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Evaluation of International Comparable Compliance, Certification, and Enforcement Requirements for Electric Motors

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September, 2015

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This report was produced by a team at Atkins and University of Coimbra.

September 28, 2015

ATKINS

UNIVERSITY of COIMBRA

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List of Abbreviations

AEDM	Alternative Efficiency Determination Method
AS/NZS	Standards Australia/Standards New Zealand
CC	Compliance Certification
CC&E	Compliance, Certification and Enforcement
CONUEE	Comision Nacional para el Uso Eficiente de la Energia (Mexico)
CSA	Canadian Standards Association
DOE	Department of Energy
EC	European Commission
ED	Ecodesign Directive
EEA	Energy Efficiency Act (Canada)
EISA	Energy Independence and Security Act (USA)
EMSA	Electric Motor Systems Annex
GB	Guobiao standard (China)
GMEE	Global Motor Energy Efficiency
Hp	Horsepower
IEC	International Electrotechnical Committee
IECEE	International Elecrotechnical Committee Energy Efficiency
IEEE	Institute of electrical and Electronic Engineering
ISO	International Standards Organisation
Kg	Kilogrammes
KEMCO	Korea Energy Management Corporation
kW	Kilowatt
GMLP	Global Motor Labelling Programme
MEPS	Minimum Energy Performance Standard
MOACIE	Ministry of Commerce, Industry and Energy (South Korea)
MVE	Monitoring, Verification and Enforcement
NEMA	National Electrical Manufacturers Association
NVLAP	National Voluntary Laboratory Accreditation Programme
OEM	Original Equipment Manufacturer

Executive Summary

Aims of this guide

The guidebook is designed as a manual for government officials, technical experts, and others around the world responsible for developing, implementing, and maintaining Compliance, Certification, and Enforcement (CC&E) programmes for motors. The aim is to detail the specific considerations when devising a CC&E regime for motors, pointing out the advantages and possible pitfalls of different approaches.

Considerations for including motors within CC&E regimes

One advantage of MEPS over many other energy efficiency policy instruments is that the initial cost to the regulator is modest. But the regulator alone carries the responsibility and cost of ensuring fair play by periodically undertaking check testing of selected motors. This cost puts a limit on the amount of check testing undertaken, costs which can be reduced by the sharing of test results between different countries.

The very low levels of compliance failures in established testing programmes show a high level of confidence that motor specifications are being met can be achieved, but ongoing testing at some level will always be needed in order to ensure that this situation can be maintained.

Key issues relating to applying MEPS to motors

There are several distinctive factors applying to motors that mean that special consideration needs to be given when devising CC&E regimes for them, the most important of which are:

Motors are not available through domestic retail outlets, and so different considerations apply to how they are procured for testing, sanctions and how results of tests are communicated.

70% of new motors are purchased as part of OEM (Original Equipment Manufacturer) products that include motors within them, but these are largely ignored by testing programmes. This is an important new area of work for all CC&E programmes.

Setting Minimum Efficiency Performance (MEPS) Levels for motors

Since the publication and widespread acceptance of new IEC standards (and effective equivalents in some countries) on both motor efficiency testing and MEPS levels for motors, it has become much easier to compare the level of ambition of motor MEPS around the globe. In the key 1 – 500hp (0.75 – 375kW) 3 phase induction motor category, it is clear that MEPS set at IE3 is now a clear rallying point, with IE2 often being used as a stepping stone towards this level. Technical and economic challenges have currently precluded the setting of MEPS at IE4 for these motors in any country, but this decision needs to be kept under review as technology and economics change. This Guide includes an up to date review of the MEPS for motors adopted in different countries, giving the global perspective for regulators looking at what level to set MEPS in their country.

The energy savings from regulating larger motors are only small, as they are inherently more efficient, there are far fewer of them, and efficiency is usually a key purchasing consideration anyway. There is consequently little global activity targeted towards regulating these motors. By contrast, the large numbers and lower efficiency of small motors, including single phase motors found in commerce and domestic settings, offer good scope for energy saving through the introduction of MEPS. This motor group is currently the subject of regulation in a small number of countries, and is something that other countries should consider once they have regulated the 1-500hp 3 phase motor.

Beyond this, the latest developments in the USA and Europe are extending the size range subject to regulation to 0.12 - 1,000kW. This expanded range should also be considered as the future span for other countries.

A Global Vision for Motor Compliance and Certification

The development of the new Global Motor Labelling Programme (GMLP) under the auspices of the IEC Energy Efficiency (IECEE) initiative will mean that a test certificate from an accredited laboratory would be accepted within any member country, effectively giving an internationally recognised motor efficiency "passport". This could be supported by a single Global Motor Database to enable easy pre-registration of motors in many countries at one time. This could dramatically reduce enforcement costs, with individual regulators ultimately being able to maintain confidence in motors sold in their country, but without the need for testing large numbers of motors. For manufacturers, the ease of registration is possibly matched only by the dramatic impact that a single test failure might have in many different markets at the same time.

Whatever the pace in the inevitable convergence of compliance, certification and enforcement initiatives for motors, it is clear that "going it alone" on a country by country basis is not only costly to all parties, but will have far less impact than joint initiatives.

Introduction

This guide is designed to be read as a "Motors" annex to the CLASP Monitoring, Verification and Enforcement (MVE) Guide (CLASP, 2010), with Figure 1 (overleaf) showing the structured approach to creating a CC&E programme taken from this MVE guide. This MVE guide explains clearly all the steps to be taken and pitfalls to be avoided in establishing effective product compliance regimes, with this Motors guide discussing the key decisions needed when devising a Compliance, Certification and Enforcement (CC&E) regime for electric motors. This guide also includes a review of current motor MEPS around the world, providing a basis for decisions on what efficiency levels are appropriate for new countries wishing to introduce MEPS for motors. To maintain a focus on the key CC&E issues that the Policymaker needs to consider, the sections covering detailed technical aspects are included in a series of dedicated annexes which can be read as needed. For an overview of wider motor systems policies, the EMSA Policy Guidelines for Electric Motor Systems Part 2: Toolkit for Policy Makers is a useful reference (IEA 4E, 2014).

Planning and Reviewing a MV&E regime

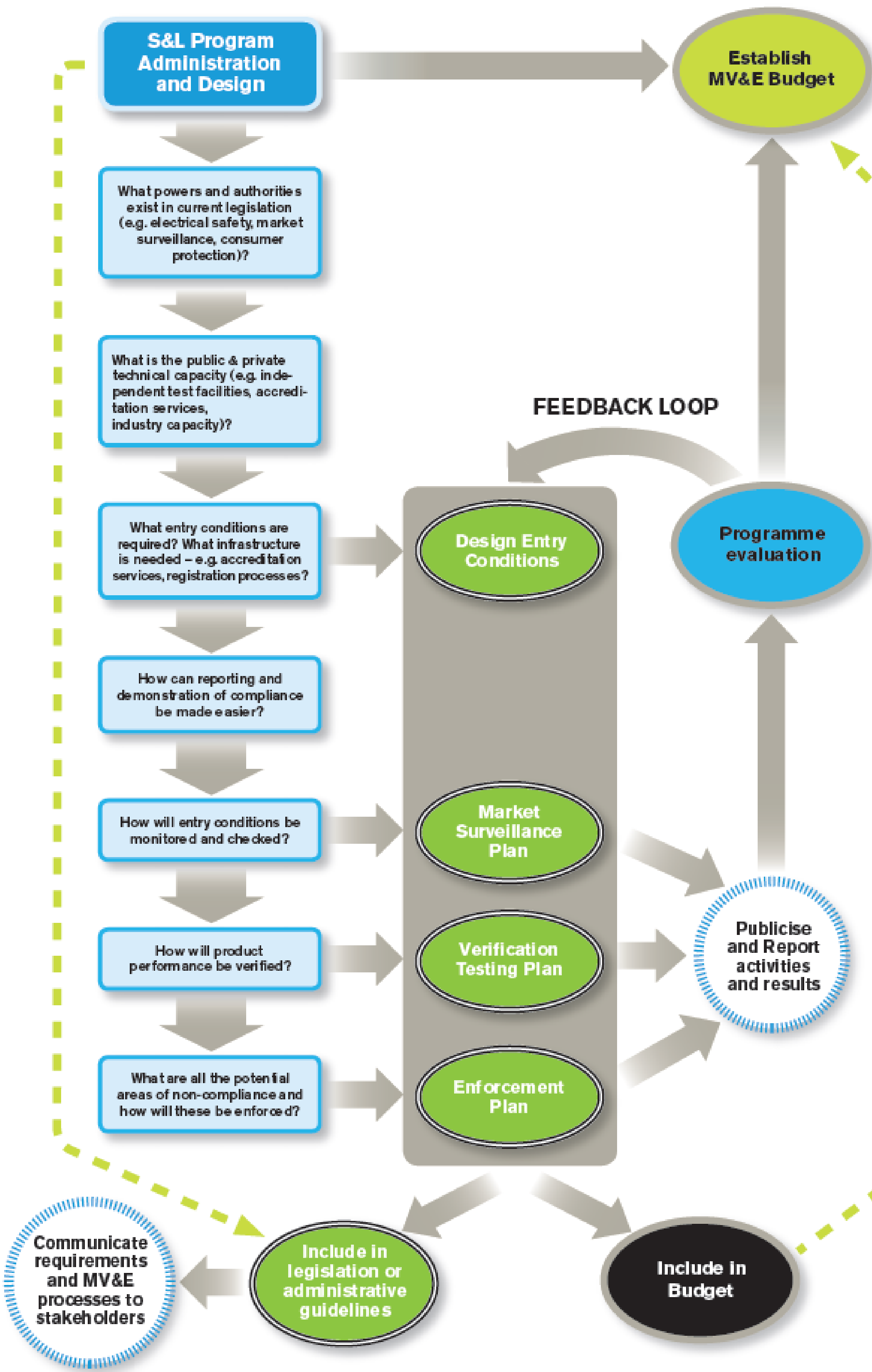

FIGURE 1. Stages in creating a CC &E programme

1. Design of Effective Motor CC&E Programmes

1.1 Summary

A compliance, certification, and enforcement (CC&E) programme is a regime that aims to ensure that products meet any claims made, which in this context relate to claims of energy efficiency performance. An effective CC&E regime is essential to the success of appliance EE policies and programmes. Without it there can be little confidence that standards are being met and manufacturers have little incentive to ensure that products are meeting performance claims. Establishing an effective CC&E regime requires careful consideration of three major components. A weakness in any one area can have a negative impact on the overall success of the programme.

Certification

Certification is the process of verifying that a product actually meets its claimed performance. The key consideration here is: Where should measurements be undertaken? Suitable test laboratories need to be identified, which might be either an independent facility or the accredited test laboratory of a manufacturer. The lack of a suitable in-country testing laboratory need not be a barrier, as test labs in other countries can be used.

The high costs of motor testing mean that the sharing of results between test regimes is to be encouraged wherever possible.

The development of standards relating to the performance of motors under part load or inverter control mean that in the future it is highly possible that measurement of the motor both at part load and under inverter driven applications will be a requirement. It is unlikely that this data would contribute to the overall efficiency rating of a motor is unlikely, and more data and experience of the draft standards in support of this is needed before the benefits are known. Such additional testing will undoubtedly cost more, but as a proportion of the overall cost of testing, (which also includes administration, procuring, shipping, attaching to the test bed), it should not be prohibitive.

Compliance

Compliance is the process of making checks against manufacturer claims to gain confidence that a particular style or group of motor types meet the specified criteria. The key consideration here is: Which motors to test? Some regimes require registration of motors before selling them in country, others have no such system, but in both cases market intelligence will be important to maximise the effectiveness of the limited CC&E budget. The available budget will limit the number of motors that can be tested, and hence the careful targeting of motors where failure will have the largest energy or deterrence impact is important. Whichever motors are selected for testing, anonymous purchasing in the same way as for retail products is almost impossible, and so thought needs to be given to the delivery addresses and name of organisation paying for the products.

Enforcement

Enforcement is the process of taking action in response to any non-compliance. The key consideration here is: What happens to motors that fail? Clear sanctions are needed, and without which the "scare factor" will be lost. Ultimately manufacturers prefer to understand what has gone wrong and reach resolution with authorities before a sanction is applied. When there is a failure, the communications route should be clearly established, ranging from a passive website notice posting to a targeted Press Release campaign. In some regimes financial penalties are defined which might apply to the entire range of similar products placed on the market.

An effective CC&E regime develops over time, and so each test should be seen in the context of developing the reputation and image of the scheme as a whole, rather than a simple pass/fail test on that individual motor.
The international nature of the motor market means that with increased information exchange, a failure in one country could in theory lead to sanctions in many countries, greatly magnifying the scare factor to manufacturers of failure.

1.2 What determines the efficiency of an Induction motor?

Efficiency in a motor is defined as the ratio of output (mechanical) power to input (electrical) power.

$$Efficiency = \frac{Output\ (Mechanical)\ Power}{Input\ (Electrical) Power}$$

The difference between input and output power is caused by the presence of losses in different parts of the motor. The electrical losses (also called Joule losses) are expressed by I2R, and consequently increase rapidly with the motor load. Electrical losses appear as heat generated by electric resistance to current flowing in the stator windings and in the rotor conductor bars and end rings. Magnetic losses occur in the steel laminations of the stator and rotor. They are due to hysteresis and eddy currents, increasing approximately with the square of the flux-density. Mechanical losses are due to friction in the bearings, ventilation and windage losses. Stray load losses are due to leakage flux, harmonics of the air gap flux density, non-uniform and inter-bar currents distribution, mechanical imperfections in the air gap, and irregularities in the air gap flux density.

As an example, Figure 2 shows the distribution of the induction motor losses as a function of the motor power.

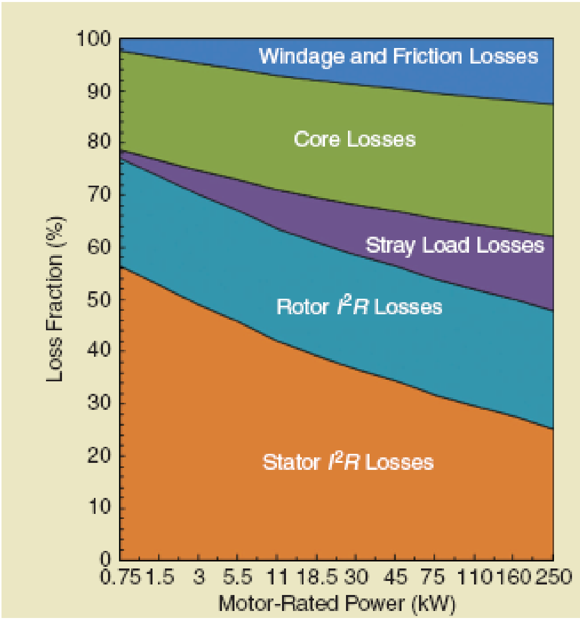

FIGURE 2. Typical fraction of losses in 50-Hz, in four-pole squirrel cage Induction Motors (de Almeida, Ferreira, & Fong, 2011)

1.3 Scope and Level of Ambition of Regulations

1.3.1 Selection of MEPS

The setting of S&L regulations should take into consideration legislation in countries which are trading partners. The establishment of a common market minimises the cost burden on manufacturers, suppliers, and end-users. It also offers scope for considerable CC&E savings to regulatory bodies.

1.3.2 Definition of Efficiency Levels

Motor efficiency should be tested in accordance with the preferred methods in the latest version of IEC60034-2-1 (IEC 60034-2-1: Methods for determining losses and efficiency of rotating electrical machinery from tests - excluding machines for traction vehicles, 2014), and the IEC60034-30-1 (IEC, 2014) "IE" efficiency classes. These efficiency classes are shown below, giving a selection of four MEPS levels, which increase slowly with motor size.

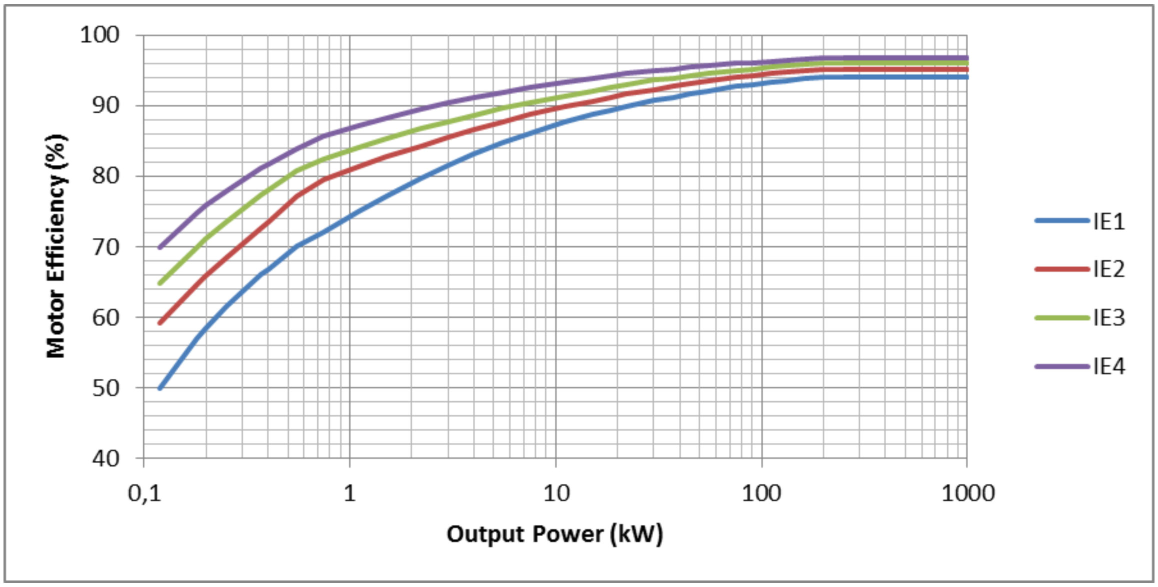

FIGURE 3. Efficiency levels in the 2014 version of IEC 60034-30-1 (example shown is for 4 pole motors, 50 Hz)

Details of the IEC test method, efficiency classes, and relevant technical standards legislation in selected countries can be found in Annex 3.

1.3.3 Global Motor MEPS

Table 1 and Figure 4 show the current status of MEPS around the world. Table 3 gives more detail on the precise scope of regulations.

Table 1 Overview of Minimum Energy Performance Standards (MEPS) Worldwide (Integral Polyphase Motors) (source: EMSA)

<table>
<tr><th>Efficiency Levels</th><th>Efficiency Classes (IEC 60034-30)</th><th>Testing Standard</th><th>Country</th><th>MEPS Regulation</th></tr>
<tr><td>Premium Efficiency</td><td>IE3</td><td rowspan="2">IEC 60034-2-1
IEEE 112B
CSA C390

Low Uncertainty</td><td>USA (< 150 kW)
Canada
Europe 2015* (>7,5kW), 2017
Korea 2015
Mexico
India</td><td>EISA 2007 / US DOE 10 CFR Part 431
Canadian EEA, CSA C390
ED Directive, Regulation 640/2009

MOCIE/KEMCO
NOM 016-ENER-2010
IS 12615:2011</td></tr>
<tr><td>High Efficiency</td><td>IE2</td><td>USA (> 150kW)
Canada (> 150kW)
Australia
New Zealand
Brazil
Korea
China
Europe
Switzerland</td><td>EISA 2007 / US DOE 10 CFR Part 431
Canadian EEA, CSA C390
AS/NZS 1359:2004
AS/NZS 1359:2004
NBR 17094-1
MOCIE/KEMCO
GB 18613-2010
ED Directive, Regulation 640/2009</td></tr>
</table>

* IE3 or IE2 + VSD

1.3.4 Rest of the World

Table 2 gives examples of countries looking to introduce MEPS in the next few years.

Table 2 Upcoming MEPS

	Japan	**Israel**	**Saudi Arabia**
Expected in	2015	2015	2016
Mandatory Efficiency level	IE2	IE3	IE2
Power range	0.2 – 160 kW	0.75 – 185 kW	0.75 – 375kW
Speed	2-6 poles	2 – 8 poles	2-6 poles
Voltage	220/220/400/440 V,	400 V	<1000 V

Although great effort has been put into the harmonization of efficiency classifications and test methods in use around the world, motor manufacturers still sometimes struggle with different regional and national requirements for certification (e.g. scope of products covered, test method used). Further rationalisation is desirable in order to make motor selection easier, especially when machinery will be exported.

In addition, there is now global interest in regulating fractional horsepower motors down to 120W, and also up to 1,000kW, as discussed in Annex 4. There is less global experience on CC&E regimes for these products, and so for countries taking first steps in regulating motors it may be sensible to initially focus on the important mid-size power range.

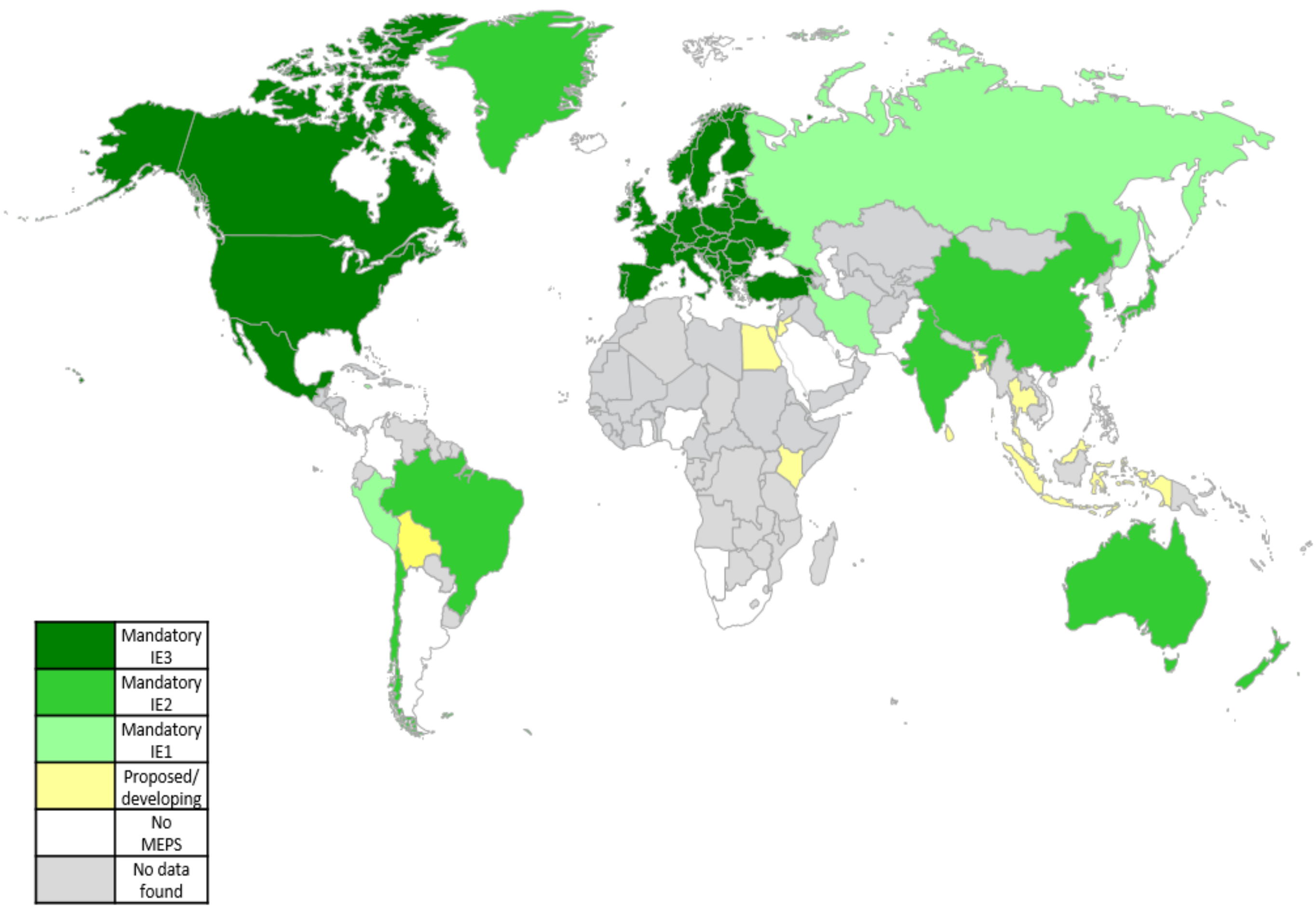

FIGURE 4. Overview of Minimum Energy Performance Standards (MEPS) Worldwide - Integral Polyphase Motors

Table 3 Summary of motor MEPS requirements in some major economies (See top of next page for important notes on this table)

Item	Australia / New Zealand	Brazil	Canada	China	European Union	Korea	USA
Regulation / Standard	AS/NZS 1359.5:2004	NBR 17094-1:2013	Energy Efficiency Act (EEA) C390-10	GB18613: 2012	Regulation 640/2009Regulation 04/2014 (Amendment)	"Operational regulation on machinery and materials subject to efficiency management"	EISA 2007
Year first introduced	2001	2009	2008	2002	2011 (to 2017 in stages)	2008	1997
Latest revision	2006	2012	2011	2012	2014	2012	2014
MEPS level (IEC equivalent)	IE2 (not identical)	IE2 (not identical)	IE2 and IE3 (50/60 Hz or 60Hz)	IE2	IE2 0,75-375kW (2011) IE3* 7,5-375 kW (2015) IE3* 0,75-375kW (2017)	IE3 37kW-200kW (2015) IE3 15kW-37kW (2016) IE3 0,75kW-15kW (2017	IE2 Firepump motors IE3 all others
Test Standard	AS/NZS1359.102.1 AS/NZS1359.102.3	NBR 5383-1:2002 Method 2	IEEE 112-B or CSA C390-10*	GB/T1032, identical to IEC 60034-2-1*	IEC 60034-2-1:2007*	KS C IEC 60034-2-1	IEEE 112-B or CSA C390-10
Power range	0,73 kW to < 185 kW	2& 4-pole 0,75 to 185kW 6-pole 0,75 to 150kW 8-pole 0,75 to 110kW	0,75 kW to 375 kW	GB/T1032 (B method), identical to IEC 60034-2-1*	0,75 kW and 375 kW	0,75 kW to 200 kW	0,75 kW to 375 kW
Speed	2, 4, 6 and 8 poles	2, 4, 6 and 8 poles	2, 4, 6 and 8 poles	2, 4 and 6 poles	2, 4 to 6 poles		2, 4, 6 and 8 poles
Voltage	≤ 1100V	≤ 1000V	≤ 600V	≤ 1000V	≤ 1000V	≤ 600V	≤ 600V
Main Exclusions	submersible motors variable or multi-speed motors integral motor-gear systems motors rated for only short duty cycles, e.g. S2	Open motors (IP23) Water cooled motors Special application motors (roller table, smoke ventilation) Ex e, Ex d(e) and for explosive atmospheres Motors for re-export and those not fed by the Eletrobras grid	- NEMA design A or C motors > 150 kW <375 kW - IEC design H motors > 150 kW <375 kW	marine brake motors motors completely integrated into a machine conical rotor motors for electrical hoist and construction machinery motors with integral brake. Only S1 or S3 with a duty of 80% or higher.	Motors designed to operate wholly immersed in a liquid; Motors completely integrated into a product (e.g. pump or fan) where the motor's energy performance cannot be tested independently from the product; Explosion-proof motors Brake motors	TENV TEAO permanent magnet motors	Customized OEM mounting

Table 3 Notes:

*Summation of losses with PLL determined from residual loss

Australia. Because two different Test Methods are allowed, there are separate tables of minimum efficiency values for each.

Brazil. Brazil started a voluntary labelling program for induction motors in 1993. The program defined periodically revised efficiency levels, for standard- and high-efficiency motors.

China. Expected raise to IE3 levels in 2015Europe*Shall not be less efficient than the IE3 efficiency level, or meet the IE2 efficiency level and be equipped with a variable speed drive.

1.3.5 Clarity on what is and what is not in scope

One of the biggest problems facing testing regimes is deciding if a product falls within a regulation's scope. The following characteristics have at some time been the cause of dispute, and so special attention should be given to being explicit about the requirements for each:

- Test method, and year of publication.
- Admissible shaft styles
- Duty (usually continuous / S1 only)
- Inclusion of Explosion proof, flameproof of hazardous area motors.
- Inclusion of motors with attached parts, such as close coupled pumps or brake motors.
- Maximum Voltage
- Torque speed characteristics (different styles available for different loads).
- IP ratings.
- The use of tolerances in assessing declared efficiency.
- Specification of Mounting / cooling styles (e.g. flange mounted, Totally enclosed fan ventilated, …)
- Non-standard cooling methods, such as axial fan or water cooled
- Minimum and maximum operating temperature
- Maximum altitude
- Inclusion of "Inverter driven" motors

Equally the wording of regulations should not be so tight that only a minor variation is sufficient for a motor to escape being in scope. Care should also be taken when specifying operating limits. For example, "being designed for operation within the range -10 to +40C" is sound, whereas "being designed for operation in the range -10 to +40C" is not because a limit of 41C could be specified on a motor and possibly escape the scope of the regulation.

1.3.6 Defining product groups

For (pre-) registration schemes, a decision has to be made at the outset as to what level of product variation is required for listing. The guiding principle is to group products with practically identical thermal characteristics, as these will have a similarly close match in efficiency. So for example variations in shaft type need not be rated separately, but variations in duty or IP rating should be listed separately. The required level of product coding will also need to be defined, which in some countries will include agreement with customs regarding the level of detail needed to identify a product type, and hence entry tariff or right to enter a country.

These decisions impact both the amount of effort required by a manufacturer to enter and maintain the data, and the number of discrete tests required of each generic motor design to enable the whole range to be put on to the market. Further, should one particular variant fail a test, which others would also be considered as part of the same generic type and so also be deemed to fail? The same factors should be also be considered when testing motors where there is no registration scheme.

1.4 Certification – Where should measurements be undertaken?

1.4.1 Testing of motors

There are essentially two methods for establishing compliance: self-declaration of conformity and compliance certification by a third-party. In Europe manufacturers place their motors on the market through a self-declaration process in which the manufacturer declares that the product is compliant to EC Directives by placing the CE mark on the motor; there is no requirement for advance registration or qualification process. By contrast, in the US each manufacturer has to request a Compliance Certification (CC) number from the Department of Energy (DOE) and motors have to be pre-validated before they can be introduced into the market. The manufacturers must either have the motors tested at a certified independent laboratory, or calculate the motors' efficiency using a tool that has been qualified as an Alternative Efficiency Determination Method or AEDM.

Any scheme to promote higher efficiency motors must have access to an independent motor testing laboratory in order to verify the claims being made by the manufacturer. Such a facility is commonly located in the country or region, but this is not essential.

As an alternative to a completely independent Third Party laboratory, the use of an "accredited" test laboratory that is managed by a motor manufacturer could be used. The requirement for appropriate accreditation would overcome the inevitable doubts over the impartiality of such laboratories. NVLAP is the major international accreditation organisation for motor testing labs.[1]

In addition to the use of accredited test laboratories, further confidence in accuracy of processing test readings can be achieved by using standardised test forms and calculation sheets. This minimises the risk of operator error in completing forms or doing calculations and allows other laboratories to understand and gain confidence in the test results. Annex 1 discusses this in more detail.

In practical terms, check testing very large motors would involve large expense if they needed to be shipped to a third party laboratory, and so using manufacturers' in house test laboratories is a practical solution. For other large industrial products such as pumps, "Witness testing" of performance at manufacturers own test facilities is a well-established way of working, and might be most appropriate for very large motors. For example, a 750kW induction motor might weigh 3,000kg, with just the shipping from the manufacturing facility to a test house, possibly in another continent, being very costly. In addition, large motors (typically above the 375kW power level at which many countries currently limit regulations), will come in many minor variants, making the selection of a particular model hard. They are therefore much less likely to be kept as stock items, and so without some flexibility in the exact model that is to be tested there is the chance that some might have been built specifically for testing purposes. With a 750kW motor costing perhaps 25,000euros, this represents a huge cost burden, and in practical terms the motor would then need to be returned and held in stock until required by a customer. These are not insurmountable barriers, but careful thought will need to be given to how CC&E regimes are extended to these larger motors.

Easier access to test laboratory services by the Regulator is a good thing, but this should not be confused with a requirement for more test laboratories. A motor test laboratory is a commercial entity, and requires a known stream of future work in order to make the investment and to maintain it and keep technician skills and technical facilities up to date. A long-term commitment to compliance checking gives test laboratories the confidence they need to invest in the equipment and technical resources needed for undertaking compliance tests. In practice, budgets might vary greatly depending on the leanings of the incumbent Government, which is a clear risk in countries where Governments are likely to change with greater frequency.

For the smaller manufacturer without access to an accredited testing house, the requirement for independent testing is costly, and maybe prohibitively so if the market is small or there is only a Voluntary Agreement in place.

[1] http://www.nist.gov/nvlap/

The global budget for motor testing will therefore set an implicit limit to the number of testing laboratories needed. The increase in countries with MEPS might suggest an increase in testing, but that is not always the case as there is a very low level of test failures and an increase in the sharing of results. More widely, motor testing is just one part of the wider product testing budgets, and in many cases will also be part of a broader and higher importance safety check budget.

All testing authorities are keen to increase the proportion of motors sold in their markets that are tested without incurring excessive costs. In response to this, the sharing of results is cost effective way to achieve both these objectives. There are several examples of sharing of results, with varying levels of formality:

- Denmark, Sweden & UK formally share costs of testing through the pilot Ecopliant[2] initiative.
- The European Commission has just recently created a platform for the sharing of information between European Member State Market Surveillance authorities – the ICSMS (Information and Communication System on Market Surveillance) database.
- Australia formally shares results with New Zealand, and sometimes informally with other IEC members.
- The US informally shares results between US, Canada, EU, Japan, Thailand, Korea and Australia.

Seeking cooperation with countries already undertaking check testing can be an excellent way for new countries to begin a check test programme. However, a lot of trust is involved, not only in the accuracy of the test results, but also in the confidentiality of shared data. Sharing data also can alert regulators to brands or models that have failed elsewhere, and provides an opportunity to double check test methods.

A ground-breaking new initiative is the IECEEE Global Motor Labelling Programme, described in detail in Annex 2. This will ultimately mean that a motor can be awarded a "Passport" based on a single test in an accredited test laboratory, with the results then being valid in any member country. Such a scheme will could revolutionise certification, and so all Regulators should stay up to date on the development of this scheme.

1.5 What happens when a motor fails a test?

1.5.1 Re-testing of motors that fail testing

Small variations in the manufacturing process mean that the actual efficiency of a particular motor design will vary slightly from unit to unit. IEC60034-1 establishes a 15% tolerance allowance on the measured efficiency (10% above 150 kW). This

[2] http://www.ecopliant.eu/

means that for example, in order to meet a 90.0% MEPS level requirement, the motor would have to have a measured efficiency greater than 88.5%.

In this example, a manufacturer with tight control of production performance might elect to design a motor with an average efficiency of 88.9%, but one with poorer control might elect to design a motor with an average efficiency of 90.1%. Either manufacturer might set a lower design point, but they would then run a greater risk of failing a check test. It is a question of calculated risk.

It is up to the regulator to decide whether or not declared efficiencies should include the allowed tolerance. It does not make a practical difference to the requirements as long as they are in accordance with IEC60034-2-1, but is important if comparing products on lists of different authorities.

The issue of allowed tolerances is sometimes seen as being a bit of a "cheat", and so the regulator needs to be careful how this issue is presented when publishing results. This has on occasion been mis-represented, leading to perhaps justifiable complaints from impacted manufacturers.

Because of this, it is accepted that statistically an individual motor may fail, and so re-testing is allowed. In this case the convention used is that if one motor fails, then the average of a further 3 motors will be taken. The manufacturer will usually be asked to pay for the cost of this re-testing.

For some more delicate products it is common practice to send a second sample in case the first one is damaged in transit or in the laboratory. Motors are robust, and providing that they are packed as normal and handled normally in the test laboratory, damage is very unlikely. Therefore, sending a spare product is unnecessary.

1.5.2 Challenges

Formal challenges of test results are rare. This is because manufacturers prefer to work with the check test authority in a constructive way to seek a resolution. Formally raising a complaint can lead to a more protracted and costly negotiation process for both sides, detracting from the image of the motor brand.

The current motor test standard has resolved the known ambiguities in the previous version, removing several possible grounds for complaint on the test procedure. Any ambiguities may be over-looked by regular users of a standard who might read it the way that was intended by the authors, whereas anybody challenging a standard will deliberately seek out ambiguities. This proved to be the case when the results from a highly reputable motor test laboratory were challenged on the basis that the standard had not been followed to the letter.

All new standards require time for any problems to be identified. IEC60034-2-1 is now considered to be robust, but tests for new motor products will inevitably take time to be refined.

The Regulator will need to consider which parameters will be for information only, and those for which mandatory MEPS will be set. In addition, for some requirements an existing international standard will suffice, for others national/international work procedures will be required.
Future products that are likely to have parameters measured within the EU include the following, with the first two (new) test standards anticipated to give rise to the greatest number of issues during initial use.

- Variable Speed Drives, (MEPS for efficiency at 100% load).
- All motors 120W to 1MW, losses when inverter driven, (initially for information only).
- Small motors down to 120W, and large motors up to 1MW, (MEPS for efficiency at 100% load).
- All motors 120W to 1MW, performance at part load, (initially for information only).

In addition, a new test procedure will be required for submersible motors requiring water or air cooling during testing.

1.5.3 Gaming

In practice there is little scope for "gaming" in order to boost the apparent efficiency of a motor, but there are several ways in which small gains might be made:

Changing nameplate ratings. Motors have to comply with testing based on the nameplate rating, and so there is some scope for declaring a motor at a lower power than they will be used in real life. This takes advantage of the fact that modern induction motors tend to have a peak efficiency at about 75% load, and so declaring the 75% load efficiency to be the 100% load efficiency will give the manufacturer an advantage. But the extra cost of effectively over-sizing the motor makes this prohibitively expensive for general purpose motors.

Real life design considerations and customer requirements mean that reducing part load efficiency in order to achieve a higher 100% efficiency at lower cost would not be very practical. However, this possibility can be largely removed by setting MEPS at both 75 and 100% load, as is the requirement in Australia. It is noted that the development of the Extended Product Approach will consider actual efficiencies of motors over their whole operating range, and so it might lead to a change in measurement points.

Changing nameplate duties. MEPS apply to motors rated for continuous duty. There is the possibility of manufacturers falsely rating the motor for intermittent duty use and in this way may circumvent the regulations. However, there are no known cases of this practice.

Under-sizing. There is some anecdotal evidence that motors at the extreme bottom end of regulations are deliberately under-sized on the nameplate in order to escape regulation.

Voltage re-rating. Although this has not yet happened in practice, it would be technically feasible to define a process that allows changes in winding voltage without having to re-register the motor.

Motor sold without VSD. In Europe, the applicable regulation allows for IE2 motors to be sold if they are sold together with a VSD (although the minimum efficiency level allowed is IE3 for Direct-on-line motors). There is the possibility of selling sub-MEPS motors by selling IE2 motors without the VSD.

1.6 Compliance – which motors to test?

1.6.1 Types of motor

Because of the costs involved, the manufacturers are keen that the process for selecting motors for testing should be fair. This means that not only should the selection of manufacturers targeted be fair, but also that the motor types selected should impose a similar amount of "pain" on each manufacturer. Therefore consideration should be given to testing the same size and style of motors in each round of testing, as unusual or extremely large motors might require special construction and possibly high shipping costs. Smaller motors are also easier to ship and test, and so it is suggested that there should be an unspoken bias in favour of these. In addition, testing large motors is more expensive, and as they are usually made to order and efficiency is an important consideration for the purchaser (with penalties for not meeting the specified efficiency), there should be a much lower risk of failure.

High volume motors are also more likely to be available from existing stock, so for example 4 pole motors in the 0.75 – 22kW motors might be a good choice.

An important consideration is the net energy impact of possible non-compliance. The total energy impact is of interest, so for example for the same total kW of stock the difference in energy consumption for smaller motors would always exceed that of larger motors.

A particular issue with motors is that they are not sold to customers through intermediaries, and so other means of procurement are needed:

Common motors will be available either from stockists or from a central warehouse. Less common motors will only be held in a central warehouse, or will be built to order. With such low volumes, it is possible that a "golden sample" might be made especially for the testing programme. One way around this is to select one serial number from a supplied list of products. Even then there is the risk of the manufacturer swapping the chosen nameplate with that on the best motor. Alternatively a motor can be ordered anonymously, but the nature of the market is such that the ultimate destination of a motor will often be guessed at.

With 70% of new motor purchases being those embedded into other machinery, targeting motors built into imported products should be a priority, but to date this source of new motors on the market has been largely ignored. There are several practical issues relating to this motor source:

- Higher cost due to the need to purchase the entire product.
- It can be difficult to determine whether the manufacturer or OEM is responsible for compliance.
- Motors might have a nameplate of the OEM attached, not that of the actual manufacturer.
- They may have/require special fittings to integrate them with the equipment they will be used with.
- They may have special cooling systems to enable them to achieve the claimed duty (for example submersible pumps or direct drive axial fans).

Many of these products will be imported from countries without stringent MEPS regimes for motors, and so there is a real risk that non-compliant motors are finding their way to market through this route. It is recommended that more attention be given to this product area by manufacturers.

In markets with established testing regimes, the selection of manufacturers to be tested is often driven by complaints from competing manufacturers, and so developing a good relationship with suppliers is important in order to encourage this market intelligence.

1.6.2 Manufacturers

In addition to market intelligence, several criteria may be used to identify which manufacturers to target:

- Administrative pre-screening: Checking for anomalies in the paperwork, which might indicate a poor product.
- Past failures: Any manufacturer who has had a previous failure should be re-tested to check that they have acted on the past failure.
- Market share: Irrespective of their previous record, it is good for appearances that manufacturers with a large market share are subject to occasional testing.
- New Entrants: Manufacturers new to a market should be targeted in order that they take compliance seriously.
- Product maturity: A product new to the market will be more worthwhile testing than one coming to the end of its life.

For some products, it is possible to do a quick pre-screening test which will give a good indication of performance without the costs of a proper test. For motors, much of the cost is in transporting and mounting the motor, and so this is not a useful option.

1.7 Enforcement

All leading manufacturers strongly welcome effective sanctions as a way to deter the sale of lower quality products on the market. This is because they will become uncompetitive if non-compliant products are sold on to the market.
There is a range of sanctions to choose, from informal agreements with the manufacturer, through to lawsuits (see Fig 8, P.71 of (CLASP, 2010)).

These will all cause a problem for the manufacturer, and so while it is useful to have a selection of these sanctions available, the emphasis should be on understanding and resolving the reasons for failure. But without the fall back of tougher sanctions, the scheme will soon lose credibility, and so even if there is little desire to use them, it is essential that they exist. It is acknowledged that it is only possible to test a small proportion of motors on a market, but the impact can be greatly improved by careful consideration of how the results are communicated. From the manufacturers' perspective, this determines the "scare factor" of the programme.

Motors are bought directly by industrial and commercial users, and so relevant sanctions are different from those applicable to domestic and some commercial products. When devising a communications programme, careful consideration should be given on how to reach out to each of the following key groups.

Named Registrants / Suppliers

These are the key target groups, as they are responsible for the failure. It is only once they have seen the publicity over a failed product that they will believe a threat is credible. In regimes where there is a register of certified products the threat of removal will have serious financial costs, both due to loss of sales during this period and from the difficulty in regaining sales from alternative suppliers who have taken over their market share during their absence.

Original Equipment Manufacturers (OEMs)

In practice, OEMs are not directly interested, as they won't be fined. The actual difference in overall life cycle costs of a motor that may not pass can be small, and they do not have to pay for these running costs.

End Users

The negative publicity for the brand will alter brand perception. However, it is not known how concerned end users will be about a potentially small increase in running costs, especially when the motor had a low purchase price. This is especially true when motors are bought "blind" in OEM products.

Cross Communications

Giving the importance of the impression of a large and active compliance regime, joint communication with the results of other product tests is a good way to increase the "scare factor". The communication strategy can range from a simple posting of test results on a website to press releases sent to key sector publications.

1.8 Conclusions

International agreement on recently revised motor test and efficiency categorisation means that it is now much easier for regulators to compare their standards with those of other countries, and so to set regulations at an appropriate level of challenge within that region. Adopting standards in line with those in other regions makes it much easier for both motor purchaser and supplier. Care should be taken to align not only the minimum permitted efficiency level but also other requirements (e.g. required documentation, etc.). Similarly, there are many detailed technical points impacting the scope of regulations, and care should be taken that these are fully and accurately documented so as to avoid ambiguity. Where there is not international consensus is on the need for pre-registration before placing products on the market; the up-front costs are greater, but it does make ongoing market surveillance easier.

While established motor test programmes are reporting few if any failures, it is still important that they maintain compliance efforts to ensure this remains the case. In countries where regulations are only just being introduced, the use of a compliance checking programme is important to send out the message that the regulations are being taken seriously. Without the threat of meaningful sanctions for non-compliance, some manufacturers might take a chance, with both the end user and other quality suppliers losing out as a result.

Cost is undoubtedly the biggest barrier to increased compliance checking, and so the growth in the sharing of efforts between several programmes is something very positive that is recommended to both existing and new programmes. Looking ahead, the finalisation and introduction of the IECEE GMLP project offers the prospect of a single test being valid in all member countries, which would transform existing CC&E practice by moving ownership from individual national programmes to a single global programme.

2. Case Study: The European Experience

In 1998 a voluntary agreement supported by the European Committee of Manufacturers of Electrical Machines and Power Electronics (CEMEP) and the European Commission was established and signed by 36 motor manufacturers, representing 80% of the European production of standard motors. In this agreement three motor efficiency levels were defined as:

- EFF1 (similar to IE2)
- EFF2 (similar to IE1)
- EFF3 (below standard)

Based on this classification scheme there was a voluntary undertaking by motor manufacturers to reduce the sale of motors with EFF3 efficiency levels (standard efficiency).

The CEMEP/EU agreement was a very important first step to promote motor efficiency classification and labelling, achieving a significant market transformation. Low efficiency motors were essentially removed from the EU motor market which, at the time, was a positive development. However, the penetration of high and premium efficiency motors in 2009 was still very modest.

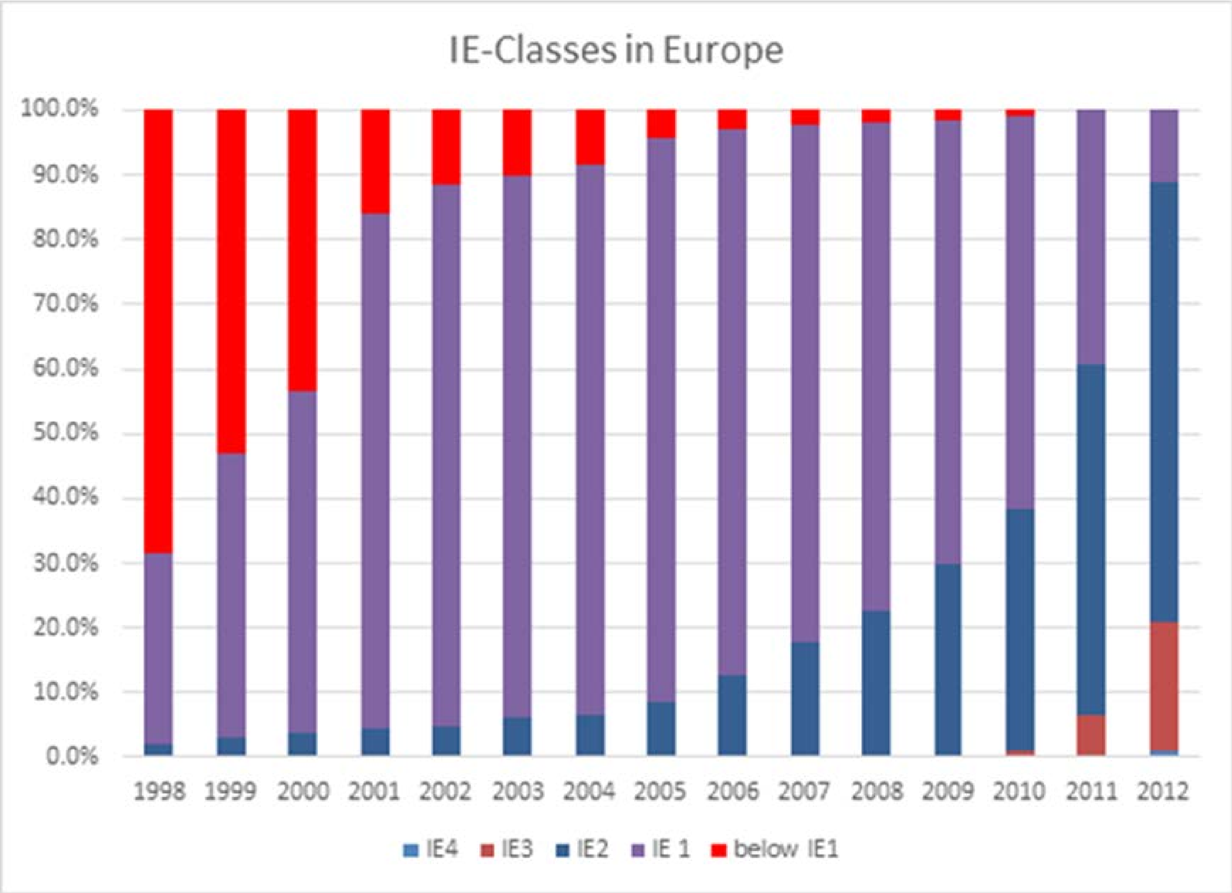

Figure 5 Total motor-sales in the scope of the CEMEP/EU Voluntary Agreement in the period 1998-2009, afterwards (CEMEP)

With the aim of improving the penetration of high-efficiency electric motors in the European market, the European Commission decided that it was time to set mandatory efficiency levels for motors sold within the European Union. Efficiency levels were based on the IEC60034-30 classification standard.

Minimum efficiency requirements were set in the Commission Regulation (EC) No 640/2009 (EC, 2009), as follows:

- from 16 June 2011, motors shall not be less efficient than the IE2 efficiency level
- from 1 January 2015: motors with a rated output of 7,5-375 kW shall not be less efficient than the IE3 efficiency level, or meet the IE2 efficiency level and be equipped with a variable speed drive.
- from 1 January 2017: all motors with a rated output of 0,75-375 kW shall not be less efficient than the IE3 efficiency level, or meet the IE2 efficiency level and be equipped with a variable speed drive.

These requirements apply to single speed, three-phase 50 Hz or 50/60 Hz, squirrel cage induction motors that:

- have 2 to 6 poles,
- have a rated voltage of UN up to 1 000 V,
- have a rated output PN between 0,75 kW and 375 kW,
- are rated on the basis of continuous duty operation.

The regulation has since been amended by Regulation (EC) No 4/2014 and will reinforce the existing Regulation by closing most of the loopholes that have become apparent by redefining the limit values applied to altitude, maximum and minimum ambient air temperatures and water coolant temperatures, and it will help to ensure fair competition in the market.

Meanwhile, a study has been conducted (Lot 30: Preparatory study on the implementation of ecodesign requirements for motors and drives) which focus on the possibility of expanding the scope of the regulation to products not currently covered, e.g.:

- small 1-phase and 3-phase motors in the power range 120W-750W
- large motors in the power range 375kW to 1000kW (<6600V)
- brake motors and explosion-proof motors
- VSDs

The Regulation 640/2009 states that in order to be placed on the market a motor must comply with its requirements (including minimum efficiency levels) and, therefore, bear the CE mark.

The CE Mark is a mandatory label, which indicates the conformity with EU legislation, and applies for a variety of products in Europe. To be placed in the European market, manufacturers must affix the CE Marking to its products.

The manufacturer or its authorised representative shall declare and ensure that the product complies with all relevant requirements by issuing a Declaration of Conformity, on his sole responsibility. The EU declaration of conformity is the document that states that the product satisfies these essential requirements in the applicable legislation, in this case the ecodesign requirements set under the Ecodesign Directive, and that the appropriate conformity assessment procedures have been successfully completed.

This document should declare key information, including:

- the name and address of the organisation taking responsibility for the product
- a description of the product
- list which requirements of which Directives and/or Regulations it complies with
- details of relevant standards used in the conformity assessment

Market surveillance activities are the responsibility of the individual Member States and are performed by nominated official bodies. Different authorities or ministries exist according to each EU member-state; the relevant authority for each country can be found in the ICSMS database (European Market Surveillance System) (www.icsms.org).

The authorities of the Member States shall verify the compliance of the regulation 640/2009 by following a verification procedure as follows:

I. A single unit shall be tested;
II. If in the efficiency of the motor at full load, the losses of the unit being tested do not vary from the values set out in Annex 1 of Regulation 640/2009 by more than 15% in the power range of 0.75 – 150 kW and 10% in the power range > 150 – 375 kW, the model complies with the requirements of the respective regulation;
III. In case that there is no compliance, the market surveillance authority shall randomly test three additional units following the same procedure described in point II.
IV. If the results are not achieved when performing tests for the samples set out in point III, the model shall be considered not to comply with the Regulation.

If a manufacturer is proven to have violated the Ecodesign directive, the manufacturer will have to fulfil the requirements set by the authorities, ranging from correcting the violation (e.g. replacement of affected motors) to paying a fine. All arising costs (e.g. technical inspection of motors, motor replacement) must be paid by the affected manufacturer. The investigation and punishment of violations are subject to a margin of discretion of the responsible supervisory body in each country, which can vary throughout the EU.

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Appendices

A.1 The use of internationally recognised test sheets for CC&E laboratory data

This annex explains the benefits of using a standard laboratory test sheet as a way of giving much greater transparency of testing between test laboratories, and minimising testing, recording and calculation errors.

The widespread adoption of IEC 60034-2-1 effectively harmonises the existing methods used to determine motor efficiency, with the "PLL determined from residual loss" test being the most commonly used for small to medium sized motors. It is expected that within the next few years this will be the test method used by all major economies. However, agreeing to a test standard does not mean that even the accredited test labs will necessarily interpret the detail of the test methods or the following calculations in the same way. The use of a standardized reporting template and a calculation spreadsheet is proposed to overcome the problems that arise from this source of error.

There are various sources of uncertainty when testing motor efficiency. Not only because small differences in materials or manufacturing methods can produce variance but also due to the introduction of errors caused by differences in the interpretation of the testing procedure, test equipment, instrumentation accuracy and calibration, operator errors, etc.

International Round-Robin tests have been organized by IEC between 2008 and 2011 to address the variation in reported energy efficiency by motor manufactures and testing laboratories and results have shown that test results present a large variance for different laboratories, even when measurements use the same standard.

As a result of this, several clarifications were included in the second edition, published June 2014. In the interim, IEA EMSA (Electric Motor Systems Annex) published a guide for the use of the standard with the aim of clarifying these ambiguities in particular by defining an order for the different parts of the test, giving interpretations for some of the most unclear points, and producing recommendations for proper test conducting.

Within EMSA, a small project was undertaken where test data was given to several different test houses in order to check that the computational part of the analysis was correct. The modest variations in results reinforced the need for a standardized worksheet to overcome this additional source of error. Two examples are shown, very similar in content but with some differences in the load points measured for some tests. On the basis solely of its more global use, the IEC format would be recommended. There are several advantages of this shared and open approach:

- Reduced risk of placing data in the wrong box by the test engineer, and easier to check the reasonableness of data relative to corresponding tests.
- Increased confidence in test results because of the ability to check for missing or clearly erroneous data.
- Specification of the number of decimal places required the risk of rounding errors is reduced.

Further to this, the logical next step would be the adoption of a standardized worksheet, such as the one included within the Canadian Standards Association (CSA) standard. This is highly recommended as a way to reduce the risk of small errors creeping into calculations.

Such a shared worksheet is seen as critical to the development and acceptance of the GMLP scheme.

Manufacturer logo	*Laboratory logo*

Date of test:		**Report number:**		**Date of issue:**	

Motor description						
Rated output power	kW			Manufacturer		
Rated voltage	V			Model Nr.		
Rated current	A			Serial Nr.		
Rated speed	min^{-1}			Duty type IEC 60034-1		
Supply frequency	Hz			Design		
Number of Phases	-			Insulation class IEC 60085		
IEC 60034-30-1 (rated)	IE-Code			Max. ambient temperature	°C	

Initial motor conditions			
Test resistance	R_i	Ω	
Winding temperature	θ_0	°C	
Ambient temperature	θ_a	°C	

6.1.3.2.1 Rated load test			
Test resistance	R_N	Ω	
Winding temperature	θ_N	°C	
Ambient temperature	θ_a	°C	

6.1.3.2.3 Load curve test			Test resistance before load test			R	Ω	
Rated output power		%	**125 %**	**115 %**	**100 %**	**75 %**	**50 %**	**25 %**
Torque	T	N.m						
Input power	P_1	W						
Line current	I	A						
Operating speed	n	min^{-1}						
Teminal voltage	U	V						
Frequency	f	Hz						
Winding temperature	θ_w	°C						
			Test resistance after load test			R	Ω	

6.1.3.2.4 No-load test					Test resistance before no-load			R	Ω	
Rated voltage		%	**110 %**	**100 %**	**95 %**	**90 %**	**60 %**	**50 %**	**40 %**	**30 %**
Input power	P_0	W								
Line current	I_0	A								
Terminal voltage	U_0	V								
Frequency	f_0	Hz								
W. temperature	θ_w	°C								
					Test resistance after no-load test			R	Ω	

6.1.3.3 Efficiency determination								
Rated output power corr.	$P_{2,\theta}$	%	**125 %**	**115 %**	**100 %**	**75 %**	**50 %**	**25 %**
Output power corrected	$P_{2,\theta}$	W						
Slip corrected	$s,_\theta$	p.u.						
Input power corrected	$P_{1,\theta}$	W						
Iron losses	P_{fe}	W						
Frict. and wind. losses corr.	$P_{fw,\theta}$	W						
Additional-load losses	P_{LL}	W						
Stator losses corrected	$P_{s,\theta}$	W						
Rotor losses corrected	$P_{r,\theta}$	W						
Power factor	cos φ	%						
Efficiency	η	%						

Tested by: ______________________ Approved by: ______________________

Figure 6 Standardised test results template from IEC 60034-2-1 Ed.2

CSA C390-10 Sample Test Report

Authorized use of the sample test report provided herein is subject to the terms and conditions of the "Legal Notice for Standards" accepted upon the loading of CSA C390-09. This sample test report is not a stand-alone calculator and the data included is provided for example only. The user assumes full responsibility for its use or application of this sample test report, and CSA accepts no responsibility whatsoever arising in any way from any use or reliance thereon.

Report Number: **CSA-** ________
Date of issue: ________

Test requested by: ________
Address of requester: ________
Date of test requisition: ________ Date of test: ________
Date sample received: ________ Test report valid until: ________

Motor description:

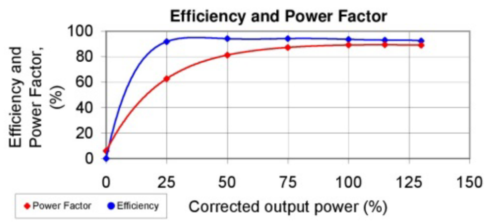
Manufacturer:				Country of origin:	
Rated power:	30 hp	Brand:		Product category:	
Number of poles:	4	Model:		Serial #:	1234567890
Rated voltage:	230 / 460 V	Frame:	286T	Sample number:	
Rated current:	71.0 / 35.5 A	Type:	CTE	Number of phases:	3
Speed:	1775 rpm	Enclosure:		Service factor:	1.15
Frequency:	60 Hz			NEMA design:	B
Time rating:	Continuous			KVA code:	G
Nominal efficiency "η":	94.1%			Insulation class:	F
Guaranteed efficiency	93.0%			Max.amb. temperature:	40 °C

7.1.2 Temperature measurement

Cold stator winding resistance, R_{cold} (Ω)	0.252
Cold winding temperature, $t_{det\ cold}$ (°C)	20

7.1.3 Heat-run

Stator winding resistance, R_{hr} (Ω)	0.305
Stator winding temperature, $t_{res\ hr}$ (°C)	75
Ambient temperature, $t_{amb\ hr}$ (°C)	22



7.1.4 Load test

% of full load	129%	115%	100%	75%	51%	25%
Torque $_{corr\ lt}$(i), (N•m)	157.0	139.0	121.0	90.4	60.7	30.3
Power input, $P_{in\ lt}$(i), (kW)	31.330	27.654	24.028	17.892	12.072	6.232
Average current, $I_{avg\ lt}$(i), (A)	44.14	38.84	33.83	25.71	18.54	12.32
Rotational speed, n_{lt}(i), (rpm)	1760.2	1764.4	1770.0	1779.3	1786.6	1793.9
Winding temperature corrected, $t_{corr\ lt}$(i), (°C)	78	84	83	73	63	57
Ambient temperature, $t_{amb\ lt}$(i), (°C)	22	23	23	23	23	23
Average voltage, $V_{avg\ lt}$(i), (V)	459.9	460.1	459.7	459.9	460.2	460.7
Frequency, f_{lt}(i), (Hz)	59.99	60.01	60.02	60.02	60.00	60.01

7.1.5 Dynamometer correction test Yes — Dyno. corr. factor, $T_{dyno\ cf}$, (N•m) 0.1

7.1.6 No-load test

% of nominal voltage,	114%	100%	85%	50%	35%	20%
Average voltage, $V_{avg\ nl}$(i), (V)	524.2	460.1	390.7	230.0	161.5	91.7
Average current, $I_{avg\ nl}$(i), (A)	12.52	9.13	7.27	4.08	2.90	1.85
Power input, $P_{in\ nl}$(i), (kW)	0.592	0.429	0.330	0.182	0.141	0.112
Winding temperature corrected, $t_{corr\ nl}$(i), (°C)	38	37	36	32	31	30
Frequency, f_{nl}(i), (Hz)	59.99	59.99	59.99	60.02	59.97	60.01

7.2 Calculations

% of Corrected output power	130%	115%	100%	75%	50%	25%
Power output corrected, $P_{corr\ out\ lt}$(i), (hp)	39.0	34.5	30.0	22.5	15.0	7.5
Power output corrected, $P_{corr\ out\ lt}$(i), (kW)	29.1	25.7	22.4	16.8	11.2	5.6
Average current, $I_{avg\ lt}$(i), (A)	44.31	38.82	33.66	25.61	18.32	12.19
Slip corrected, $S_{corr\ lt}$(i), (p.u.)	0.022	0.019	0.017	0.012	0.008	0.004
Power input, $P_{in\ lt}$(i), (kW)	31.450	27.645	23.902	17.809	11.879	6.093
Core loss, P_{core}(i), (kW)	0.279	0.281	0.283	0.287	0.290	0.294
Windage-fiction losses, $P_{wind\text{-}frict.}$ (kW)	0.099	0.099	0.099	0.099	0.099	0.099
Stray-load losses, $P_{stray\text{-}load\ lt}$(i), (kW)	0.403	0.313	0.235	0.131	0.058	0.014
Stator losses corrected, $P_{corr\ stator\ lt}$(i), (kW)	0.907	0.696	0.523	0.303	0.155	0.069
Rotor losses corrected, $P_{corr\ rotor\ lt}$(i), (kW).	0.668	0.519	0.382	0.205	0.087	0.021
Power factor, PF_{lt}(i), (%).	89.1	89.4	89.2	87.3	81.3	62.8
Efficiency, $E_{ff\ lt}$(i), (%)	92.5	93.1	93.6	94.2	94.2	91.9

** The measured efficiency at 100% of rated power is equal to or greater than the associated minimum efficiency in accordance with Table 2-5 and Table 6 of CSA C390-2010.*

Laboratory name: Laboratory name — Tested by: ________
Address: Address — Approved by: ________

Warning: This report is confidential and cannot be reproduced other than in its entirety. The results obtained concern only the motor tested.

Figure 7 Standardised test results template from CSA 390

A.2 The IECEE Global Motor Labelling Programme (GMLP)

This annex describes the ambition and current development of a project that will enable much wider sharing of performance verification data between different countries.

For motor manufacturers and regulators alike, the lack of sharing of test results is a major inconvenience that results in both higher costs and less comprehensive testing.

In answer to this need, the Global Motor Labelling Programme (GMLP) initiative is being developed under the IECEE (International Electrotechnical Committee Energy Efficiency) framework . The idea of this is that a single Certificate of performance ("Passport") for a motor will be valid in any country that is a member. This will bring many benefits:

- Decrease the time it takes for manufacturers to enter new markets by removing the need for separate certification in each market.
- Reduce manufacturers' testing costs because motors only need to be tested by one laboratory.
- Lower costs of global CC&E effort through sharing of test results.
- Amplify impacts of CC&E activity due to the threat of global action on infringements.
- Make it possible for MEPS to be adopted in countries or regions without testing labs.
- Accelerate the harmonisation of test requirements.
- Develop a mark of confidence to motor purchasers.

The programme will oversee the quality of testing, with the ambition of becoming as well accepted internationally as UL certified product testing. It will in effect underwrite any claims for energy efficiency, for example catalogue or nameplate information. In the same way that a UL label on a product is seen as a "gold standard" of compliance, a new GMLP label might be developed. But it is explicitly not the intention for the GMLP to supersede the existing IEC IE motor efficiency labelling scheme.

So while the GMLP is not designed as the basis of a future global motor labelling programme, it does contain the following useful building blocks for any legislature looking to regulate electric motors: (1) internationally recognisable test certification or "passport", and (2) testing laboratory requirements. The generic IECEE scheme on which the GMLP is based is popular, with 53 countries in the IECEE scheme, and many other non-members recognising the labels that it produces. An advantage of using the existing IECEE Certification Body scheme means that the rules for devising and running the programme are already defined. This IECEE scheme also includes the protocol for the design of a comprehensive factory inspection programme performed by independent inspectors. This facility is based on the requirement for safety inspections, and is not seen as being relevant to this Motors GMLP.

Despite significant advances in the standardisation of motor test procedures, there are still some small variations among testing methodologies or countries' policies. The advantage of this single GMLP test protocol is that small supplementary tests or calculations could be performed to meet the requirements of particular countries. But a balanced approach needs to be agreed upon in order to avoid excessive cost to the many countries not interested in this additional data. Again, this reinforces the need to harmonise test methods.

The scope of the programme is focused simply on verifying test results, and the use of these results in national programmes remains the decision of each country. The GMLP will not be involved in enforcement activities, although within the larger IECEE there is the structure in place to do so. No decisions have yet been made on the impact of a product being found to be non-compliant, which offers the potential to lead to sanctions in all countries that are signatories to the GMLP.

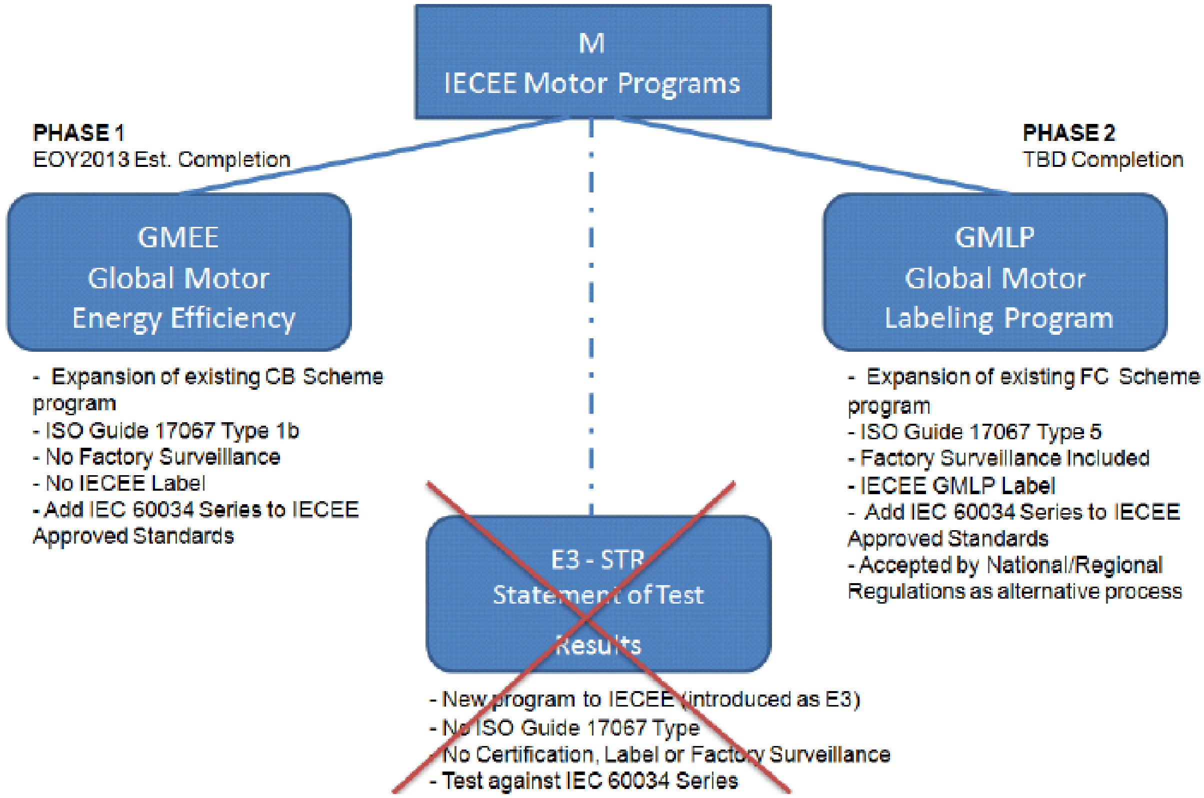


Figure 8 Summary of proposed phasing of the GMLP (Dan Dalaney, 2013)

Operating providers, testing laboratories and certification bodies may at a later stage be subject to quality checking under the IEC Peer Review programme, checked against ISO/IEC 17025 standard - general requirements for the competence of testing and calibration laboratories, and/or ISO/IEC 17065 - Conformity assessment – Requirements for bodies certifying products, processes and services.

The driving motivation for the establishment of the GMLP initiative was for the NEMA Efficiency Electric Motors Programme to be more internationally accepted.

A.3 International Test Standards

This Annex gives an overview of the recent evolution of testing and classification standards used in the most high profile motors CC&E schemes around the world.

A.3.1 Comparison of different methods for determining motor efficiency

Efficiency in an electric motor can be determined in two ways, directly and indirectly. Direct test methods rely on measuring the input power on the basis of the voltage and current supplied, and the output power based on the rotational speed and torque. The disadvantage with this simple approach is that with very high efficiency motors, the difference between input and output power is only small, making high demands on the accuracy of the instruments used. Indirect methods involve measuring the input power and calculating the total losses by measuring and adding individual loss components.

To enable MEPS to be compared on a fair basis, there needs to be alignment of test methods and efficiency thresholds (for both 50Hz and 60Hz models).

An important technical consideration is that since Power = Torque x Speed, a higher mains frequency will deliver additional power for no additional material cost, meaning that 60Hz motors have an inherent design advantage. In addition, differences in frame styles will impose limitations on the maximum commercially acceptable diameter of the motor. This means that in order to accommodate the additional active materials required, the alternative option of extending the stack length must be used. For alignment of "techno-economic challenge" in achieving a particular efficiency value for all motor types globally, the different constraints offered by both the mains frequency and different frame styles used need also to be taken into account.

Prior to 2000, there were effectively three test methods for electric motors in use around the World. These were:

- IEC60034-2 Rotating electrical machines - Part 2: Methods for determining losses and efficiency of rotating electrical machinery from tests
- ANSI/IEEE 112-1984, Test Procedure for Poly-phase Induction Motors and Generators (Method B)
- JIS C4210 Low voltage three phase squirrel cage motors for general purpose

All three methods rely on the summation of losses method for the determination of efficiency, the main difference being the way they account for the stray-load losses. In IEEE 112B these are determined directly by measurement, under IEC 34-2 they were assumed to be a constant 0.5% of input power for all motor sizes, while under the former Japanese JIS method these losses were ignored (i.e. assumed to be 0%).

In 2007, IEC published the improved efficiency test standard IEC 60034-2-1 which supersedes the old IEC 34-2 and also the intermediate publication IEC 61972. This version of the IEC 60034-2-1 standard contained a test procedure ("Indirect loss determination with PLL determined from residual loss"), similar to IEEE 112B with some additional improvements especially for smaller motors (1 kW and below), effectively harmonizing the different test methods standards used internationally.

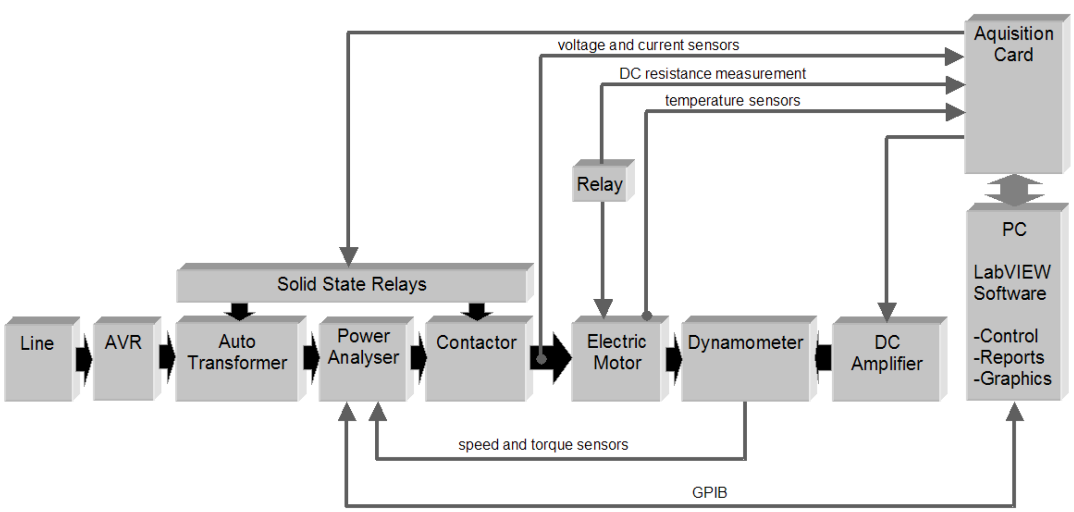
More recently, in 2014, the standard was again revised to remove ambiguities and possible causes for confusion. Its text has also been edited to make it more readable and user friendly. The requirements regarding instrumentation have been detailed and refined. The description of tests required for a specific method is now given in the same sequence as requested for the performance of the test. This will avoid misunderstandings and improve the accuracy of the procedures. In addition, for each method a flowchart shows the sequence of tests graphically. To maintain compatibility with existing national standards very few technical modifications are introduced. The test methods are now grouped into preferred methods and methods for field or routine testing. Preferred methods have a low uncertainty, and for a specific rating and type of machine only one preferred method is now defined.

For the purpose of efficiency classification according to standard IEC 60034-30-1, the preferred test method as indicated in standard IEC 60034-2-1 for testing must be used. This means that in practice the "Summation of losses, with and without load test, PLL determined from residual losses" is used for all 3 phase motors in the 0.75 – 375kW power range,

Similarly, the standard for testing induction machines in the US, Institute of Electrical and Electronics Engineers (IEEE) 112 (IEEE 112, 2004), recognizes five methods for determining motor efficiency. Because dynamometer testing based on IEEE 112 method B test standard provides consistent, representative, and verifiable motor performance data required for proper motor comparison, it is the basis for MEPS.

Most authorities now test to the IEC 60034-2-1 Summation of losses method with stray losses determined from residual loss, and efforts are being undertaken by national authorities to base their regulations on this standard in countries where it is not yet so (e.g. China). This test method has been transposed to national or regional standards by the respective standardisation bodies. In practice, it is considered that the different test standards using the Indirect loss determination with PLL determined from residual loss method can be considered to be equivalent. This also means that there is no additional burden on test laboratories wishing to move from one method to another. A recent paper (Angers, Baghurs, & Doppelbauer, 2013) gives an excellent overview of the minor comparisons between the differing test standards used.

The next figure gives an example of a test facility capable of performing tests according to both indirect testing and direct testing methods.



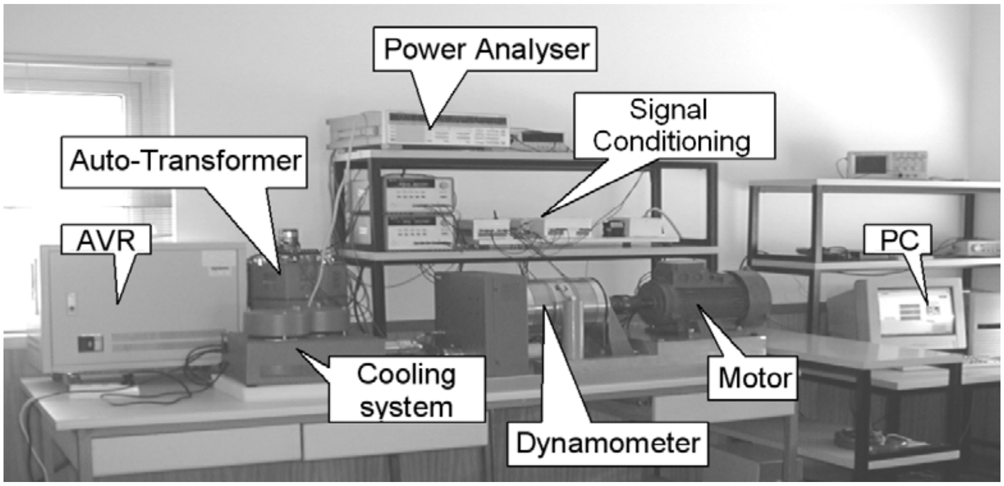


Figure 9 Testing facility photograph and block diagram (de Almeida & Ferreira, 2005)

A.3.2 The development of the IEC efficiency measurement and labelling standards

This section gives interesting background on some of the considerations in the evolution of these standards.

Until circa 2010, several different energy efficiency levels/classes were in use around the world, based on different test methods, increasing potential confusion and creating market barriers, for example:

- CEMEP-EU 1999 — Eff1 / Eff2 / Eff3 (based on IEC 60034-2)
- USA — EPAct / NEMA Premium (based on IEEE 112B)
- Australia — A and B (based on IEC 60034-2:1996)
- China — GB 18613:2006 (based on IEC 60034-2:1996)

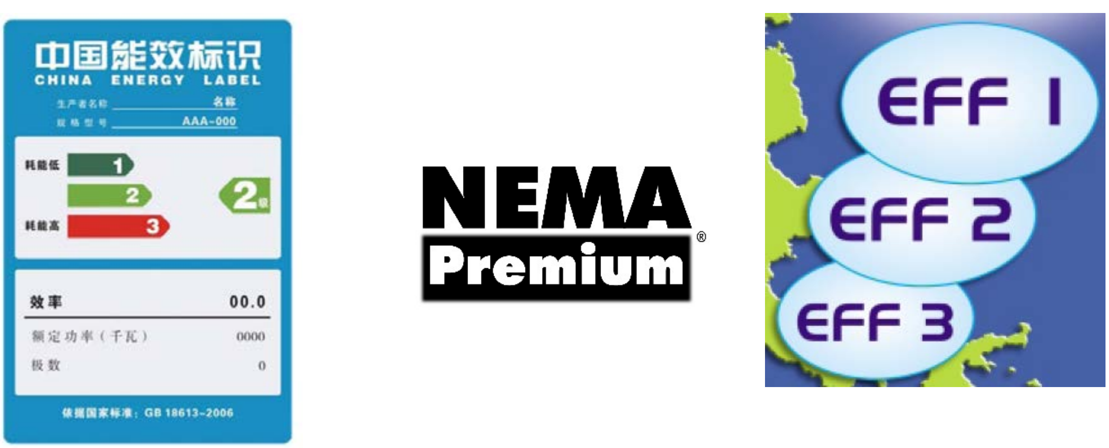


Figure 10 Examples of labels in use in China, USA, and Europe

In 2007, a project for a new harmonized global standard for energy classes for electric motors was initiated by IEC, resulting in the IEC 60034-30 efficiency classification standard, published in October, 2008.

The example of the new IE label shown below ensures the use of a consistent test method and efficiency classification scheme, overcoming the confusion created by the range of different standards in existence prior to this.

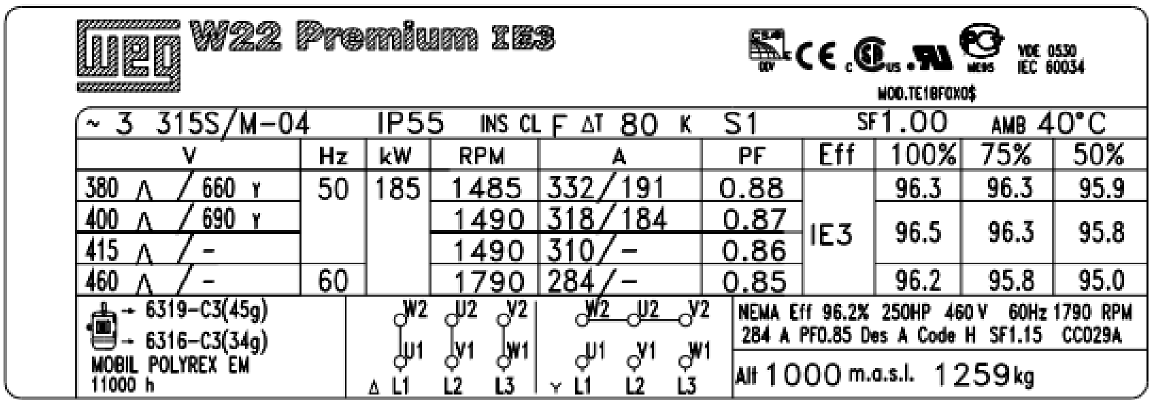


Figure 11 Example of the use of the new IEC motor

The standard is applicable to both 50 and 60Hz motors, irrespective of frame type. It should be noted that the supply frequency (50 Hz or 60 Hz) has an impact on efficiency. For motors using the same amount of active materials, leading to similar torque, the operation at 60 Hz will provide slightly higher efficiency, because although some losses increase with the frequency (e.g. the mechanical losses and magnetic losses) the output power increases more intensively (20%). To take this influence into account, limit efficiency values are presented for 50 Hz and 60 Hz.

This IEC standard has since been revised and is divided into two parts:

- Part 1 - Efficiency classes of line operated AC motors
- Part 2 - Efficiency classes of variable speed AC motors (in development)

IEC 60034-30-1 significantly broadens the scope of products currently covered. The power range has been expanded to cover motors from 120 W to 1000 kW, in line with proposed regulations in the EU and USA. Apart from a few exclusions, all technical constructions of electric motors are covered as long as they are rated for direct on-line operation. One exception is for motors integrated into other products, such as submersible motors, for which a new procedure will need developing to standardize some critical elements:

- Removal of motor from housing.
- Replacement of bearings with horizontal bearings for running on the test rig.
- Standardised cooling of the motor using either blown air or flowing water to mimic typical working conditions.

The IEC 60034-30-1 standard defines four efficiency classes IE1, IE2, IE3 and IE4. The IE4 efficiency level is now included in the standard while an IE5 level is envisaged for a future revision, with the goal of reducing the losses of IE5 by some 20% relative to IE4.

The efficiency levels in the power range 0,75 to 375 kW, already covered by the current edition of the standard remain the same. Between 0,12 and 0,75 kW the limit values of efficiency were extrapolated, and between 375 and 1000 kW the fixed values were maintained.

The standard has been written with the intention of being applicable to any type of motor operated on a sinusoidal supply (Direct-on-line). This will have the big advantage of being future proofed to allow its use with any new technologies that are developed. It should be noted that not all of the motor technologies covered by this standard will be capable of reaching the highest efficiency levels.

A requirement of the standard is that the rated efficiency and the efficiency class shall be durably marked on the rating plate, for example 89,0 (IE3). This means that the full-load efficiency of any motor, when tested at rated voltage and rated frequency, shall not be less than the rated efficiency minus the tolerance of the total losses in accordance with IEC 60034-1.
The publication of this standard has led to the progressive harmonization of requirements and threshold efficiency levels between different economies, although different nomenclatures are still in use.

Motor efficiency regulations around the world are to date limited to AC induction motors. In principle other types might be included, but given the much smaller amount of energy used by these other types, the potential energy saving will be much smaller. However, the new EU regulations propose including shaded pole motors, which have very low efficiencies. Universal motors would be a poor target on the basis that their brushgear means that the motors are only used in very limited duty applications where energy consumption is not so critical to life cycle cost.

Regulations mainly target three phase induction motors only, but single phase motors can be subject to the same efficiency values in IEC60034-30-1. The US and the EU (possibly) are setting MEPS for single phase motors.

A.4 MEPS for small motors (<0,75 kW)

The success of regulations for 3 phase motors, and the high costs of mandatory MEPS for motors beyond the current IE3 "rallying point", has led to a new focus on smaller fractional horsepower motors. So far only China and the US have approved regulations for these types of motors, with the EU likely to follow suit.

A.4.1 United States of America

The USA has recently issued a regulation, Energy Conservation Standards for Small Electric Motors, regarding the efficiency of "small induction motors", either single-phase or polyphase, ranging from 1/4 to 3 horsepower (0,18 to 2,2 kW), to be enforced in 2015. The Energy Policy and Conservation Act (EPCA) defines small electric motors as a NEMA (National Electrical Manufacturers Association) general purpose alternating current single-speed induction motor, built in a two-digit frame number series in accordance with NEMA Standards Publication MG1–1987.

The standards apply to three types of electric motors:

- Poly-phase Small Electric Motor
- Single-phase Capacitor-Start Induction-Run
- Single-phase Capacitor-Start Capacitor-Run

Minimum efficiency levels are set at IE3 levels according to the new IEC60034-30-1 (IEC, 2014) for poly-phase motors. Minimum efficiency levels set for single-phase motors have no standard IE equivalent. The standards do not apply to motors integrated in already regulated equipment (e.g. refrigerators, washing machines, clothes dryers).

A.4.2 Europe

The European Commission is considering expanding the scope of current motor efficiency regulations to include 120-750W motors. Proposed MEPS are at IE2 efficiency levels. These would include both single-phase and poly-phase induction motors. Motors with mechanical commutators would remain excluded based on their low number of operating hours which translates into a small environmental impact. Other proposed exclusions are:

- Motors in cordless or battery operated equipment (off-grid applications)
- Motors in hand-held equipment whose weight is supported by hand during operation
- Motors completely integrated into a machine (for example pump, fan and compressor) that cannot be practically tested separately from the machine even with provision of a temporary end-shield and drive-end bearing.

A.4.3 China

MEPS for small motors were recently enforced in China (GB 25958-2011 - Minimum allowable values of energy efficiency and efficiency grade for small-power motors)

This standard applies to:

- small three-phase asynchronous motors (10W - 2.2kW)
- capacitor-run asynchronous motors (10W - 2.2kW)
- capacitor-start induction motors (120W - 3.7kW)
- double-value capacitor induction motors (250W - 3kW) for general purpose with the voltage ≤ 690V, 50Hz AC power
- fan motors for room air conditioner (6W - 550W)

Since September 2014, a new standard (GB30254-2013), has been in force giving MEPS for induction motors up to 25,000 kW.

A.5 Comparison of MEPS and CC&E requirements in different countries

This annex gives an overview of MEPS levels and CC&E schemes in a selection of important markets, and is essential reading to learn from and select features most appropriate to the circumstances of a particular country. When feasible it is ideal to align with existing initiatives in scope, ambition and timing to make compliance simpler for manufacturers, end users and the regulator.

A detailed overview of the product requirements, laboratory requirements and market surveillance activities applicable for motors is given for the following economies: Australia, Brazil, Canada, China, European Union, Mexico and the US.

A.5.1 Australia

A.5.1.1 Product Requirements

Each motor should have a rating plate marked in accordance with section 9 of AS/NZS 1359.101 (AS/NZS). However, according to the Energy Efficiency and Conservation Authority each rating plate should have the following as a minimum (EECA, 2004):

- manufacturers name or mark
- manufacturers serial number, or identification mark
- rated output(s)
- rated voltage(s) range of voltages
- rated speed(s) range of rated speeds
- IP code
- number of phases
- class(es) of rating of the machine if designed for other than rating for continuous running S1
- for AC machines, the rated frequency or range of rated frequency.

Three phase electric motors from 0.73kW to <185kW should be registered and shall comply with the regulation before importing or sale in Australia/New Zealand. The registrations have to be done on the E3 (Equipment Energy Efficiency) web site.

A.5.1.2 Applicable test procedures

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 (AS/NZS 1359.102.3) corresponds to IEEE 112B and IEC 60034-2-1 ("PLL from residual loss") while test B (AS/NZS 1359.102.1) is compatible with the now obsolete IEC 34-2 (fixed 0,5% stray load losses.

A.5.1.3 Laboratory Requirements

In Australia, the National Association of Testing Authorities (NATA) is the authority responsible for the accreditation of laboratories, inspection bodies, calibration services, producers of certified reference materials and proficiency testing scheme. Testing may take place at manufacturer accredited labs, independent labs, and selectively at foreign accredited labs.

A.5.1.4 Market surveillance

Program

Market surveillance in Australia is done by the E3 Committee which administers a monitoring, verification and enforcement program. The aim of this program is to ensure and maximize compliance with energy efficiency regulations for energy products including electric motors. It is based on the following activities (E3, 2011):

- Aiding compliance through education, stakeholder forums and other communication activities;
- Maintenance of a registration database and on-line registration facility (energyrating.gov.au);
- In-store surveys to check that the correct labels are being displayed;
- Checks to ensure that products on the market are registered; and
- Verification (Check) testing.

Monitoring

The E3 check testing activity aims to confirm whether individual models meet the performance requirements of MEPS. It also aims to confirm if product information shows the correct level of performance.

Check testing can be divided in two stages. In the first stage, also known as the screen test, one sample of the model randomly sourced and independently purchased (usually through a retail outlet), and paid for by the regulatory authority, is tested. The test shall be carried out in an accredited laboratory appropriated for such model. In case that the model presents non-compliance, the supplier has two choices:

- Accept the result and nominating to cancel the model's registration, or
- Challenging the initial finding by agreeing to proceed to the second stage of Check Testing.

The second stage, involves testing of a minimum of two further units which depends on the selected product. The registration holder of the product has to pay such units and an accredited test facility by his choice.

Note that products are not selected for check testing on a random basis. The factors taken into account in determining which models will be tested are: market share, major suppliers, sizes and poles, not covered in previous check testing, referrals by third parties, suppliers with history of noncompliant products (IEA 4E Electric Motor Systems Annex, 2011).

Enforcement

Enforcement actions by the E3 Committee have been and will continue to be undertaken in association with the ACCC (Australian Competition and Consumer Commission). It is therefore important that products selected for testing meet the priorities of both organisations. (E3, 2012)

The major sanction for companies supplying non-compliant products is deregistration or referral to the ACCC.

A.5.2 Brazil

A.5.2.1 Product Requirements

Regulated motors must meet IE2 efficiency levels to be placed on the market. Each motor shall have the efficiency and power factor at full load marked on the rating plate as well as the applicable specifications described in accordance with section 18.2 of the standard NBR 7094 (e.g. number of phases, rated power, rated voltage, rated current, rated frequency, and rated speed).

A.5.2.2 Applicable test procedures

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 ("PLL from residual loss").

A.5.2.3 Laboratory Requirements

Testing procedures are carried out in accredited laboratories or in those authorized by the National Institute of Metrology, Standardization and Industrial Quality (INMETRO) in order to prove the fulfilment of the required minimum rated efficiency of motors manufactured or sold in the country.

A.5.2.4 Market surveillance

The evaluation process for verification of compliance with the minimum energy efficiency requirements of induction motors is the responsibility of INMETRO, through the Brazilian Labelling Program – PBE.

Evaluation Process

Before placing a basic model of a motor in the market, it shall be submitted by the manufacturer or importer to INMETRO for the authorization of commercialization. Note that, a basic model means an electric motor which represents a set of motors with the same electrical and mechanical characteristics, and manufactured by the same manufacturer.
The evaluation process is based on the requirements of ENCE labelling program, and is described in Regulation INMETRO 243 which includes the following stages:

1. Request for labelling;
2. Analysis of the request for labelling;
3. Interlaboratory Comparison;
4. Measurement/Control;
5. Authorization for use of the label;
6. Signing a term for commitment;
7. Monitoring of production – AcP.

Monitoring

In order to monitor the compliance of products, tests are carried out annually. The sampling method selected by INMETRO is the following:

- Number of poles: II, and IV – 20% (for both poles) – 1 (one) model at each 5 (five) of the same production line;
- Number of poles: VI, and VIII – 10% (for both poles) – 1 (one) model at each 10 (five) of the same production line;

These samples can be collected on the manufacture/importer stock, on the market, or even sent by the manufacture/importer to the reference test laboratories. The manufacture/importer is responsible for contracting and payment of tests related to the reference laboratory.

Enforcement
In case of noncompliance with mandatory requirements of the INMETRO 243, the company is subject to the following sanctions:

- Obligation to eliminate the non-compliances observed within a specified period (30 days) after which a financial penalty is applied per motor placed on the market of up to 100% the price of the motor.

A.5.3 Canada

A.5.3.1 Product Requirements

Motors covered by the regulation must meet minimum efficiency levels (see 1.4.1).

According to Canadian Regulations there is no mandatory labelling requirement for electric motors.

A.5.3.2 Applicable test procedures

Efficiency and losses shall be determined by the CSA C390-10 test method

Procedure similar to IEC 60034-2-1 ("PLL from residual loss")

A.5.3.3 Laboratory Requirements

Tests shall be performed in accredited and approved laboratories in accordance with the Standards Council of Canada (SCC) and NRCan internal criteria. Note that many accredited laboratories are based on internationally-accepted laboratory accreditation entities:

- CSA International
- Intertek Testing Services NA Inc.
- Intertek Testing Services NA Ltd.
- Underwriters Laboratories Inc. (UL)

A.5.3.4 Market surveillance

The Energy Efficiency Act of 1992 gives the Government of Canada authority to make and enforce regulations that prescribe standards and labelling requirements for energy-using products including electric motors.

According to such regulations, an energy efficiency report has to be submitted by the dealer (manufacturer/importer) to NRCan (National Resources of Canada) before importing or shipping a new motor model between provinces.

In case that the dealer imports electric motors into Canada, the following information must be included on the customs release document:

- Name of the product
- Model number
- Brand name
- Address of the dealer importing the product
- Purpose for which the product is being imported (i.e. for sale or lease in Canada without modification; for sale or lease in Canada after modification to comply with energy efficiency standards; or for use as a component in a product being exported from Canada).

Equipment must bear an energy efficiency verification mark indicating that the energy efficiency reporting requirements are third party verified by a certification body accredited by the Standards Council of Canada.

A.5.4 China

A.5.4.1 Product Requirements

Marking motor nameplate

According to GB 18613-2012, section 6 (Marking of energy efficiency grades), the manufacturer shall mark the energy efficiency grade and number of the standard that provides the basis for such grade on the data plate of applicable products.

A.5.4.2 Market surveillance

According to the Law of the People's Republic of China on Energy Conservation No.77, special equipment, which consumes excessive quantities of energy, shall be subject to examination and control for energy conservation as required by the State Council.

A key energy-using unit shall annually submit a report on the energy utilized in the preceding year to the department in charge of energy conservation. The report shall include information on energy consumption, energy efficiency, achievement of the goal for energy conservation, analysis of the results of energy conservation, measures taken for energy conservation, etc.

A.5.5 European Union

A.5.5.1 Product Requirements

Motor Data

According to the Regulation 640/2009 EC, Annex I, the motor data described on the following paragraph shall be visible and displayed on the technical documentation of the motor, technical documentation of the product in which motors are incorporated, free access websites of manufactures of motors, and also on free access websites of manufacturers of products in which motors are incorporated.

- *Motor Data:* the nominal efficiency at full, 75%, and 50% rated load and voltage (UN); efficiency level (IE2 or IE3); the year of manufacture; manufacturer's name or trade mark, commercial registration number and place of manufacturer; product´s model number; number of motor poles; the rated power output(s) or range of rated power output (kW) of the motor; the rated input frequency(s) of the motor; the rated voltage(s) or range of rated voltage; the rated speed(s) or range of rated speed; information relevant for disassembly, recycling or disposal at end-of-life; and also information on the range of operating conditions for which the motor is specifically designed: altitudes above sea-level, ambient air temperatures, including for motors with air cooling, water coolant temperature at the inlet to the product, maximum operating temperature, and potentially explosive atmosphere.

The motor data described above do not need to be published on the motor manufacturer's free access website for tailor-made motors with special mechanical and electrical design manufactured on the basis of client request.

Rating Plate

A rating plate is also necessary for each motor and the following information shall be durably marked on it as a minimum:

- The nominal efficiency at full, 75%, and 50% rated load and voltage (UN);
- Efficiency level: IE2 or IE3;
- The year of manufacture;

CE Mark

CE Mark is a mandatory label, which indicates the conformity with EU legislation, for a variety of products in Europe, including electric motor. There are mainly four different European Directives related to electric motors:

- 2009/125/EC – "Ecodesign Directive" establishing a framework for the setting of ecodesign requirements for energy-using products and amending Council Directive 92/42/EEC and Directives 96/57/EC and 2000/55/EC of the European Parliament and of the Council.
- 89/392/EEC - "Machine Directive" Describes several machine requirements for operator safety and health;
- 89/336/EEC - "EMC Directive" Describes equipment requirements for electromagnetic compatibility;
- 2006/95/EC - "Low Voltage Directive" on the harmonisation of the laws of Member States relating to electrical equipment designed for use within certain voltage limits.

The manufacturer or its authorised representative shall declare and ensure that the product complies with all relevant directives. They have the responsibility for ensuring that only MEPS compliant motors are introduced into the market. As a result effective market surveillance is essential. Responsibility for organizing surveillance lies with the EU member states, which have nominated official bodies to perform the actual surveillance work.

A.5.5.2 Applicable test procedures

Regulation 640/2009 specifies that the measurements and calculations during tests shall be performed using a reliable, accurate and reproducible method. Such method shall be recognised as the state-of-the-art, and its results are associated with low uncertainty. This deliberately does not reference specific standards, meaning that the regulation will not become obsolete if the test method changes. The two methods for the determination of losses allowed, which are described in IEC 60034-2-1, are:

- Measurement of total losses, or
- Determination of spare losses for summation (PLL determined from residual loss)

A.5.5.3 Laboratory Requirements

Laboratories authorised to perform verification tests must be selected under a strict accreditation scheme. As a general rule, the laboratories must have a national accreditation, like ENAC certification in Spain, accreditations delivered by the Estonian Centre of Accreditation in Estonia, by the Hellenic Accreditation System (ESyD) in Greece, etc. international accreditations may also be considered while authorizing laboratories to perform verification tests, as well as ISO/IEC 17025 on the "General requirements for the competence of testing and calibration laboratories".

A.5.5.4 Market surveillance

Conformity assessment

Before placing an electric motor on the market or even putting it into service, the manufacturer or its authorised representative shall ensure that an assessment of the product conformity with all relevant requirements of the Regulation is carried out.

The conformity assessment procedure can be chosen by the manufacturer, and shall be one of those defined in the Ecodesign Directive 2009/125/EC:

1. The internal design control

   The manufacturer or its authorised representative who carries out the obligations described below on a technical documentation file ensures and declares that a product satisfies the relevant requirements of the regulation (Annex IV):

   - A general description of the product and of its intended use;
   - The results of relevant environmental assessment studies carried out by the manufacturer, and/or references to environmental assessment literature or case studies, which are used by the manufacturer in evaluating, documenting and determining product design solutions;
   - The ecological profile, if required by the implementing measure;
   - Elements of the product design specification relating to environmental design aspects of the product;
   - A list of the appropriate standards referred to in Article 10, applied in full or in part, and a description of the solutions adopted to meet the requirements of the applicable implementing measure where the standards referred to in Article 10 have not been applied or where those standards do not cover entirely the requirements of the applicable implementing measure;
   - A copy of the information concerning the environmental design aspects of the product provided in accordance with the requirements specified in Annex I, Part 2;
   - The results of measurements on the ecodesign requirements carried out, including details of the conformity of these measurements as compared with the ecodesign requirements set out in the applicable implementing measure.
   - The Declaration of conformity may cover one or more products and must be kept by the manufacturer.

2. Management system for assessing conformity:

   The manufacturer shall ensure and declare that the product satisfies the requirements of the regulation by following the obligations of a management system in accordance with Annex V of the Ecodesign Directive which is based on the following elements.

- The environmental product performance policy;
- Planning;
- Implementation and documentation;
- Checking and corrective action;

Verification procedure for market surveillance purposes

The authorities of the Member States shall verify the compliance of the regulation 640/2009 by following a verification procedure as follows:

I. A single unit shall be tested;
II. If in the efficiency of the motor at full load, the losses of the unit being tested do not vary from the values set out in Annex 1 of Regulation 640/2009 by more than 15% in the power range of 0.75 – 150 kW and 10% in the power range > 150 – 375 kW, the model complies with the requirements of the respective regulation;
III. In case that there is no compliance, the market surveillance authority shall randomly test three additional units following the same procedure described in point II.
IV. If the results are not achieved when performing tests for the samples set out in point III, the model shall be considered not to comply with the Regulation.

A.5.6 Mexico

A.5.6.1 Product Requirements

Motors must have a permanent rating plate in accordance with the minimum efficiency levels of the respective standard. According to section 10 of the NOM-016-ENER-2010, the following data shall be on the rating plate and in Spanish:

- Name of the manufacturer or of the distributor, or logotype or registered trademark;
- Model designated by the manufacturer or distributor used for commercial identification;
- Type of enclosure (open or enclosed, according to the informative Annex D);
- Country of origin of manufacture;
- Rated efficiency, as a percentage, preceded by the symbol "η" (2 whole digits and 1 decimal point);
- The rated output in kW;
- Electrical voltage in V;
- The electrical frequency in Hz, and
- The rotation frequency in min-1 or r/min.

Also the information specified by any other applicable official Mexican Standards shall be marked on the rating plate.
Motors certified in compliance with this official Mexican Standard, may carry the official approval of the certifying body inside or outside the rating plate.

A.5.6.2 Applicable test procedures

Test method is given by regulation NOM-016-ENER-2010 on section 9. Such test method is partially equivalent to IEEE Std 112 and with CAN/CSA C390.

A.5.6.3 Laboratory Requirements

The conformity assessment of the motor requirements presented on the standard NOM-016-ENER-2010 shall be performed by accredited and approved laboratories.

Examples of accredited and approved laboratories in Mexico related to the respective standard are:

- Asociación de Normalización y Certificación, A.C. (ANCE);
- Siemens, S.A de C.V.;
- USEM de México, S.A. de C.V.;
- WEG de México, S.A. de C.V.

A.5.6.4 Market surveillance

CONUEE (Comision Nacional para el Uso Eficiente de la Energia) is responsible for verification and monitoring the compliance of the standard NOM-016-ENER-2010. Failure to comply with the standard shall be punished in accordance with Federal Law on Metrology and Standardization, and other applicable laws.

Verification and Monitoring

According to the Federal Law on Metrology and Standardization Act, manufacturers or importers may be required to provide to the authorities documents, reports, and data that they require in writing, and samples of products that may be requested as needed.

Appropriate Inspection bodies are able to carry out verification visits in order to monitor compliance with the laws.
The costs of the verifications by acts of conformity assessment have to be paid by the manufacturer or importer to whom it is made.

Another check may be performed if the first check of the product or service does not successfully comply with the requirements. This verification can be done in the same laboratory or in another accredited laboratory. If this second verification complies with the requirements, it shall be invalidated the first result. If not satisfied, it shall be confirmed as an invalid product Samples shall be selected only by authorized and competent persons.

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