

# How the efficiency of induction motor is measured?

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## 1. Introduction

The efficiency is of paramount importance nowadays due to increasing electrical energy demand, increasing awareness of environmental problems as greenhouse effects and increasing fossil fuel prices. Moreover electrical motors are major consumers of electricity in the modern industrial society; they consume approximately 69% of electricity in the industrial.

To begin this study, it is going definition the energy efficiency and energy losses. Although efficiency is a simple concept, measuring and comparing motor efficiency with the different standards can be challenging. So, the main differences between these standards (IEEE 112 in United States, IEC 60034-2 in Europe and JEC-37 in Japan) are going to be discussed and illustrated with some numerical examples.

But this disagreement would be eliminated. As an example in Europe, there is an initiative called SEEEM (Standards for Energy Efficiency of Electric Motors Systems), to stimulate this process of harmonization in order to save energy.

To finish this paper, it is going to describe the three steps to estimate the efficiency on the jobsite, and mentioned the identification of efficiency on the market by means of three classes introduced thanks to voluntary agreement between CEMEP (the European Committee of Manufacturers of Electrical Machines and Power Electronics) and the European Commission.

## 2. Losses and Efficiency

### A. Definition of energy efficiency

Efficiency is the ratio of mechanical energy output divided by the electrical energy input. There are different efficiency definitions that describe the relationship between a motor's rating and efficiency test results, like tested, nominal, minimum, nameplate or apparent efficiency.

### B. Motor Losses

Energy losses are the determining factor in motor efficiency. These losses can be divided in five classes:

core losses, windage and friction, stator losses, rotor losses and additional load losses.

The main difference between the standards emerges from the way in which the additional load losses, is treated. The IEC 34.2 standard assumes a standard value for the additional load losses at rated load of 0.5% of the input power. The new proposed IEC 61972 standard gives two possibilities for the assessment of the additional losses. The first one is a determination by means of the measured output power, as in the IEEE 112-B; the second one gives a fixed amount to every machine of the same rated power. The Japanese JEC standard 37 completely neglects the additional load losses.

$$P_{addit} = (P_{in} - P_{out}) - (P_{Fe} + P_{stator} + P_{rotor} + P_{fr,w}) \quad (1)$$

## 3. Motor Efficiency Testing Standards

The next table shows test standards for medium size induction motors that are used in different parts of the world.

United States	Institute of Electric and Electronic Engineers	IEEE 112
United States	American National Standards Institute	C50.20 (based on IEEE 112)
United States	National Electrical Manufacturers Association	MG1-12.58.1 (based on IEEE 112)
Canada	Canadian Standards Association	C-390
International	International Electrotechnical Commission	IEC 34-2
Japan	Japanese Electrotechnical Committee	JEC-37
Great Britain	British Standards	BS-269

Table 3.1 – Motor Testing Standards [2].

### A. IEEE Standard 112

This standard includes a total of ten test methods for efficiency. Next, we'll quote the most important:

- Method A: Simple Input-Output.
- Method B: Input-Output with loss segregation (or separation).
- Method C: Back to back machine test with separation of losses.

- Method F: Equivalent circuit calculation.

### B. IEC Standard 60034-2

The IEC's test can be classified in three types:

- Input-Output Measurement Power of one machine.
- Input-Output Measurement Power in back-to-back machines.
- Measurement Real Losses of one machine.

In the next paragraph, it is going to be mentioned the different methods that are included in this standard:

- *Method of Tared Motor*
- *Method with Power Factor zero.*
- *Method of deceleration.*
- *Method back-to-back.*
- *Method calorimetric.*

### C. Comparative cases between Standards

The following graphic is supported in a study of University of Nottingham published by CEMEP 2005. Seven motors were tested with different standard methods (Standard IEEE 112-E, Standard IEEE 112-B, EN 60034-2, and IEC 61972). The tests were done different sizes of motors such as 11kW, 75kW and 110kW.

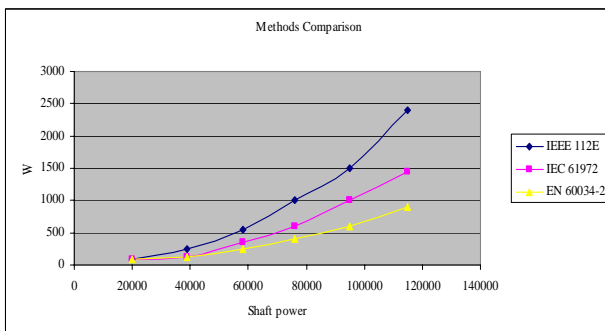


Figure 3.1 – University of Nottingham: Result of 1 of 5 motors of 75kW [5].

## 4. Estimation Efficiency on the Jobsite

Three steps are used to estimate efficiency and load. First, use power, amperage or slip measurements to identify the load imposed on the operating motor. Second, obtain a motor part-load efficiency value consistent with the approximated load. Finally, derive a revised load estimate using both the power measurement at the motor terminals and the part-load efficiency value.

## 5. Identification of Efficiency on the Market

A classification scheme was introduced that categorized motors into three efficiency classes depending on motor type, number of poles, and most importantly, size (see figure 5.1). There are three labels in order to classify the efficiency: Eff1, Eff2 and Eff3.



Figure 5.2 – Efficiency labels [3].

## 6. Conclusions

The analysis presented shows that it can be obtained different results depending on the standard used. It is necessary to eliminate the disagreements between the methods of the different standards because they make for serious consequences in order to certificate and to declare efficiency values.

This fact can be got through International Harmonization Initiative promoting by SEEEM. This process of harmonization deals the energy saving and the reduction greenhouse emissions.

To sum up, this study has tried to shed light of knowledge of different standards for efficiency measurement and to emphasize the necessity of harmonization worldwide.

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