A REVIEW ON EFFICIENCY OF ENERGY EFFICIENT MOTOR STANDARDS

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Abstract- *It is proved that of all electricity generated worldwide, about 30-40% is consumed by Industrial electric motors. The electric motor system uses about 70% of the electrical energy which is consumed by the industries in which induction motor observes major part. Now a day we go for Energy efficient electric motors, which not only saves the electricity bill but also reduces the emission of greenhouse gases. Many countries in the world started to pay their attention in establishing appliance standards as Europe and North America introduced. There is no single methodology to establish standards for electric motor as the methodology for electric motor efficiency standards is still in developing stage. This paper reviews the recently developed standard IEC 60034-30:2008 which is intended to harmonize efficiency classes throughout the world. It also includes the initiatives for standardization progress of the three-phase asynchronous motor efficiency levels in the main world regions, highlighting the Indian scenario for adopting the standard IEC 60034-30:2008.*

Keywords: *IEC Standard 60034-30:2008, MEPS, CEMEP, EPAct, Energy Efficient Motors, IS 12615.*

1. Introduction

In the context of the challenges faced by the energy sector, it is the responsibility of the governments to have information, incentives and regulation. This is translated in national and international agreements, incentives, initiatives, directives and publications [1-6]. Concerning induction motors, there are many examples of initiatives by organizations or governments. The majority of such programmes focus on induction motor efficiency and attempt to increase the significance of Induction motors with high-efficiency in the market. These market transformation programmes (MTPs) are mostly based on voluntary or mandatory minimum efficiency performance standards (MEPS), agreements or motor labeling programmes. Motor market data and experience with such projects show that this method effectively uplifts the overall efficiency values of the motor [7].

On a global scale, the main problem with MEPS is that they are not harmonized. There is a real proliferation of various minimum efficiency measures of which the differences range from efficiency levels and referred motor standards to ways of implementation and even nomenclature.

In the past years the world-wide development of energy efficient motors has led to a variety of country-specific regulations, laws and standards. For example, Green Motor Programme is being followed in Korea and High Efficiency Motor Program is implemented in Thailand. In fact, Brazil, Canada, China, Mexico, New Zealand, USA and Australia have already installed mandatory Minimum Efficiency Performance Standards. In Europe there are different ongoing programmes on a voluntary basis. For instance, the European committee of Manufacturers of Electrical Machines and Power Electronics (CEMEP) agreement and the European Motor Challenge Programme are in practice. Additionally, the various national and international standards to determine the efficiency of electric motors require revision as they are used in the different MEPS. The following are the some of the standards / regulations which are currently available to define the electric motor efficiency. (NEMA & EPAct in USA, NRCan, CEMEP, COPANT, AS/NZS, IEC 60034-2, IEEE 112, CSA 390 etc)[8, 9, 10], and some others are in preparation. They offer different methods to determine the performance of electric motors; subsequently, their results differ. Several international publications reveal that the declared efficiency values can differ by several percentages [11-15]. This causes an obstacle for free trade for purchasers, as it is very difficult to compare these characteristics. To design the motors for global market is a challenging task for the manufacturers and for the users. The motor efficiency testing standards differ primarily in their treatment of stray load losses [16-22]. The Canadian Standards Association (CSA) methodology and IEEE 112 - Test Method B determine the stray load loss through an indirect process[23]. The IEC standard assumes stray load losses to be fixed at 0.5 percent of input, while the JEC standard assumes there are no stray load losses. 64% of the imported motors follow the International Electrotechnical Commission protocols (IEC 34-2), 16% follow the National Electrical Manufacturers Association (NEMA) protocols which conform to Institute of Electrical and Electronic

Engineers protocols (IEEE 112), 8% follow the Japan Industrial Standards (JEC-37) and 12% follow other protocols (the percentage values are given on a dollar value basis)[24].

It is difficult to understand the similarities and differences between standards being followed in different countries. So, there is a need for the harmonization and simplification of various efficiency test procedures and also their tolerances.

The paper is organized into the following sections; Section II describes the introductory part of the Standard IEC 60034-30:2008, Standard IEEE 112, Standard JEC 37 and their comparison. Section III describes the Standards Scenario for Energy Efficient Motors in India and Barriers need to be addressed for Implementing Premium Efficiencies in India. Section IV presents a brief study about the Problems to be addressed in IEC 60034-30 by the authorities concerned and Section IV dealing with concluding remarks.

2. Standard IEC 60034-30:2008

In Europe, a new efficiency standard and directives applicable for three-phase cage induction motors were introduced. It will clarify the complicated situation for all those involved in this present market. The principle to be adopted is clearly defined in the Standard IEC 60034-30 [25] which bring global harmonization to electric motor energy efficiency classes all over the world.

The Commission's regulation 640/2009 for application of the Energy related Product (ErP) was published in July 2009. It depends on standard IEC 60034-30:2008 and according to EU directive, No.640/2009, 22 July, defines the three International Efficiency classes for single-speed, three-phase, cage induction motors whose future use is inevitable. It specifies the necessary levels of efficiency should be attained for machines to be sold in the European market and gives the time limits for their implementation. The new MEPS will supersede the existing voluntary 1999 CEMEP efficiency standards (EFF1 meant for High efficiency motors, EFF2 meant for Improved Efficiency or Medium efficiency motors, and EFF3 meant for Low efficiency motors or Standard Efficiency motors). This new standard uses a new labeling approach based on the letters IE followed by a number ranging from one to three or four. The lower the number, the lower is the efficiency level, with the possibility of upgrading without changing the labeling system. IE1 corresponds to the current EFF2 level, IE2 to "Energy Efficiency" in EPAct'92 which is followed in USA and is applicable from June 2011 and IE3 could be compared with the current NEMA Premium level which can be applicable from January 2015 or 2017 based on the power ratings. The potential IE4 MEPS level is a Super Premium level which is currently in preparation.

Under the EuP Directive, the existing 'EFF' scheme will be replaced by IE system and it will be implemented in specific time limits. From June 2011 it is necessary that all the motors placed on the market should fall within the scope of IEC60034-30 or to be at least IE2 level. From January 2015, IE3 or IE2 level is necessary for the motors rated from 7.5 to 375kW and it should have a variable-speed drive. From 2017, this requirement will be made compulsory for the motors in the range 0.75 to 7.5kW.

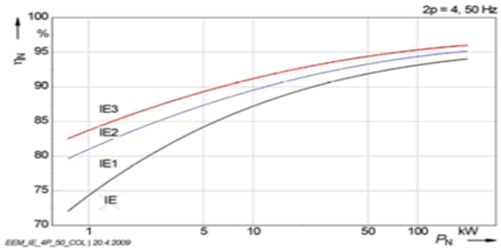
The motors manufactured by the companies within the EU borders before 16th June 2011are allowed for trading and installing even though they are not fulfilling the requirements of IE2. The standards for marking the motors are also defined in the directive. The name plate should clearly clarify the efficiency and the efficiency class. The new demands for controlling the efficiency of the motors are also introduced in the directive. The random control for the motors introduced in the market will be conducted by EU members on a continuous basis. Fig. 1 shows the comparison of the three efficiency classes for the most important motor group (Four poles, 50 Hz).Therefore the scales are relatively coarse.

Below the standard efficiency (EFF3) no IE marking will be given. The exact values necessary for the classification of the motor efficiencies are given in tables 2, 6 and 7. The standard has the scope of covering majority of industrial motors and so it includes geared motors, motors, and brake motors rated up to 1000V, with 2, 4 or 6 poles and capable of operating direct online and are also operated for continuous duty or operation on an 80 % duty cycle or higher. The

Fig. 1. Comparison of the three efficiency classes for four pole 50 Hz motors with Rated power in the range of 0. 75 kW - 200 kW.

Motors manufactured solely for converter operation (which are covered by Technical Specification IEC TS 60034-25:2007 Rotating electrical machines - Part 25: Guidance for the design and performance of AC motors specifically designed for converter supply) and motors which are integrated within machinery such that they cannot be isolated and tested are excluded specifically from the scope [26 – 30].

The Table 1 below shows the EU MEPS and IEC efficiency classes, with the CEMEP and EPAct classes for rough comparison. EU MEPS efficiency classes are based on IEC 60034-30: 2008. Note that the scope of



IEC 60034-30: 2008 is wider than that of EU MEPS. The IEC standard covers hazardous area and brake motors, for example, which are excluded from EU MEPS. The test methods given in IEC 60034-2-1: 2007 is the basis for the efficiency levels defined in IEC 60034-30 with low priority for IE2 and IE3. Since November 2007 this part has been valid and from November 2010, the previous IEC 60034-2 part of the standard is replaced by this. The methods with IEC 60034-2-1:2007 determine efficiency values more accurately than the methods previously used. With the new measuring technique IEC 60034-2-1, the stray load losses are no longer assumed to be a lump sum value of 0.5 %; instead, they are determined by making measurements. ie) The actual additional losses are now measured and are no longer added as lump sum.

The comparison between the nominal IEC-values for 50 Hz, 4-pole motors for IE1 and IE2 are based on the known CEMEP-EC-values EFF2 and EFF1 are shown in Table.2. To compensate for the additional losses in the measurement method, the values have been slightly modified. This means that the nominal efficiencies decrease from EFF1 to IE2 or EFF2 to IE1 respectively, although there are no changes at the motor - neither technically nor physically. This is shown in Table 2. The resulting efficiency values differ from those obtained under the previous IEC testing standard, IEC 60034-2: 1996, which generally gave higher overall efficiency values as the estimated additional losses were too low. As an example the efficiencies for three IE2 motors according to the new as well as the old measuring techniques are listed in the following Table 4. Note that the efficiency values can only be compared if they are based on the same testing method. The test results obtained from the standard IEC 60034-30 are largely compatible with those obtained by IEEE 112 B or CSA C390. Table 5 shows that the comparison between various important factors in the new standard IEC 60034-30 and the existing CEMEP classifications.

3. Standard IEEE 112

IEEE 112-method B standard is the most important in the industrial field because it is applicable to horizontal-axis polyphase squirrel-cage induction motors with power in the range 1–190 kW. This standard is commonly used in North America. Method B requires three tests [31]. They are as follows.

• Thermal test at the rated load—The machine works at the rated load until the main motor temperatures (stator winding, stator lamination core, and external frame), measured each 30 min, do not change less than 1 C. At the end of this test, the stator winding resistance has to be measured.

• No-load test—The motor, supplied with the rated voltage and frequency, runs without mechanical load until the bearings are stabilized (between two consecutive measures spaced out of 30 min, the input power not increases over 3%), then a variable voltage test is performed.

• Variable-load test at rated conditions—With the motor in steady-state thermal condition at rated load, the motor is loaded with six decreasing load torques (from 150% down to 25% of the rated torque). The winding temperature has to change not more than 10 C with reference to the rated one.

Using these tests it is possible to determine all the motor loss contributions and to calculate the motor efficiency. Conventional iron losses and mechanical losses are evaluated by the no-load test. Through the load test the stator and rotor Joule losses are evaluated, whereas the stray-load losses are calculated by the variable-load test data and the other losses previously determined. These standards require that the electrical quantities be measured with accuracy better than 0.2%, and with a 0.5% voltage stability and a 0.1% frequency tolerance. The absolute maximum speed error is 1 r/min. It is important to remember that the IEEE 112 standard reports other methods. These methods are applicable to particular sizes or types of motors (for example, Method A regards motors with a rated power less than 1 kW) or they prescribe tests and procedures different than the analyzed ones.

For comparing IEC 60034 with IEEE 112 B, three error sources are considered: instrumental, methodological, and testing procedures and human factors. These in combination determine the overall accuracy of power losses and efficiency of the induction motor under test. On testing six induction motors rated at 5.5, 11, 45, 90, 132, and 150 kW following the standard input–output methods defined in IEEE 112-B and 60034. In Table 3 these motors are named from A- F. From this table , it is understood that the effectiveness of the new IEC standard 60034, which can offer similar efficiency values to the IEEE counterpart. It can also be said that IEC 60034 has well aligned with IEEE 112. However, the two standards present some distinctions in determining stator conductor loss, core loss, and stray-load loss. Compared to IEEE 112, the IEC standard can provide more accurate but lower core loss values, and thus, higher stray-load loss values. Clearly, the rated efficiency values for the two standards are approximately the same since the overall power losses by the standard methods are still similar [32- 36]. Table 3 shows the comparison of losses and efficiency by IEEE112 B and IEC 60034 standards [37].

In Japan, Poly phase electric motors accounted for about 40% of total AC electric motors produced in Japan throughout the 2000s except in 2009 and 2010. The production of poly phase electric motors dropped from 44.3% in 2008, to 23.3% in 2009, and to 26.5% in 2010 (Ministry of Economy, Trade and Industry (METI). More than 98% of poly phase motor production was for motors of less than50hp. Although production share of polyphase electric motors is less than 45% of total AC electric motors, the electric power capacity of polyphase motors comprises more than 80% of total AC electric motors (Ministry of Economy, Trade and Industry (METI)). In general, motors of 50hp or less comprises approximately 50% of total poly phase electric motors. Poly phase electric motors are the largest users of electricity across the residential, commercial, transportation, and industrial sectors. In2008, total in-service poly phase electric motors consumed approximately 543 TWh accounting for about 55% of the nation's total power consumption. In the industrial sector, poly phase motor-driven equipment consumed about 360TWh accounting for about 75% of the total electricity used by industry. The international energy efficiency standard IEC 60034-30 was formally integrated into JISC4034-30 and the testing standard IEC60034-2-1 into JISC4034-2-1 in early 2011 (Japan Standards Association (JSA), 2011). The JISC4034-30 is a voluntary industry standard for poly phase motors. According to the Japan Electrical Manufacturers' Association (JEMA), production of JIS-qualified poly phase electric motors accounted for approximately 24% of the total, where as the majority was manufactured to meet the specifications for OEMs and end- users.

4. Standard JEC37

This standard is less restrictive of the USA and European ones. The efficiency evaluation through the Japanese standard can be considered as an indirect method. JEC 37 neglects the stray-load losses[38]. For this reason, the obtained efficiencies are generally higher. Furthermore, no thermal correction of the joule losses is specified. Because it is very difficult to find the measurement procedures prescribed by the Japanese standard, it is reasonable to evaluate the machine efficiency using the results of the tests required by the other standards. For all the motors, the JEC 37 standard overestimates the efficiency, in particular, for loads greater than the rated one. Fig. 2 shows the motor efficiency determined by JEC 37, IEC 37, IEEE 112 B standards for 5,10,20,75 Hp motors.

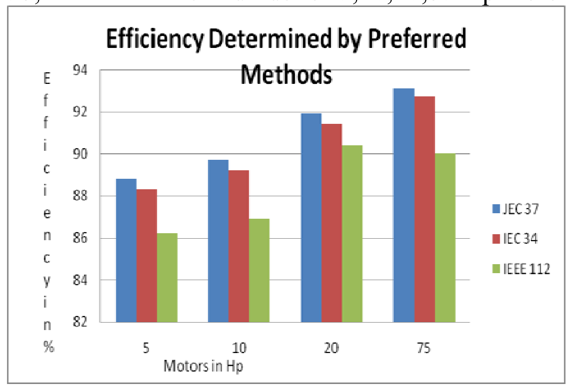


Fig. 2 Efficiency Determined by Preferred Methods

A. *Introduction to Super Premium Class IE4*

This technology is in the developing stage and the draft of the standard IEC 60034- 30 handles this. It can be available in the application guide IEC 60034-31. For information, the intended values for Super-Premium efficiency IE4 have 15% less losses when compared to that of IE3. The class IE4 is applicable for all types of electrical machines and exclusively for cage rotor or PMSM with inverter supply. In Fig. 3, we can depict that IE4 identifies the efficiency of motor approximately from 88% to 97% where as IE3 has 84% to 96% in the same output power scope. One aspect needed to point out here that is the power electronics (frequency converters) are necessary to these advanced motors for IE4. These motors are typically rated for their speed range and classified on the basis of torque rather than power, as described in IEC 60034-30 Ed. 1.0 draft. This is because the speed is not directly related to grid frequency/ number of poles. The total efficiency is calculated including inverter losses and the process advantages of speed regulation. Therefore, a direct comparison of the motor relevant classes IE4 and IE3 is not effective [39, 40].

According to IEC 60034-30 (2008), Table 6 and Table 7 shows the threshold levels of the motor efficiency classes for two-, four- and six-pole motors between the ratings 0.75 kW and 355 kW for 50 Hz and 60 Hz respectively. The IEC60034-30 only defines the requirements for the efficiency classes and aims to create a basis for International consistency. It does not specify which motors must be supplied with which efficiency level. This is left to the respective regional legislation and European Directive. Each country will be advised to adopt the minimum efficiency levels compatible with EU Directive as a way to assure availability of the most efficient motors for users. Table 8 shows the detailed survey about the various standards followed globally.

5. Standards Scenario for Energy Efficient Motors in India

The standards body in India, Bureau of Indian Standards, first introduced an exclusive standard for energy efficiency motors in 1989 (IS 12615) which covered 4 pole motors up to 37 kW. Later, the same was revised in 2004 with a proactive approach from the motor manufacturers. This revision covered the based on this standard IS12615: 2004 [41].

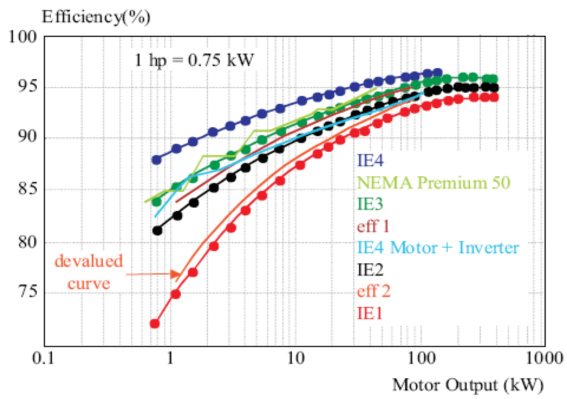


Fig. 3 Comparison of different efficiency levels by CEMEP

Table 1. Comparison between the Standard IEC 60034-30 and With Existing Standards

Description of the Efficiency Class in IEC 60034-30		**Comparison WithCEMEP Classification at 50 HZ**		**EU MEPS**	**US EPAct at 60 Hz**	**Local regulations**
Efficiency Clas	Notation	Efficiency	Logo	Efficiency	Efficiency	-
Super Premiur Efficiency	IE4	-	-	-		-
Premium Efficiency	IE3	Extrapolated IE with 10 to 15% lower losses	-	IE3: Premium efficiency Class	Identical to NEMA Premium Efficiency Clas	-
High Efficienc	IE2	High Efficiency	EFF 1	IE2: High efficienc Class	Identical to NEMA Energ Efficiency /EPACT Class	Canada Maxico Australia Newzealand Brazil 2000 China 2011 Switzerland 2012

Tandard Efficiency	IE1	Improved Efficiency	EFF 2	-	Below Standar Efficiency Clas	China Brazil Costa Rica Israel Taiwan Switzerland 2010
Below Standar Efficiency	No Designation	Normal Efficiency	EFF 3	-	Identical to NEMA Premium Efficiency Clas	-

Scope for all standard continuous duty motors up to 160 kW (2 pole and 4 pole), 132 kW (6 pole) and up to 110 kW (8 pole). Based on CEMEP, efficiency levels Eff2 (improved efficiency) and Eff1 (high efficiency) have been defined. Apart from the efficiency class this standard also specifies other performance parameters like breakaway torque, breakaway current, minimum speed, maximum full load current etc. for each of the rating. In other words this standard is a standard specifying performance specifications for energy efficient motors. The Bureau of Energy Efficiency launched its voluntary labeling plan in 2007. The labeling plan had a limited success since it awarded voluntary endorsement labels of Eff2 and Eff1 to the eligible applicants. The major motor manufacturers had realized efficiency as a differentiator from the other motor manufacturers and introduced motors with higher efficiency values than the Eff1 levels. Hence the endorsement label failed to encourage such manufacturers to adopt the labels. The introduction of new IEC standard 60034-30 for the efficiency classes for induction motors and subsequent adoption regulations based on the same by different countries, the Indian manufacturers, BIS, BEE and other stakeholders realized the threat of trade barriers for exports from India and potential influx of inefficient motors in to the Indian market.

A. Barriers need to be addressed for Implementing Premium Efficiencies in India

Standard making body, BIS and the regulatory body BEE have been working towards bringing the supply chain, the end users and other stakeholders together to harmonize Indian standards with IEC taking care of the Indian market needs and conditions. The effort of harmonization of motor standards globally and the regulations introduced in different countries has been a trigger to move in a positive direction. On publishing the new motor standard, BIS and BEE are planning to draw a realistic but firm time line to withdraw IE1 and IE2 efficiency levels progressively in next 3 to 5 years.

Table 2. Comparison between the Efficiency Classes of CEMEP and IEC 600034-30:2008 for 4- Pole Motors

Nominal Power at 50 Hz		**EFF.1 Class**	**IE2- High Efficiency**	**EFF.2 Class**	**IE1-Standard**
kW	**Hp**	-	79.6	-	72.1
0.75	1.0				
1.1	1.5	>83.8	81.4	≥76.2	75.0
1.5	2.0	>85.0	82.8	≥78.5	77.2
2.2	3.0	>86.4	84.3	≥81.0	79.7
3.0	4.0	>87.4	85.5	≥82.6	81.5
4.0	5.5	>88.3	86.6	≥84.2	83.1

5.5	7.5	>89.2	87.7	≥85.7	84.7
7.5	10.0	>90.1	88.7	≥87.0	86.0
11.0	15.0	>91.0	89.8	≥88.4	87.6
15.0	20.0	>91.8	90.6	≥89.4	88.7
18.5	25.0	>92.2	91.2	≥90.0	89.3
22.0	30.0	>92.6	91.6	≥90.5	89.9
30.0	40.0	>93.2	92.3	≥91.4	90.7
37.0	50.0	>93.6	92.7	≥92.0	91.2
45.0	60.0	>93.9	93.1	≥92.5	91.7
55.0	75.0	>94.2	93.5	≥93.0	92.1
75.0	100.0	>94.7	94.0	≥93.6	92.7
90.0	120.0	>95.0	94.2	≥93.9	93.0
110.0	150.0	-	94.5	-	93.3
132.0	180.0	-	94.7	-	93.5
160.0	220.0	-	94.9	-	93.8
200.0 ….	270.0 …. 483.0	-	95.1	-	94.0

Table 3. Losses and Efficiency by IEEE112 B and IEC 60034 standards

Motor	**Std**	**Stator I^2R**	**Rotor I^2R**	**Core loss**	**F&W**	**Stray Loss**	**Efficiency**
A	IEEE	411.2W	212.9w	131.5w	22.5w	72.8w	86.7%
	IEC	409.4W	213.3W	120.4W	21.8W	80.2W	86.7%
B	IEEE	556.1W	238.5W	269.1W	35.3W	120.5W	90%
	IEC	557.7W	238.6W	265.2W	35.9W	135.5W	89.9%
C	IEEE	801.8W	697W	730.9W	386.4W	363.1W	93.8%
	IEC	801.3W	696.8W	722.1W	387.6W	378W	93.8%
D	IEEE	1362.8W	829.2W	1645W	719.W	520.4W	94.6%
	IEC	1361.4W	829.3W	1633W	718.1W	539.9W	94.6%
E	IEEE	2357.6W	1704.8W	1925.3W	3434W	475.1W	93%
	IEC	2359.7W	1705.2W	1891.6W	3431W	511.4W	93%
F	IEEE	1981.1W	1017.6W	2118.2W	772.9W	1112W	95.6%
	IEC	1983.9W	1017.3W	2075.1W	772.1W	1149W	95.5%

Table 4. Comparison of Efficiencies for Three IE2 Motors Based On Various Efficiency Measuring Methods

Motor Rating/Number of Poles	**Previous efficiency measuring method based on IEC 60034-2: 1996 @ 50 Hz (Including Lump Sum Losses)**	**New method to determine losses based on IEC 60034-2-1:2007 @ 50 Hz**	**New method to determine losses based on IEC 60034-2-1:2007 @ 60 Hz**
5.5 kW / 4-pole	89.20%	88.20%	89.50%
45 kW / 4-pole	93.90%	93.10%	93.60%
110 kW / 4-pole	95.90% (Not defined according to CEMEP voluntary agreement, EU)	94.50%	95.00%

Table 5. Comparison between Various Important Factors in the Standard IEC 60034-30 And The Existing CEMEP Classifications

Parameters	**CEMEP Voluntary Agreement (EU)**	**EU Regulation No 640/2009 Passed 07/2009 based upon standard IEC 60034-30**
Description	Voluntary agreement between the EU Commission and the European Manufacturers Association CEMEP	The EU regulation does apply to all EU Countries. IEC 60034-2-1:2007 is the basis for determining the losses and therefore the efficiency.
Number of poles available	2,4	2,4,6
Power range (kW)	1.1- 90	0.75- 37.5
Efficiency Class	EFF3- Standard Efficiency Class EFF2-Improved Efficiency Class EFF1-High Efficiency Class	IE1- Standard Efficiency Class IE2-Improved Efficiency Class IE3-Premium Efficiency Class
Voltage Rating	400 V, 50 Hz only	< 1000 V, 50 Hz /60 Hz
Degree of Protection	IP5X type.	All types.
Motors with Brake	Not available.	Not available.
Geared Motors	Not available.	Included.
Ex motors	Not available	EU regulation-No
Validity	Voluntary agreement is withdrawn with the implementation of domestic legislation.	Standard IEC 60034-30, Valid since October 2008; EU regulation is becoming effective on 6.06.2011.The manufacturers may no longer market IE1 (Standard Efficiency Class) motors in the European market.

Few of the barriers need to be addressed for smooth implementation of these policies.

- Capacity Building of small and medium scale motor manufacturers
- Adequate test facility establishment as per prescribed testing standards
- Awareness creation among the end users regarding life cycle cost
- Establishment of incentive mechanisms for adopting high and premium efficiency motors and penalties in case of deviations
- Technical issues by way of effects on the other performance parameters due to premium efficiency designs
- Integrate motor Driven Systems in to the process so that the original

Equipment Manufacturers also appreciate benefits of premium efficiencies. In India, the comparative star labeling of pump sets is the best example in this direction. The global harmonization of motor efficiency standards has triggered similar activities in India resulting in to revision of its current standard for energy efficient motors IS 12615 in order to harmonize with the IEC standards. BIS and the BEE have been working with all the stakeholders to implement this standard by addressing the barriers and planning a way forward to move towards premium efficiencies in next 3 to 5 years and compete in the global market.

6. Problems to be addressed in IEC 60034-30

The legislation is not effective in ATEX motors. They are excluded in the legislation. These motors should also be included as they account for some 10%

of the total installed based and are continuously used in processes of chemical, oil and gas. And also more amount of energy is consumed by these motors as they have to work for the entire day and throughout the year. Therefore even for 10%of the installed based, they require more than 10% of energy consumption. Furthermore, 375 kW motors are not included in the legislation. Even though, the motors are greater than 355 kW, they have only 0.3 per cent of the installed base; the total energy bill has considerable part by them as they account for more than 29% of the total energy bill. The reason for omitting the powers above 375kW is not indicated Table 6. Threshold Values Of The Motor Efficiency Classes Based On IEC 60034-30 (2008) For 50Hz Motors.

Table 6. Threshold Values of the Motor Efficiency Classes Based on IEC 60034-30 (2008) For 50Hz Motors

kW Motor Rating (kW/Hp)	**IE1 – Standard Efficiency Class**			**IE2 – High Efficiency Class**			**IE3 – Premium Efficiency Class**		
	2-pole	**4-pole**	**6-pole**	**2-pole**	**4-pole**	**6-pole**	**2-pole**	**4-pole**	**6-pole**
0.75 /1	72.1	72.1	70.0	77.4	79.6	75.9	80.7	82.5	78.9
1.1 /1.5	75.0	75.0	72.9	79.6	81.4	78.1	82.7	84.1	81.0
1.5 /2	77.2	77.2	75.2	81.3	82.8	79.8	84.2	85.3	82.5
2.2 /3	79.7	79.7	77.7	83.2	84.3	81.8	85.9	86.7	84.3
3 /4	81.5	81.5	79.7	84.6	85.5	83.3	87.1	87.7	85.6
4 /5.5	83.1	83.1	81.4	85.8	86.6	84.6	88.1	88.6	86.8
5.5 /7.5	84.7	84.7	83.1	87.0	87.7	86.0	89.2	89.6	88.0
7.5 /10	86.0	86.0	84.7	88.1	88.7	87.2	90.1	90.4	89.1
11/15	87.6	87.6	86.4	89.4	89.8	88.7	91.2	91.4	90.3
15/20	88.7	88.7	87.7	90.3	90.6	89.7	91.9	92.1	91.2
18.5 /25	89.3	89.3	88.6	90.9	91.2	90.4	92.4	92.6	91.7
22/30	89.9	89.9	89.2	91.3	91.6	90.9	92.7	93.0	92.2
30/40	90.7	90.7	90.2	92.0	92.3	91.7	93.3	93.6	92.9
37 /50	91.2	91.2	90.8	92.5	92.7	92.2	93.7	93.9	93.3
45 /60	91.7	91.7	91.4	92.9	93.1	92.7	94.0	94.2	93.7
55 /75	92.1	92.1	91.9	93.2	93.5	93.1	94.3	94.6	94.1
75/100	92.7	92.7	92.6	93.8	94.0	93.7	94.7	95.0	94.6
90 /120	93.0	93.0	92.9	94.1	94.2	94.0	95.0	95.2	94.9
110 /150	93.3	93.3	93.3	94.3	94.5	94.3	95.2	95.4	95.1
132 /180	93.5	93.5	93.5	94.6	94.7	94.6	95.4	95.6	95.4
160 /220	93.8	93.8	93.8	94.8	94.9	94.8	95.6	95.8	95.6
200 /270	94.0	94.0	94.0	95.0	95.1	95.0	95.8	96.0	95.8
220	94.0	94.0	94.0	95.0	95.1	95.0	95.8	96.0	95.8
250 /335	94.0	94.0	94.0	95.0	95.1	95.0	95.8	96.0	95.8
315/423	94.0	94.0	94.0	95.0	95.1	95.0	95.8	96.0	95.8
355/483	94.0	94.0	94.0	95.0	95.1	95.0	95.8	96.0	95.8

Table 7. Threshold values of the Motor Efficiency Classes Based on IEC 60034-30 (2008) for 60Hz Motors

Motor Rating (kW/Hp)	**IE1 – Standard Efficiency Class**			**IE2 – High Efficiency Class**			**IE3 – Premium Efficiency Class**		
	2-pole	**4-pole**	**6-pole**	**2-pole**	**4-pole**	**6-pole**	**2-pole**	**4-pole**	**6-pole**
1 /0.75	77.0	78.0	73.0	75.5	82.5	80.0	77.0	85.5	82.5
1.5/1.1	78.5	79.0	75.0	82.5	84.0	85.5	84.0	86.5	87.5
2 /1.5	81.0	81.5	77.0	84.0	84.0	86.5	85.5	86.5	88.5
3 /2.2	81.5	83.0	78.5	85.5	87.5	87.5	86.5	89.5	89.5

5 /3.7	84.5	85.0	83.5	87.5	87.5	87.5	88.5	89.5	89.5
7.5/5.5	86.0	87.0	85.0	88.5	89.5	89.5	89.5	91.7	91.0
10/7.5	87.5	87.5	86.0	89.5	89.5	89.5	90.2	91.7	91.0
15 /11	87.5	88.5	89.0	90.2	91.0	90.2	91.0	92.4	91.7
20 /15	88.5	89.5	89.5	90.2	91.0	90.2	91.0	93.0	91.7
2518.5	89.5	90.5	90.2	91.0	92.4	91.7	91.7	93.6	93.0
30 /22	89.5	91.0	91.0	91.0	92.4	91.7	91.7	93.6	93.0
40/30	90.2	91.7	91.7	91.7	93.0	93.0	92.4	94.1	94.1
50/37	91.5	92.4	91.7	92.4	93.0	93.0	93.0	94.5	94.1
60 /45	91.7	93.0	91.7	93.0	93.6	93.6	93.6	95.0	94.5
75/55	92.4	93.0	92.1	93.0	94.1	93.6	93.6	95.4	94.5
100 /75	93.0	93.2	93.0	93.6	94.5	94.1	94.1	95.4	95.0
125 /90	93.0	93.2	93.0	94.5	94.5	94.1	95.0	95.4	95.0
150 /110	93.0	93.5	94.1	94.5	95.0	95.0	95.0	95.8	95.8
200 /150	94.1	94.5	94.1	95.0	95.0	95.0	95.4	96.2	95.8
250/185	94.1	94.5	94.1	95.4	95.4	95.0	95.8	96.2	95.8
300 /220	94.1	94.5	94.1	95.4	95.4	95.0	95.8	96.2	95.8
350/250	94.1	94.5	94.1	95.4	95.4	95.0	95.8	96.2	95.8

It is clear that the efficiency of larger motors is higher than that of smaller motors, but a detailed benchmark is needed for a customer to understand that they are buying high efficiency and high power motor. Theoretically, the unscrupulous manufacturers are able to claim any motors rated greater than 375Kw is having high efficiency without any minimum efficiency standard. Clearly large motors are inherently more efficient than smaller motors but without a detailed benchmark then how does a customer actually know that they are buying a high efficiency, higher power motor? In theory, the door is open for claiming any motor rated greater than 375 kW is high efficiency without needing to meet any minimum efficiency standards. The lifecycle of majority of the installed motors is 10 to 30 years. Therefore it is not possible to ensure that the installed base satisfies to IE2/IE3 within a sufficient period of time. The ATEX directive has a window in which the end-users have to ensure that all their installed motors should meet the legislation. Instead the proposed efficiency legislation does not have such window. So the motors that have been put into operations before the legislation taking effort, there is no need for them to meet the minimum efficiency standards.

The end-users do not have any problem until the motor fails. If the motor fails, then they have the choice of rewind or replace. When the motor is sent for rewind, then the trouble shooter cannot ensure that the rewind will meet the latest minimum efficiency standards. Even if they are compelled for that the increased active material need to attain the higher levels of efficiency stipulated for IE2 and IE3 are unable to accommodate in these motors as their physical size is too small for that. So if the guidelines ensure the rewind then it will enable the market harmonized to the new efficiency levels and there by extending the ultimate aim of reduction in CO_2 emission. The above points are not addressed in the standard. Hence it should be addressed.

Table 8. Detailed Survey about the various Standards Followed Globally.

Name of the country	Voltage Rating/ Frequency Range	Power rating	Number of poles	Existing Directive Law/ Regulation	As per Law, minimum efficiency ensured	Future scope
Europe	400 Volts, ±10%, 50 Hz and/or 60 Hz	(0.75kW-375 kW)	2-pole, 4-pole and 6-pole	Directive 2005/32/ EC	IE2 is Essential from 16.6.201 onwards	From June 16, 2011, motors shall not be less efficient than the IE2. From January 1, 2015 motors with a rated output of 7.5-375 kW shall not be less efficient than the IE3 or meet the IE2 efficiency and be equipped with a Variable speed drive. From January 1, 2017 all motors with a rated output of 0.75-375kW shall not be less efficient than the IE3 or meet the IE2 and be equipped with a variable speed drive.
USA	480 V, ±10%,60 Hz	(1 HP- 200 HP)	2,4and 6 poles	NEMA EPAct Energy Independence and Security Act (EISA) 2007	IE3,IE2 is Essential from 19.12.2010 for General purpose, subtype I and General purpose, subtype II motors respectively	From10.12.2010: NEMA EPAct- IE2 level. From 1.1.2011: EISA- IE3 level.
Canada	480 V/575 V, ±10%, 50 or 60 Hz	(1 HP- 200 HP)	2,4,6 and 8-poles	CSA C390(CSA 2009)	IE3 is Essential from 1.1.2011 onwards.	Efficiency legislation will follow the US model
India	415V/690V, ±10%,50 Hz	(0.37 kW-315 kW)	2,4,6 and 8-poles	IS:4889/IS: 12615-2004	IE2 is Expected from 2013	Efficiency levels IE1/IE2-based regulations

						assumed by 2013.
Switzerl -and	400 V, ±10%, 50 Hz and/or 6 Hz	(0.75 kW-375 kW)	2-pole, 4-pole and 6-pole	Energy ordinance (EnV)	IE2 is Essential from 1.7.2011	From 2015& 2017, The minimum efficiency levels are expected to be increased to IE3, although this has not yet been finally confirmed.
China	380V, ±10%, 50 Hz	(0.55 kW-315 kW)	2-pole, 4-pole and 6-pole	GB 18613-2006	IE2 is Essential from 1.7.2011 onwards	Scope of motor output will be changed from (0.5 kW-315) kW to (0.75 kW-375 kW in near future.

7. Conclusion

This paper discusses the review and compares the new standard IEC 60034: 2008 with existing standards. In order to harmonize with the International Electro technical Commission (IEC) standards, the current standard for energy efficient motors IS 12615 in India is taken in to revision is also reported. At present there are various standards of efficiency for asynchronous motors in the various regions and countries throughout the world. There are also great differences, whether these are standards. In addition to the various standards and laws for efficiency classes, a wide range of different test methods are available for determining the efficiency.

Therefore, an International comparison of individual efficiency classes is not only difficult; the certification of motors for individual markets is also very expensive. Under these circumstances, a recent standard IEC 60034-30:2008 has been developed by the International Electro technical Commission. This standard is intended to harmonize efficiency classes throughout the world, and making the comparison easier. The other advantage is that an excellent opportunity for reducing the consumption of energy and CO_2 emissions of the asynchronous motors. The proficient work to harmonize standards of asynchronous motor continues.

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