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Pakistan
Minimum Energy Performance Standard (MEPS)
For 0.37kW – 7.5 kW (Single & Three Phase) 50Hz; AC Induction Motors

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FOREWORD

In order to reduce energy consumption and achieve energy conservation through the use of energy efficient appliances, there is a need to promote a new culture of energy efficient products, by taking appropriate measures through development of polices and promulgation of laws, rules/ regulations and standards.

To cope with the above mentioned requirement, a document describing the limiting values of energy efficiency and rating criteria for single and three phase line operated AC induction motors ranging from 0.37 kW to 7.5 kW (0.5 HP – 10.0 HP) widely being used for domestic applications/services, has been developed. This document lays down Minimum Energy Performance Standard (MEPS) to be followed/ met by the local manufacturers and importers of electric AC motors to get their product qualified through testing as "Energy Efficient Product".

This activity will help reduce the level of energy consumption in the country and facilitate transforming the present market culture into energy efficient culture, thereby contributing greatly towards energy conservation in the country and achieving the reality of tomorrow's "GREEN PAKISTAN".

Managing Director ENERCON/
National Project Director, BRESL
Pakistan

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Minimum Energy Performance Standard (MEPS)
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1. Purpose:

To provide guidelines on setting up of minimum requirement limits for energy performance testing and rating of (single & three phase); AC induction motors, in Pakistan and to match with world best practices of energy performance testing and evaluation of this type of electric motors.

2. Scope:

The purpose of this guide is to provide information on new standards for electric motors that will facilitate trade of high efficient motors across the globe. A study states that roughly 30 million new electric motors are sold each year for industrial purposes, some 300 million motors are in use in industry, infrastructure and large buildings across the globe. These electric motors are responsible for 40 % of global electricity used to drive pumps, fans, compressors and other mechanical traction equipment.

Motor technology has evolved in the last decades. Now superior so called “premium” products are also available, ready to change the market towards energy efficiency and to contribute in lowering greenhouse gas emissions worldwide.

Until recently diverging regional national standards for efficiency and energy classifications have been in use. They make a source of misunderstanding between manufacturer and user and are responsible for trade and efficiency barriers between national markets.

This MEP specifies the harmonized rating criteria, minimum values of energy efficiency, test procedures and selection of samples for inspection and testing of different categories of electric motors.

The standard shall apply to all types of general purpose line operated AC electric motors (with outage power ranging from 0.37 kW – 7.5kW (0.5 HP – 10.0 HP) being manufactured, traded and imported into /exported from Pakistan, irrespective of their use.

This standard also apply to specially designed or tailor made motors (Falling in the above mentioned category) for special purposes such as; (Motors built for Hazardous or high temperature environment).

The standard does not apply to battery powered DC electric motors mainly used in toy industry and electronic gadgets.

2.1. Motor Categories Covered by this Standard

The scope of the new standard is wider than that of the agreement previously in force in Pakistan. IEC 60034-30-1 covers almost all motors (for example standard, hazardous area, marine, brake motors):

- Single-speed, single & three-phase, 50 Hz
- 2, 4 or 6-pole
- Rated output power P_N from 0.37 kW to 7.50 Kw (0.5 HP – 10.0 HP)
- Rated voltage U_N up to 460 V
- Duty type S1 (continuous duty) or S3 (intermittent periodic duty) with a rated cyclic duration factor of 80% or higher
- Motors partially integrated into domestic pumps namely 'Mono Pumps'.

The following types of motors are excluded from this standard;

- Motors made solely for converter operation
- Motors with variable speed & frequency such as synchronous motors
- Motors completely integrated into a machine (for example, pump, fan or compressor) that cannot be tested separately from the machine following their integration
- Brake motors when the brake coil is an integral part of the motor construction and can neither be removed nor energized from a separate source during the testing of motor efficiency

The efficiency levels defined in IEC 60034-30 are based on test methods specified in IEC 60034-2-1(2007) with low uncertainty for IE2 and IE3 efficiency class. The methods available in IEC 60034-2-1 determine efficiency values more accurately than the methods previously used.

3. Normative References:

The following documentary standards, through reference in this text, constitute the provision of this standard. The latest edition of the normative documents is applicable for this standard.

- PS IEC : 60034-1; Rotating electrical machines Part 1: Rating and Performance;
- PS IEC : 60034-30-1(2014-03) ; Efficiency classes of line operated AC motors;
- PS IEC : 60034-2-I; Part2-1: Standard methods for determining losses and efficiency of rotating electrical machines from tests;
- PS IEC: 60034-12; Starting performance of single-speed cage induction motors.

4. Terms & Definitions:

The following terms and definitions apply to this standard in addition to those already defined internationally.

4.1 Commercial Levels of Motor Energy Efficiency as defined in PS IEC-60034-30 (2008)

This parameter for evaluating the efficacy level of subject motors is defined in the backdrop of the above mentioned standard as follows;

Premium Efficiency	IE3
High Efficiency	IE2 Comparable to Eff1
Standard Efficiency	IE1 Comparable to Eff2.

The above standard also introduces IE4 (Super Premium Efficiency), however the products falling under this category are yet to be commercialized.

4.2 Minimum Allowable Value of Energy Efficiency of Motors

The lowest allowable guaranteed value of motor efficiency under test conditions is specified in this standard.

4.3 Evaluating Values of Energy Conservation of Motors

The lowest guaranteed efficiency values for energy conservation of motors shall read under the test conditions as specified in this standard.

5. Technical Requirements:

5.1 Basic Requirements

The motor efficiency is determined through the calculation of losses. In order to calculate motor efficiency the losses must be determined first, since all the electrical energy is being transformed into mechanical energy by the motor.

Mainly the motor efficiency is derived through accounting for the five following losses:

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

5.2 Criteria for Rating Energy Efficiency Class

The criteria defined in the table below are extracted from latest IEC Standard 60034-30-1 which is currently adopted /approved by PSQCA.

The energy efficiency values for rating of efficiency class have been improved according to new international standard (IEC: 60034-30-1) and are given in Table-1 below

50Hz									
IE1 – Standard Efficiency (%)				IE2 – High Efficiency (%)			IE3 – Premium Efficiency (%)		
Rated Power (kW)	2-pole/ 3000 rpm	4-pole/ 1500 rpm	6-pole/ 1000 rpm	2-pole/ 3000 rpm	4-pole/ 1500 rpm	6-pole/ 1000 rpm	2-pole/ 3 000 rpm	4-pole/ 1500 rpm	6-pole/ 1000 rpm
0.37	63.9	66.0	59.7	69.5	72.7	67.6	73.8	77.3	73.5
0.40	64.9	66.8	61.1	70.4	73.5	68.8	74.6	78.0	74.4
0.55	69.0	70.0	65.8	74.1	77.1	73.1	77.8	80.8	77.2
0.75	72.1	72.1	70	77.4	79.6	75.9	80.7	82.5	78.9
1.1	75.0	75.0	72.9	79.6	81.4	78.1	82.7	84.1	81.0
1.5	77.2	77.2	75.2	81.3	82.8	79.8	84.2	85.3	82.5
2.2	79.7	79.7	77.7	83.2	84.3	81.8	85.9	86.7	84.3
3.0	81.5	81.5	79.7	84.6	85.5	83.3	87.1	87.7	85.6
4.0	83.1	83.1	81.4	85.8	86.6	84.6	88.1	88.6	86.8
5.5	84.7	84.7	83.1	87.0	87.7	86.0	89.2	89.6	88.0
7.5	86.0	86.0	84.7	88.1	88.7	87.2	90.1	90.4	89.1

Table-1

5.2.1 Criteria for Energy Efficiency *and Star Rating*

The above efficiency parameters are recommended in order to fulfill the international "performance and labeling" harmonization requirements.

The criterion for rating the energy efficiency *class* for the motors category selected is described corresponding to the *values* defined in Table 1.

In the starting stage of fulfilling the above mentioned criterion, the initial % efficiency values have been reduced *(5%)* and are specified in the Table-2 (Targeted Efficiency Values for initial stage) below, these values will enable manufacturers and suppliers to take initiatives in order to meet the international energy efficiency standards by following this standard.

Those motors which meet the efficiency values according to number of poles and rated power, will be eligible to use corresponding star rating in the energy label , as given in table-2;

50Hz									
Standard Efficiency (%) Values (1 Star)				High Efficiency (%)Values (2 Star)			Premium Efficiency (%)Values (3 Star)		
Rated Power (kW)	2-pole/ 3000 rpm	4-pole/ 1500 rpm	6-pole/ 1000 rpm	2-pole/ 3000 rpm	4-pole/ 1500 rpm	6-pole/ 1000 rpm	2-pole/ 3 000 rpm	4-pole/ 1500 rpm	6-pole/ 1000 rpm
0.37	60.7	62.7	56.7	66.0	69.0	64.2	70.1	73.4	69.8
0.40	61.6	63.5	58.0	66.9	69.8	65.4	70.9	74.1	70.7
0.55	65.6	66.5	62.5	70.4	73.1	69.4	73.9	76.8	73.3
0.75	68.5	68.5	66.5	73.5	75.6	71.8	76.7	78.4	75.0
1.1	71.2	71.2	69.3	75.6	77.3	74.2	78.6	79.9	76.9
1.5	73.3	73.7	71.4	77.2	78.7	74.9	80.0	81.0	78.4
2.2	75.7	75.7	73.8	79.0	80.1	77.7	81.6	82.4	80.1
3.0	77.4	77.4	75.7	80.4	82.2	79.1	82.7	83.3	81.3
4.0	78.9	78.9	77.3	81.5	82.3	80.4	83.7	84.2	82.5
5.5	80.5	80.5	83.1	82.6	83.3	81.7	84.7	85.1	83.6
7.5	81.7	81.7	80.5	83.7	84.3	82.8	85.6	85.9	84.6

Table: 2- Targeted Energy Efficiency Values (Initial Stage)

5.2.2 Minimum Values of Energy Efficiency of Motors

The minimum allowable vales of energy efficiency for motor categories under this standard shall not be less than those specified for class IE1 requirements as defined in above Table-2 at rated power in addition to 75% rated output.

The minimum values of other parameters for energy efficiency qualifying criteria also apply to the following sub categories of motors;

- General purpose motors.
- Motors partially integrated into domestic pumps namely ‘Mono Pumps’.
- The motor material, insulation and duty types as defined in applicable IEC standards.

5.3. Calculation of Motor Losses and Efficiency Parameters

Motor loses & efficiency Parameters will be determined according to the provisions as defined in the Standards PS-IEC 60034-2-Part I or as agreed by the manufactures / suppliers.

5.4. Evaluation of Energy Conservation of Motors

Evaluating values of energy conservation of motors at rated power and 75% rated output shall not be less than the grade IE requirements as defined in table -2.

5.5. Power Factor

Power factor of motors covered under this standard shall be in accordance with the values specified in corresponding product standard but shall not be less than 0.80.

6. Testing Protocol:

6.1 General Requirement of Test

A clear, unambiguous and unique (efficient) test method is required to ensure a 'level-playing field' for manufacturers and suppliers. Such method/s may be agreed between PCSIR, PSQCA and Manufacturers/Suppliers.

The tests shall be carried out according to the general requirements as specified in the standard PS IEC 60034-2-1, preferably "Round Robin" Testing techniques are currently being adopted by regional courtiers therefore same test method should be adopted and applied in Pakistan.

The extensive tests requiring measurement of thermal efficiency may be conducted under IEEE 112B which is similar to IEC 60034-2, yet temperature problems have been eliminated and a test procedure to determine additional load losses has been added to avoid the fixed allowance.

6.2 Accreditation of Test Facilities and Certification

PNAC is the designated authority in the country, to accredit test facilities and provide relevant certification against the tests conducted in accordance with the procedures defined in PS IEC 60034-2-1.

6.3 Motors Repair and Maintenance

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

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

6.4 Replacement Motors

Replacement motors already in circulation, e.g. in stock at a distributor or a service centre independent from the manufacturer, can be used without restriction. Replacement motors that are put into circulation for the first time, i.e. by the manufacturer or a service centre of the manufacturer, must comply with the new regulations as of the date on which the minimum energy efficiency levels come into effect**.**

7. Selection of Samples for Inspection and Testing

7.1 Quality Acceptance Test for Market Delivery

The manufacturers shall carry out quality level acceptance test for minimum energy efficiency values and those rejected in the test shall not be allowed in the market. The motors used for the acceptance test shall be selected among the lot of same type of motors produced daily. The test shall be carried out according to the requirement of standard PS IEC 60034-2-1 and IEEE 112B.

7.2 Routine Test

The manufacturer shall carryout routine test on the minimum values of energy efficiency, at e (half yearly basis) in a year on its motors. The routine test shall also be carried out if one of the following conditions prevails;

(i) Identifying product's trial production and settings

(ii) The performance may be altered due to change in the design, technology or material of the product.

(iii) Reinstating the production of the product after a halt of more than 1year.

(iv) Requirement of routine test is proposed by standards regulatory body/organization.

7.3 Indication of Energy Efficiency Grades

The manufacturers /suppliers shall define the energy efficiency of their product as per requirement of this standard and the test results.

The manufacturers /suppliers shall also indicate the energy efficiency grade and the number of the compliance standard on the name plate of their products.

7.4 Useful Formulae for quantification of parameters for Motors

To Find	Formula (For Three Phase Motor)
Amperes Knowing Input power, kW	$\frac{Input\ kW \times 1000}{1.732 \times Volts \times Power\ Factor}$
Amperes Knowing Output Horse power	$\frac{Horsepower \times 746}{1.732 \times Volts \times efficiency \times Power\ Factor}$
Amperes Knowing KVA	$\frac{KVA \times 1000}{1.732 \times Volts}$
Horse power Output	$\frac{Volts \times Amps \times Efficiency \times PowerFactor \times 1.732}{746}$
Efficiency Knowing Output kW	$\frac{kW \times 1000}{1.732 \times Volts \times Amps \times Power\ Factor}$
Power Factor	$\frac{Input\ Watts}{1.732 \times Volts \times Amps}$
Motor Application Formulae	$Torque\ (lb-ft) = \frac{Horsepower \times 5250}{RPM}$ $Torque\ (Nm) = \frac{Kilowatts \times 9550}{RPM}$
	$Kilowatts = \frac{Torque\ (Nm) \times RPM}{9550}$ $Horsepower = \frac{Torque\ (lb-ft) \times RPM}{9550}$
Speed	$Synchronous\ RPM = \frac{Hertz \times 120}{Poles}$ $Percent\ Slip = \frac{Synchronous\ RPM - Full\ Load\ RPM \times 100}{Synchronous\ RPM}$

8. Labeling

8.1 Affixing of energy efficiency label

The energy efficiency rating label shall be in the form of a sticker and affixed to the body of the motor, as well as on the packing (if any), so that the label is prominent and clearly visible. The label shall display the approved energy star rating for the model/type of the motor. The format of the energy efficiency rating label shall be as given in Figure-1.

8.2 Color of energy efficiency label

Sample energy efficiency rating label is given in Figure-2 for information only and the colors of the energy efficiency label shall follow Adobe RGB or s RGB color profile, as under:

Yellow:	R=255,	G=255,	B=0
Red:	R=255,	G=0,	B=0
Green:	R=0,	G=150,	B=60

where, R = Red, G = Green, and B = Blue

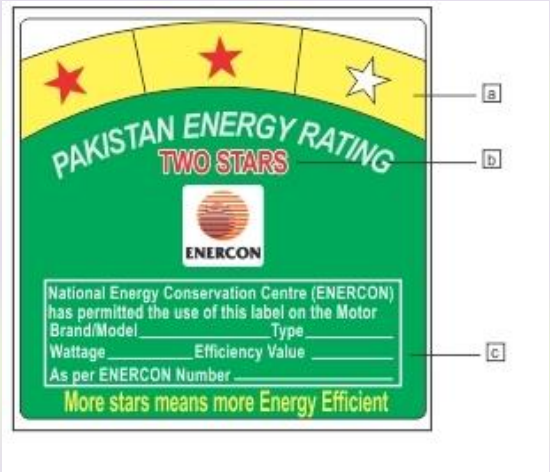

Figure-1: Format for the Energy Efficiency Rating Label

a) Number of stars appearing on the curved band depends on the energy rating determined as per section 4 of this standard. More stars mean more energy efficient.

b) Number of stars (in words) permitted for the model/type.

c) Brand name, model number, rated wattage (in kW and equivalent HP) and efficiency value of the motor are printed in the space provided.

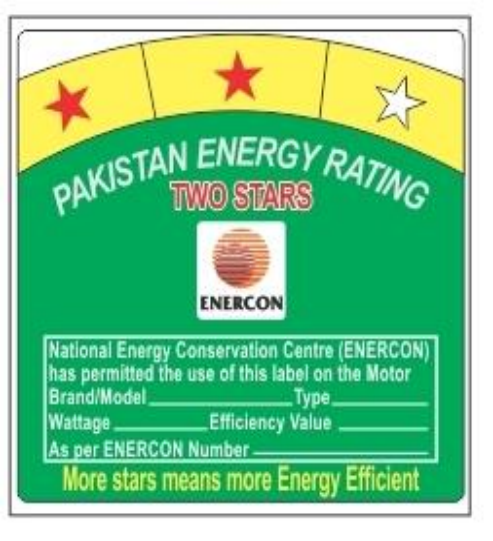

Figure-2: Sample of Printed Energy Efficiency Rating Label

8.3 Dimensions of the energy efficiency rating label

Dimensions of the energy efficiency label shall be as given in Figure-3.

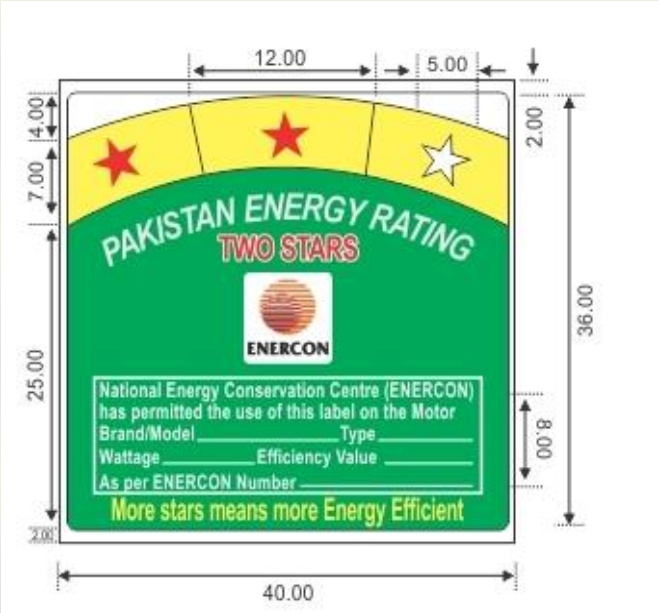

Figure-3: Dimensions of the Energy Efficiency Rating Label (all values in mm)

8.4 Character size (height) of the energy efficiency rating label

Character size (height) of the energy efficiency label shall be as given in Figure-4.

Figure-4: Print Type and Character Size of the Energy efficiency Rating Label

8.5 Color of energy efficiency endorsement logo

Sample energy efficiency endorsement logo shown in the energy efficiency star rating label is given in Figure-5 for information only and the colors of the logo shall follow Adobe RGB or s RGB color profile, as follows:

1)	Outer/large **e**:	R=153,	G=174,	B=106
2)	Inner/small **e**:	R=0,	G=109,	B=51
3)	Outer loop of logo:	R=31,	G=26,	B=23
4)	Middle loop of logo:	R=161,	G=41,	B=39
5)	Inner loop of logo:	R=129,	G=40,	B=42

where, R = Red, G = Green, and B = Blue

Figure-5: Sample of Energy Efficiency Endorsement Logo

8.6 Dimensions of the energy efficiency endorsement logo

Dimensions of the energy efficiency endorsement logo shall be as given in Figure-6.

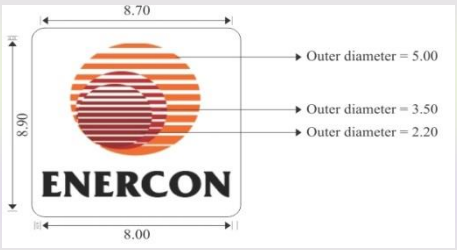

Figure-6: Dimensions of Energy Efficiency Endorsement Logo (All values in mm)

Details of the dimensions given in Figure-6 are further elaborated as under:

1) Outer/large circle:

Outer Diameter = 22.0mm
Thickness = 4 pt
Number of horizontal bars = 11

2) Inner small circle:

Outer Diameter = 15.8mm
Thickness = 4 pt
Number of horizontal bars = 11

3) Inner most circle:

Outer diameter = 12.8mm
Thickness = 4 pt
Number of horizontal bars = 11

7.7 Character size (height) of the energy endorsement logo

Character size (height) of the energy efficiency endorsement logo shall be as given in Figure-.

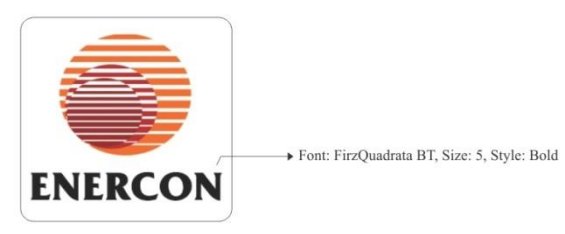

Figure-7: Print Type and Character Size of the Energy Efficiency Endorsement Logo

7.8 Prohibited information

Advertising information, other than that being included on the energy efficiency label, is prohibited.

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