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IEC Advisory Committee on energy efficiency (ACEE)

Case study: electric motors

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IEC Central Office
3, rue de Varembé
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
info@iec.ch
www.iec.ch

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CONTENTS

CASE STUDY: ELECTRIC MOTORS

This case study is provided to illustrate a practical example (in practice) on how IEC Guide 118 [1][1] concepts can be applied/found in electric motors standards and, more generally, on how International Standards can support the energy efficiency market and national energy efficiency policies.

1 Electric motors and energy efficiency

More than 50 % of all electricity worldwide is converted into mechanical energy by electric motors. Increasing the efficiency of these motors is probably by far the biggest and most affordable energy efficiency opportunity. The biggest user of motors is industry. Industry consumes 40 % of global electricity, of which the large majority drives electric motors in machines, pumps, fans, compressors, conveyer belts, and the like (source: IEA [2]).

Due to their energy saving potential, electric motors have been a key focus for several both mandatory and voluntary national energy efficiency policies, adopting minimum energy performance standards (MEPS) for the main class of industrial electric motors.

It is estimated that if all countries adopted best practice MEPS for industrial electric motors, by 2030 approximately 322 TWh of annual electricity demand would be saved, giving rise to corresponding savings of 206 Mt of CO_2 emissions.

If using the best available technology will typically save about 4 % to 5 % of all electric motor energy consumption, it is through the optimization of the complete system (motor, driven equipment, converter, control equipment and strategy) that much larger savings can be achieved (20 % to 30 % of all electric motor systems' energy consumption).

2 Standardization and energy efficiency: IEC approach

IEC has set up an Advisory Committee on Energy Efficiency (ACEE) to coordinate its activities in this domain.

ACEE has developed two Guides (IEC Guide 118 and IEC Guide 119) with the aim of defining the concept of Energy Efficiency Aspects (EEAs) to provide guidance to IEC Technical Committees (TCs) on how to approach energy efficiency standardization, promoting a systems approach and defining procedures for the preparation of such standards.

IEC Guide 118 proposes a general approach to energy efficiency standardization by defining the concept of EEAs as all those elements/services that a standard can provide to support a generic “energy efficiency improvement” process. Five categories of EEA that should be considered when developing a standard have been proposed:

– energy efficiency definition;
– energy efficiency measurement;
– energy efficiency assessment;
– energy efficiency improvement;
– energy efficiency enabling.

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[1] Numbers in square brackets refer to the Bibliography.

EEAs should ensure the development of a rational and effective standardization process in the energy efficiency domain as they provide a systematic approach to identify the relevant scope for standardization and might serve as a taxonomy to map existing standards to identify standardization gaps and areas where standards can support regulation and to streamline the activity of IEC TCs.

3 Electric motors and energy efficiency: boundaries

Boundary definition is key for defining the scope for energy efficiency.

To highlight the importance of boundary definition and to illustrate how standardization support (needs) may vary and how the same EEA may be implemented differently when boundaries change, this case study will consider three possible boundaries (see Figure 1):

– the motor (boundary 1, see Clause 4);
– the motor driven by a converter (boundary 2, see Clause 5);
– the motor (plus a converter) driving a pump (motor driven unit – boundary 3, see Clause 6).

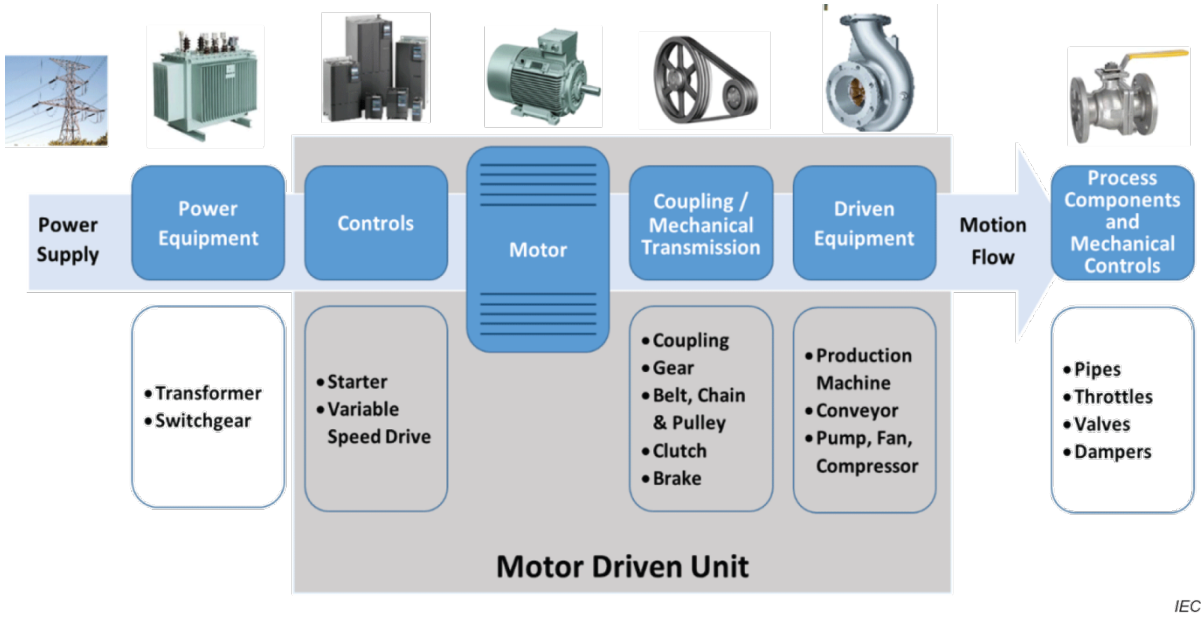

Figure 1 – Motor driven unit

4 Electric motors and energy efficiency: EEAs

4.1 General

The development of a set of International Standards, including a scheme for energy efficiency classification, has been highly effective in supporting national MEPS policies for electric motors and ultimately the transition to higher (electric) motor efficiency.

The key success factor was to prepare a coherent set of publications that covers the most important issues at stake. Table 1 provides a list of energy efficiency related motor IEC publications.

Table 1 – Current energy efficiency related IEC publications for electric motors

Reference	Title
IEC 60034-1:2017	Rotating electrical machines – Part 1: Rating and performance
IEC 60034-2-1:2014	Rotating electrical machines – Part 2-1: Standard methods for determining losses and efficiency from tests (excluding machines for traction vehicles)
IEC 60034-30-1:2014	Rotating electrical machines – Part 30-1: Efficiency classes of line operated AC motors (IE code)
IEC TS 60034-31:2010	Rotating electrical machines – Part 31: Selection of energy-efficient motors including variable speed applications – Application guide

This set of publications provides:

– a definition of the product scope, thus defining the boundaries for energy efficiency;
– a scheme for energy performance classification and tolerances;
– a method for measuring energy performance;
– guidelines for the selection and application of energy efficient motors, including variable-speed applications.

To say it in IEC Guide 118 words, this set of publications addresses the following EEA categories:

– energy efficiency definition, by defining the scope for energy efficiency and the energy efficiency key performance indicators;
– energy efficiency measurement, by defining the test methods for the energy efficiency key performance indicators;
– energy efficiency improvement, by providing technical guidelines for the application of energy efficient electric motors.

Table 2 provides examples of EEA inclusion in energy efficiency related motor IEC publications.

4.2 Define energy efficiency

When approaching energy efficiency improvement, a clear identification and definition of the boundary used for energy efficiency considerations is key.

IEC 60034-1, together with IEC 60034-30-1, provides a definition of electric motors involved in terms of type, rated power, voltage and number of poles, including the definition of their operating environment and modes of operation.

IEC 60034-30-1 contributes to the definition of the scope for electric motors energy efficiency by:

– defining the energy efficiency key performance indicator for electric motors, and
– providing an efficiency classification scheme with clear thresholds set between classes including maximum allowable tolerances.

These two standards establish a set of limit efficiency values based on frequency, number of poles and motor power:

– making different motor technologies fully comparable with respect to their energy efficiency potential;

– allowing harmonized national decisions on the classifications for energy labels and performance tiers for MEPS.

4.3 Measure energy efficiency

IEC 60034-2-1 establishes methods of determining efficiencies from tests and specifies methods of obtaining specific losses.

IEC 60034-2-1 sets the provisions for measuring the energy efficiency key performance indicator for electric motors (efficiency) with the appropriate accuracy and repeatability allowing for:

– minimum energy performance standards (MEPS) to be compared and assessed, and
– fair industry competition based on the energy efficiency of their products.

4.4 Improve energy efficiency

In addition to the standards mentioned in 4.2 and 4.3, IEC TC 2 has developed a Technical Specification (IEC TS 60034-31) to support selection and application of energy efficient electric motors, in both constant-speed and variable-speed applications, thus:

– supporting the dissemination of energy efficient technologies, and
– overcoming lack of trained personnel and technical or managerial expertise.

Table 2 – Energy efficiency aspect categories and examples of inclusion in energy efficiency related motor IEC publications

Energy efficiency aspect category	Energy efficiency aspect	Example of inclusion in publication
Define energy efficiency of a motor	Define system boundaries (including the scope for energy efficiency)	IEC 60034-1:2017, Rotating electrical machines – Part 1: Rating and performance
Define energy efficiency of a motor	Define EE KPIs (energy efficiency key performance indicators)	IEC 60034-30-1:2014, Rotating electrical machines – Part 30-1: Efficiency classes of line operated AC motors (IE code)
Measure energy efficiency of a motor	Define test methods	IEC 60034-2-1:2014, Rotating electrical machines – Part 2-1: Standard methods for determining losses and efficiency from tests (excluding machines for traction vehicles)
Improve energy efficiency of motor and converter	Application guidelines	IEC TS 60034-31:2010, Rotating electrical machines – Part 31: Selection of energy-efficient motors including variable speed applications – Application guide

5 The motor driven by a converter

The scope for energy efficiency now includes not only the electric motor but its controlling devices, e.g. a converter (boundary 2). The energy efficiency boundaries have changed, and additional standards are needed to address the EEAs considered in Clause 4.

Consequently, the converter and its testing and efficiency classification standards have to be taken into account and the interaction between converters and motors and their resulting combined efficiency and eventual energy savings while delivering an adequate service need also to be considered.

Table 3 lists energy efficiency related IEC publications dealing with converter driven motors, while Table 4 provides examples of EEA inclusion in energy efficiency related IEC publications for this specific boundary.

Table 3 – Current energy efficiency related IEC publications for converter driven motor

Reference	Title
IEC TS 60034-30-2:2016	Rotating electrical machines – Part 30-2: Efficiency classes of variable speed AC motors (IE-code)
IEC TS 60034-2-3:2013	Rotating electrical machines – Part 2-3: Specific test methods for determining losses and efficiency of converter-fed AC induction motors
IEC TS 60034-31:2010	Rotating electrical machines – Part 31: Selection of energy-efficient motors including variable speed applications – Application guide
IEC TS 60034-25:2014	Rotating electrical machines – Part 25: AC electrical machines used in power drive systems – Application guide

Table 4 – Energy efficiency aspect categories and examples of inclusion in energy efficiency related IEC publications for converter driven motors

Energy efficiency aspect category	Energy efficiency aspect	Example of inclusion in publication
Define energy efficiency of converter driven motor	Define EE KPIs (energy efficiency key performance indicators)	IEC TS 60034-30-2:2016, Rotating electrical machines – Part 30-2: Efficiency classes of variable speed AC motors (IE-code)
Measure energy efficiency of converter driven motor	Define test methods	IEC TS 60034-2-3:2013, Rotating electrical machines – Part 2-3: Specific test methods for determining losses and efficiency of converter-fed AC induction motors
Define energy efficiency and efficiency classification of converter and converter with motor	Define test method and energy efficiency key performance indicators for converters and motors driven by converters	IEC 61800-9-2:2017, Adjustable speed electrical power drive systems – Part 9-2: Ecodesign for power drive systems, motor starters, power electronics and their driven applications – Energy efficiency indicators for power drive systems and motor starters
Improve energy efficiency of motor and converter	Application guidelines	IEC TS 60034-31:2010, Rotating electrical machines – Part 31: Selection of energy-efficient motors including variable speed applications – Application guide

6 The motor driven unit

Widening the scope for energy efficiency further to include the entire motor drive unit, boundary 3 is now considered.

To deal with energy efficiency of such a system, the interaction between the motor (and its converter) and the driven equipment has to be taken into account. From a standardization point of view, this interaction requires an agreement and coordination between electric products standardized by IEC (motors and converters) and mechanical products standardized by ISO (pumps, fans, compressors, etc.).

Table 5 lists energy efficiency aspect categories and examples of their inclusion in energy efficiency related ISO publications on pumps, fans and compressors.

Table 5 – Energy efficiency aspect categories and examples of inclusion in energy efficiency related ISO publications on pumps, fans and compressors

Category	Pumps	Fans	Compressors
Definitions	-	ISO 13349:2015, Fans – Vocabulary and definitions of categories	ISO 5390:1977, Compressors – Classification ISO/TR 12942:2012, Compressors – Classification – Complementary information to ISO 5390
Testing	ISO 9906:2012, Rotodynamic pumps – Hydraulic performance acceptance tests – Grades 1, 2 and 3	ISO 5801:2017, Fans – Performance testing using standardized airways	ISO 1217:2009, Displacement compressors – Acceptance tests ISO 5389:2005, Turbocompressors – Performance test code
Efficiency calculation method	-	ISO 12759:2010, Fans – Efficiency classification for fans ISO 12759:2010/Amd.1:2013	ISO 1217:2009/Amd.1:2016 Calculation of isentropic efficiency and relationship with specific energy
Efficiency classification	-	-	-
Audit	ISO/ASME 14414:2015, Pump system energy assessment ISO/ASME 14414:2015/Amd.1:2016	-	ISO 11011:2013, Compressed air – Energy efficiency – Assessment
SOURCE: EMSA PG MDU 2017			

Bibliography

[1] IEC Guide 118:2017, *Inclusion of energy efficiency aspects in electrotechnical publications*

[2] IEA, *Energy Efficient End-use Equipment, Electric Motor Systems Annex: Policy Guidelines for motor driven units, part 2: recommendations for aligning standards and regulations for pumps, fans and compressors*, 2017

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INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

3, rue de Varembé
PO Box 131
CH-1211 Geneva 20
Switzerland

Tel: + 41 22 919 02 11
Fax: + 41 22 919 03 00
info@iec.ch
www.iec.ch