basis for indirect loss determination in most countries with 50 Hz power supply frequency until very recently. For example, all efficiency values according to the European CEMEP-EU agreement (Eff1, Eff2, and Eff3) are based on this test procedure.

However IEC 34-2 (or IEC 60034-2 as it is called today) has some drawbacks which are not so important when testing low-efficient motors but which have a great influence on the testing results of high-efficient motors. For example, the operating temperature of the motor is not adequately accounted for and additional load-losses are not tested at all. Instead, a global allowance of 0.5 % of input power is added for additional stray load losses to the other four losses. Recent studies have demonstrated that in reality additional load losses play a much greater role. Therefore, IEC 60034-2 has a clear tendency to overestimate efficiency. It also does not allow a fair comparison of motors with low and high additional load-losses.

In North-America and some other countries with 60 Hz power supply frequency the test standard IEEE 112 has been used since more than 20 years instead of IEC 34-2. The standard contains several test procedures but for high efficient induction motors procedure B is usually used (sometimes referred to as IEEE 112B). The same test procedure was also adopted in the Canadian standard CSA C390. In principle, IEEE 112B is similar to IEC 34-2 but the temperature problems have been eliminated and a test procedure to determine additional load losses has been added to avoid the fixed allowance.

Unfortunately, there is no straightforward method to determine additional load losses. IEEE 112B uses the well known direct input-output test (wattmeter, torque sensor and tachometer) to determine the total losses and subtracts all the other known losses to calculate the remaining additional load losses. In order to reduce the influence of testing errors, a procedure was included which uses several tests with different loads and a regression analysis to fit the test results to the predicted behavior of the additional load losses. The procedure includes the calculation of a correlation factor as an indicator for the validity of the tests.

IEEE 112B and CSA C390 remain the standard test procedures for high-efficient induction-motors in North-America referred to in laws and regulation on motor performance.

Due to the fact that additional load losses are just estimated in IEC 34-2 it is impossible to predict the test results of IEEE 112B for any given motor on the basis of an IEC 34-2 test alone.

In 2007, the improved standard IEC 60034-2-1 was published which supersedes the old IEC 60034-2 and also the intermediate publication IEC 61972. The new IEC 60034-2-1 contains a test procedure «Indirect loss determination with P_{LL} determined from residual loss» similar to IEEE 112B with some additional improvements especially for smaller motors (1 kW and below). This test is now the standard procedure for efficiency classifications IE2 and IE3 according to the new international standard IEC 60034-30. The test results are largely compatible with those obtained by IEEE 112B or CSA C390. However, IEC 60034-2-1 offers several more procedures including other indirect tests («Eh-Star») with greater uncertainty which may be used for efficiency determination of IE1 motors only.

Currently a round-robin test is being conducted by IEC which includes over 20 test facilities of different manufacturers plus independent laboratories from all around the world. Its purpose is to compare test standards and procedures in order to gain a better understanding of the errors and uncertainties and to further improve the standard IEC 60034-2-1. Results are anticipated for the beginning of 2009.

Other efficiency standards with local importance:

Brazil
NBR 5383-1 Part 1, Electric Machines – Part 1: Three-Phase Induction Motors – Standard Tests. ABNT, Brazilian Association of Technical Norms, 1999: «Dynamometric test with indirect measurement of additional losses and direct measurement of losses in stator, rotor, core and from friction and ventilation».
Procedure similar to IEEE 112B and IEC 60034-2-1 («P_{LL} from residual loss»).

India
IS 4889, Method of determination of efficiency of rotating electrical machines.
Procedure similar to the old IEC 34-2.

China
GB/T 1032, Test Procedure for three-phase Induction Motors.
Used to be similar to the old IEC 34-2 but has been updated in 2004 and includes now the improved procedures of IEEE 112B and IEC 61972 (IEC 60034-2-1).

Japan
JIS C 4212, Low-voltage squirrel-cage high-efficiency inductions motors, 2000.
Procedure similar to IEEE 112B and IEC 60034-2-1.

Australia / New Zealand
AS NZS 1359.5, Rotating electrical machines–General requirements, Part 5: Three-phase cage induction motors–High efficiency and minimum energy performance standards requirements, 2004.
The standard references two test procedures A and B. Different efficiency tables are given for each procedure. Test A corresponds to IEEE 112B and IEC 61972 (60034-2-1) while test B corresponds to AS NZS 1359.102.1 which is compatible with the now obsolete IEC 34-2.

4. What label requirement will be used?

It is very important that motor efficiency labeling be handled in a consistent way. Motors are built and distributed globally. Individual markets including countries will be advised to utilize global MEPS as a way to assure availability of the most efficient motor products for their users. With IEC 60034-30, a dominant labeling scheme has emerged for polyphase electrical motor efficiency in the world today. It has been ensured that IEC 60034-30 is compatible with and can be used together with the US-American DOE/NEMA labeling scheme as well. As the result of work done to harmonize test methods, lab accreditation and efficiency levels the individual motor efficiency label has become a relatively simple task.

Motors of the covered type always include a permanently attached durable nameplate. This nameplate includes the necessary information to correctly install and operate the motor. This may include connections, horsepower or kW, design code, power supply, amps and nominal motor efficiency expressed as a percentage of 100 % at full load. IEC 60034-1 states all the necessary rating plate information.

In addition to the nominal efficiency motors measured in kW will include the efficiency class expressed as IE1, IE2 or IE3 and the efficiency (according to IEC 60034-30). 60 Hz Motors sold under the NEMA scheme in the US will also include nominal efficiency plus a unique manufactures' compliance number issued to the manufacturer by the regulatory agency, Department of Energy (DOE). NEMA motors that meet NEMA Premium [IE3] efficiency levels will also include the NEMA Premium logo licensed by NEMA to qualifying motor manufacturers. By treating both NEMA and IEC with equal regard for 60 Hz the motor user's selection maintains the broadest product selection meeting the desired efficiency levels.

Global manufacturers now produce both IEC and NEMA products that meet or exceed efficiency performance standards. All products that meet both IE3 and NEMA Premium should be labeled with the nominal efficiency levels plus the IE3 and NEMA Premium logo, if the manufacturer is licensed to use the NEMA Premium trademark.

The European Commission is also considering the introduction of MEPS in the European Union by 2011. At that time, motors which comply with minimum efficiency requirements should bear the «CE» marking, in order to enable them to be placed on the internal market and move freely.

5. How will test labs be evaluated and accredited?

In the US, the Department of Energy (DOE) requires motor performance data to be certified in an accredited lab. To assure product quality all motor efficiency labs follow either NVLAP or CSA guide lines. NEMA Premium nameplated motors that follow NVLAP [National Voluntary Lab Accreditation Program] accreditation use regulations as set forth in US Federal Code [CFR10 part 431].

The NVLAP motors reference is «NIST Handbook 150-10 Checklist Efficiency of Electric Motors Program». This document may be obtained online from the NIST [National Institute of Standards] website. To have a lab accredited NIST will provide personnel to inspect labs and certify policy and procedures. In addition to the NIST program both CSA and Underwriter Laboratories UL provide product certification programs that are accepted in the US, Canada and Mexico.

In addition, NVLAP has been recognized by International Laboratory Accreditation Cooperation ILAC which maintains conformance with ISO/IEC 17011, and related ILAC guidance documents including accredited laboratories compliance with ISO/IEC 17025 or ISO 15189.

IEC 60034-30 name-plated motors are not governed by any lab accreditation standard. However there are national requirements for lab accreditation for MEPS testing in various countries (like Australia, Brazil, Canada, China, South Korea).

6. How will compliance be enforced?

IEC regulations
Minimum energy efficiency performance standards will require national legislation. IEC sets the guidelines for testing and classification. It can not regulate efficiency, stipulate compliance tests and measures when non-compliance is determined.

There are already a number of countries with national MEPS relating directly or indirectly to IEC performance-standards (for example Australia, Brazil, South Korea) and more are likely to follow in the near future (for example China, Europe, South Africa).

Although national compliance enforcement procedures vary, the general motor design specifications, efficiency classification and test standards all meet IEC requirements. Therefore, motor manufacturers and users of industrial electrical motors can operate on a level playing field.

European regulations
In Europe, manufacturers will self-declare conformity by attaching the CE-mark to the relevant products. Tight market surveillance by independent bodies will be organized under the Framework for Market Surveillance Directive. For example in Germany, this task is going to be handled by the trade supervisory offices. Non-complying products will be forced to be withdrawn from the market.

Market surveillance means the activities carried out and measures taken by public authorities to ensure that products are in compliance with legal requirements set out in the relevant Community harmonization legislation or do not endanger health, safety or other issues of public interest protection.

Common minimum requirements in all Member States; Organisational/operational requirements:
- Infrastructures, resources and powers
- Oblige checks, take samples
- Checks at external borders
- Inform users of risks
- Ensure follow up of complaints and accidents

Co-operation mechanism:
- National level
- Community level

Improvement of safeguard clause mechanism & information procedure.

Proposal was adopted by the Commission on 14 February 2007. Entry into force 1 January 2010.

The new regulations only apply to products that are «put into circulation» in Europe for the first time. Existing motors in plants and stocks at distributors, independent service centers and OEMs are not affected. They can be distributed and used without any restrictions.

Exception: Importers who purchase motors directly from non-European countries and sell them in Europe are considered to «put the product into circulation». As of the date on which the minimum efficiency levels come into effect (about 2010/2011), the same regulations will apply to these importers than to European distributors.

Spare parts are not marked with a CE label and can continue to be supplied without restrictions for replacing old motors (by distributors and OEMs and by the manufacturing plant).

If a motor is repaired without changing the technical properties and the existing nameplate is kept, the old CE label is still valid and the new regulations concerning minimum efficiency levels do not apply. This also applies if the motor is re-wound according to original data.

If a motor is changed during repairs in such a way that the technical data change and a new nameplate must be attached, the repair workshop is responsible for the new CE label. It must comply with all current regulations, including the regulations for minimum efficiency levels.

Replacement motors «already in circulation», e.g. in stock at a distributor or a service center independent from the manufacturer, can be used without restriction.
Replacement motors that are «put into circulation» for the first time, i.e. by the manufacturer or a service center of the manufacturer, must comply with the new regulations as of the date on which the minimum efficiency levels come into effect (IE2 about 2010/2011). This is regardless of whether

the manufacturer has just assembled the motor or taken it from an internal warehouse.

US-American regulations
(Note: Section 6 is paraphrased from CFR10 part 431 or US energy code)

Test notice
Upon receiving information in writing, concerning the energy performance of a particular electric motor sold by a particular manufacturer or private labeler, which indicates that the electric motor may not be in compliance with the applicable energy efficiency standard, or upon undertaking to ascertain the accuracy of the efficiency rating on the nameplate or in marketing materials for an electric motor, the regulatory commission may conduct testing of that electric motor by means of a test notice addressed to the manufacturer in accordance with the following requirements:

(1) The test notice procedure will only be followed after the regulatory commission or a designated representative has examined the underlying test data (or, where appropriate, data as to use of an AEDM (alternative efficiency determination method) provided by the manufacturer and after the manufacturer has been offered the opportunity to meet with the regulatory commission to verify, as applicable, compliance with the applicable efficiency standard, or the accuracy of labeling information, or both. In addition, where compliance of a basic model was certified based on an AEDM, the regulatory commission shall have the discretion to invoke the test notice procedure. A representative designated by the regulatory commission shall be permitted to observe any re-verification procedures undertaken by the manufacturer and to inspect the results of such re-verification.

(2) The test notice will specify the model or basic model to be selected for testing, the method of selecting the test sample, the date and time at which testing shall be initiated, the date by which testing is scheduled to be completed and the facility at which testing will be conducted. The test notice may also provide for situations in which the specified basic model is unavailable for testing, and may include alternative basic models.

(3) The regulatory commission may require in the test notice that the manufacturer of an electric motor shall ship at his expense a reasonable number of units of a basic model specified in such test notice to a testing laboratory designated by the regulatory commission. The number of units of a basic model specified in a test notice shall not exceed 20.

(4) Within five working days of the time the units are selected, the manufacturer shall ship the specified test units of a basic model to the testing laboratory.

Testing laboratory
Whenever the regulatory commission conducts enforcement testing at a designated NVLAP accredited laboratory in accordance with a test notice under this section, the resulting test data shall constitute official test data for that basic model. Such test data will be used by the regulatory commission to make a determination of compliance or noncompliance if a sufficient number of tests have been conducted to satisfy the requirements of appendix A.

Sampling
The determination that a manufacturer's basic model complies with its labeled efficiency, or the applicable energy efficiency standard, shall be based on the testing conducted in accordance with the statistical sampling procedures set forth in appendix A of this subpart and the test procedures set forth in appendix B to subpart B of this part.

Test unit selection
A regulatory commission inspector shall select a batch, a batch sample, and test units from the batch sample in accordance with the provisions of this paragraph and the conditions specified in the test notice.

(1) The batch may be subdivided by the regulatory commission utilizing criteria specified in the test notice.

(2) A batch sample of up to 20 motor units will then be randomly selected from one or more subdivided groups within the batch. The manufacturer shall keep on hand all units in the batch sample until such time as the basic model is determined to be in compliance or non-compliance.

(3) Individual test units comprising the test sample shall be randomly selected from the batch sample.

(4) All random selection shall be achieved by sequentially numbering all of the units in a batch sample and then using a table of random numbers to select the units to be tested.

Test unit preparation
(1) Prior to and during the testing, a test unit selected in accordance with paragraph (d) of this section shall not be prepared, modified, or adjusted in any manner unless such preparation, modification, or adjustment is allowed by the applicable regulatory commission of energy test procedure. One test shall be conducted for each test unit in accordance with the applicable test procedures prescribed in appendix B to subpart B of this part.

(2) No quality control, testing, or assembly procedures shall be performed on a test unit, or any parts and sub-assemblies thereof, that is not performed during the production and assembly of all other units included in the basic

model.
(3) A test unit shall be considered defective if such unit is inoperative or is found to be in noncompliance due to failure of the unit to operate according to the manufacturer's design and operating instructions. Defective units, including those damaged due to shipping or handling shall be reported immediately to the regulatory commission. The regulatory commission shall authorize testing of an additional unit on a case-by-case basis.

Testing at manufacturer's option
(1) If a manufacturer's basic model is determined to be in noncompliance with the applicable energy performance standard at the conclusion of regulatory commission testing in accordance with the sampling plan specified in appendix A of this subpart, the manufacturer may request that the regulatory commission conduct additional testing of the basic model according to procedures set forth in appendix A of this subpart.

(2) All units tested under this paragraph shall be selected and tested in accordance with the provisions given in paragraphs (a) through (e) of this section.

(3) The manufacturer shall bear the cost of all testing conducted under this paragraph.

(4) The manufacturer shall cease distribution of the basic model tested under the provisions of this paragraph from the time the manufacturer elects to exercise the option provided in this paragraph until the basic model is determined to be in compliance. The regulatory commission may seek civil penalties for all units distributed during such period.

(5) If the additional testing results in a determination of compliance, a notice of allowance to resume distribution shall be issued by the regulatory commission.

7. How much time will be allowed from enactment to implementation?

The time necessary to enact a motor efficiency standard will be directly impacted by the level of conformance to existing standards. To assure the quickest time to enact a standard the efficiency levels, test methods and labeling will need to conform to NEMA Premium and IEC. By harmonization of the efficiency test methods and levels the only remaining issues are labeling and timing.

Both IEC and NEMA labeling requires that the nominal efficiency be stated on a permanent motor nameplate. In addition NEMA Premium motors may include a NEMA Premium logo if the manufacture has complied with NEMA standards and sign a memo of understanding with NEMA. Countries following the NEMA/IEC methods would only need to allow time for manufacturer's logistics to fill the supply system.

Additional labels added by individual countries may serve to identify products in the local market. The addition of country specific labels may inadvertently reduce the number of available motors for that country and disrupt supply to motor users within the country. Countries that add a special labeling scheme may expect to add six to twelve months to implementation and will risk a reduction in available product for local needs.

Should a country elect to use a different test method or efficiency levels the time for manufacturers to comply would be expected to be between three and five years depending upon the level of variation.

Annex 1: Tables with efficiency classes: IEC 60034-30 (2008)

50 Hz									
	IE1 – Standard Efficiency			IE2 – High Efficiency			IE3 – Premium Efficiency		
kW	2-pole	4-pole	6-pole	2-pole	4-pole	6-pole	2-pole	4-pole	6-pole
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	94.0	94.0	94.0	95.0	95.1	95.0	95.8	96.0	95.8
220	94.0	94.0	94.0	95.0	95.1	95.0	95.8	96.0	95.8
250	94.0	94.0	94.0	95.0	95.1	95.0	95.8	96.0	95.8
300	94.0	94.0	94.0	95.0	95.1	95.0	95.8	96.0	95.8
330	94.0	94.0	94.0	95.0	95.1	95.0	95.8	96.0	95.8
375	94.0	94.0	94.0	95.0	95.1	95.0	95.8	96.0	95.8

60 Hz										
		IE1 – Standard Efficiency			IE2 – High Efficiency			IE3 – Premium Efficiency		
HP	kW	2-pole	4-pole	6-pole	2-pole	4-pole	6-pole	2-pole	4-pole	6-pole
1	0.75	77.0	78.0	73.0	75.5	82.5	80.0	77.0	85.5	82.5
1.5	1.1	78.5	79.0	75.0	82.5	84.0	85.5	84.0	86.5	87.5
2	1.5	81.0	81.5	77.0	84.0	84.0	86.5	85.5	86.5	88.5
3	2.2	81.5	83.0	78.5	85.5	87.5	87.5	86.5	89.5	89.5
5	3.7	84.5	85.0	83.5	87.5	87.5	87.5	88.5	89.5	89.5
7.5	5.5	86.0	87.0	85.0	88.5	89.5	89.5	89.5	91.7	91.0
10	7.5	87.5	87.5	86.0	89.5	89.5	89.5	90.2	91.7	91.0
15	11	87.5	88.5	89.0	90.2	91.0	90.2	91.0	92.4	91.7
20	15	88.5	89.5	89.5	90.2	91.0	90.2	91.0	93.0	91.7
25	18.5	89.5	90.5	90.2	91.0	92.4	91.7	91.7	93.6	93.0
30	22	89.5	91.0	91.0	91.0	92.4	91.7	91.7	93.6	93.0
40	30	90.2	91.7	91.7	91.7	93.0	93.0	92.4	94.1	94.1
50	37	91.5	92.4	91.7	92.4	93.0	93.0	93.0	94.5	94.1
60	45	91.7	93.0	91.7	93.0	93.6	93.6	93.6	95.0	94.5
75	55	92.4	93.0	92.1	93.0	94.1	93.6	93.6	95.4	94.5
100	75	93.0	93.2	93.0	93.6	94.5	94.1	94.1	95.4	95.0
125	90	93.0	93.2	93.0	94.5	94.5	94.1	95.0	95.4	95.0
150	110	93.0	93.5	94.1	94.5	95.0	95.0	95.0	95.8	95.8
200	150	94.1	94.5	94.1	95.0	95.0	95.0	95.4	96.2	95.8
250	185	94.1	94.5	94.1	95.4	95.4	95.0	95.8	96.2	95.8
300	220	94.1	94.5	94.1	95.4	95.4	95.0	95.8	96.2	95.8
350	250	94.1	94.5	94.1	95.4	95.4	95.0	95.8	96.2	95.8
400	300	94.1	94.5	94.1	95.4	95.4	95.0	95.8	96.2	95.8
450	330	94.1	94.5	94.1	95.4	95.4	95.0	95.8	96.2	95.8
500	375	94.1	94.5	94.1	95.4	95.4	95.0	95.8	96.2	95.8

Annex 2: Tables with efficiency classes: NEMA Premium

60 Hz: Induction Motors Rated 600 Volts Or Less (Random Wound)						
	Totally Enclosed Fan-Cooled			Open Drip-Proof		
HP	2-pole	4-pole	6-pole	2-pole	4-pole	6-pole
1	77.0	85.5	82.5	77.0	85.5	82.5
1.5	84.0	86.5	86.5	84.0	86.5	87.5
2	85.5	86.5	87.5	85.5	86.5	88.5
3	85.5	89.5	88.5	86.5	89.5	89.5
5	86.5	89.5	89.5	88.5	89.5	89.5
7.5	88.5	91.0	90.2	89.5	91.7	91.0
10	89.5	91.7	91.7	90.2	91.7	91.0
15	90.2	93.0	91.7	91.0	92.4	91.7
20	91.0	93.0	92.4	91.0	93.0	91.7
25	91.7	93.6	93.0	91.7	93.6	93.0
30	91.7	94.1	93.6	91.7	93.6	93.0
40	92.4	94.1	94.1	92.4	94.1	94.1
50	93.0	94.5	94.1	93.0	94.5	94.1
60	93.6	95.0	94.5	93.6	95.0	94.5
75	93.6	95.0	94.5	93.6	95.4	94.5
100	93.6	95.4	95.0	94.1	95.4	95.0
125	94.1	95.4	95.0	95.0	95.4	95.0
150	94.1	95.8	95.4	95.0	95.8	95.8
200	95.0	95.8	95.4	95.4	96.2	95.8
250	95.0	95.8	95.4	95.8	96.2	95.8
300	95.4	95.8	95.4	95.8	96.2	95.8
350	95.4	95.8	95.4	95.8	96.2	95.8
400	95.8	95.8	95.8	95.8	96.2	95.8
450	95.8	96.2	96.2	95.8	96.2	95.8
500	95.8	96.2	96.2	95.8	96.2	95.8

60 Hz: Induction Motors Rated Medium Volts 5 kV or Less (Form Wound)						
	Open Drip-Proof			Totally Enclosed Fan-Cooled		
HP	2-pole	4-pole	6-pole	2-pole	4-pole	6-pole
250	94.5	95.0	95.0	95.0	95.0	95.0
300	94.5	95.0	95.0	95.0	95.0	95.0
350	94.5	95.0	95.0	95.0	95.0	95.0
400	94.5	95.0	95.0	95.0	95.0	95.0
450	94.5	95.0	95.0	95.0	95.0	95.0
500	94.5	95.0	95.0	95.0	95.0	95.0

Annex 3: Abbreviations and units

4E	IEA Implementing Agreement on Efficient Electrical End-Use Equipment
AC	Alternating current
AEDM	Alternative efficiency determination method
CEMEP	European committee of manufacturers of electrical machines and power electronics
CSA	Canadian Standards Association
DOE	US Department of Energy
DC	Direct current
EC	European Commission
EPAct	Energy Policy Act 1992, MEPS for US motors at IE2
EU	European Union
EuP	European Ecodesign Directive on Energy-using Products
Eff1/Eff2/Eff3	Efficiency classification 1999 CEMEP/EU
HP	Horse power (1 hp = 0.7457 kW)
IE1/IE2/IE3	Efficiency classes according to IEC 60034-30
IEA	International Energy Agency, Paris France
IEC	International Electrotechnical Commission, Geneva Switzerland
IEEE	Institute of Electrical and Electronics Engineers, USA
ILAC	International Laboratory Accreditation Cooperation
kW	Kilowatt (10^3 W)
MEPS	Minimum Energy Performance Standards
NEMA	National Electrical Manufacturers Association, Rosslyn VA USA
NVLAP	National Voluntary Lab Accreditation Program

Annex 4: Bibliography

- EN 50347: General purpose three-phase induction motors having standard dimensions and outputs – Frame numbers 56 to 315 and flange numbers 65 to 740, 2003
- Energy-using Products EuP Lot 11 Motors, Final Report, Anibal De Almeida et al., University of Coimbra, for EC-DG-TREN, April 2008 (www.ecomotors.org)
- IEC 60034-2-1 (Ed. 1.0): Rotating electrical machines – Part 2-1:Standard methods for determining losses and efficiency from tests (excluding machines for traction vehicles), 2007 (www.iec.ch)
- IEC 60034-30 (Ed.1.0): Rotating electrical machines – Part 30: Efficiency classes of single-speed, three-phase cage-induction motors (IE-code), 2008 (www.iec.ch)
- IEC 60034-31 (Ed. 1.0): Guide for planning and application, CD draft May 2008
- NEMA MG 10: NEMA Standards Publication, 2001 (www.nema.org)
- NEMA MG1: Motors and generators, 2006 (www.nema.org)
- NIST: Handbook 150-10 Checklist Efficiency of Electric Motors, 2007 http://ts.nist.gov/Standards/Accreditation/handbook.cfm
- IEEE 112: Standard Test Procedure for Polyphase Induction Motors and Generators, 2004