Guide to EU MEPS and Using Hazardous Area Motors with inverters (VSD's)

20104E revision 3

BROOK CROMPTON

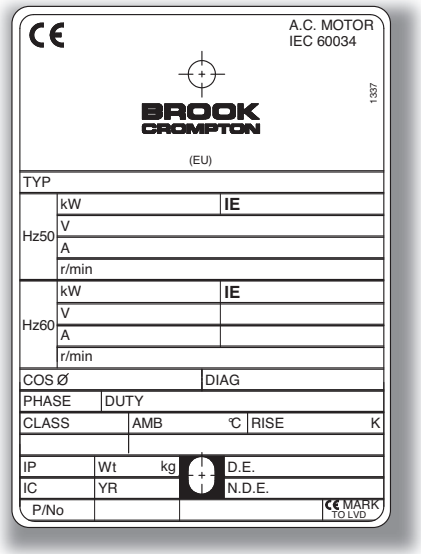
MEPS

2

The New Standard

The EU MEPS scheme sets new **mandatory** minimum efficiency levels for most single speed 3 phase induction motors up to 375kW rated up to 1000V, unlike the narrow definition of the CEMEP voluntary scheme which only covered a small number of standard motors. Aiming to reduce energy consumption throughout Europe and the rest of the world, it came into effect on the 16th June 2011. The effect of this is to maximise potential savings in electric motor driven systems.

New Efficiency levels in Europe (time line)



The Voluntary Agreement, since 1998, of CEMEP for motor manufactures has expired (classes EFF3 / EFF2 / EFF1). The new standard for motors is now **mandatory** regulation in Europe.

The scope of EU MEPS covers safe area 2, 4 & 6 pole single speed 3 phase induction motors from 0.75 to 375kW, rated up to 1000V based on continuous duty operation.

Base of the regulation is a new international IEC 60034-30 standard.
It defines the following efficiency classes :

IE1 - Standard Efficiency (comparable to EFF2)
IE2 - High Efficiency (comparable to EFF1 and USA EPACT 60 Hz)
IE3 - Premium Efficiency (comparable to USA "NEMA Premium" 60 Hz)

IEC 60034-30 uses the efficiency levels set in the MEPS Guide 1st Edition February 2009 which also helps to assist in the explanation of the standards.
(MEPS: Minimum Efficiency Performance Standard).

Former situation:	Voluntary Agreement 2 and 4 pole, 1.1 to 90 kW, Efficiencies: EFF3, EFF2, EFF1.
Mandatory time lines:	
Since 16th June 2011	Minimum efficiency requirement at IE2 for all motors covered 0.75 - 375kW
From 1st January 2015	Minimum efficiency requirement at IE3 level for 7.5 - 375kW motors or IE2 level for motors equipped with an appropriate variable speed drive.
From 1st January 2017	Minimum efficiency requirement at IE3 level for 0.75 - 375kW motors or IE2 level for motors equipped with an appropriate variable speed drive.

Summary table relating to the scope for the Eup & IEC

Category	Affected by Eup	Affected by IEC 60034-30
Standard Motors 2, 4 & 6 pl 0.75 to 375 kW S1	Yes	Yes
ATEX, Brake Motors 2, 4 & 6 pl 0.75 to 375 kW S1	No (Measurements taken without Accessory)	Yes
Std Motors & Accessories Force Vent, Encoder etc.	Yes (Measurements taken without Accessory)	Yes
High Temp Motors for Smoke Extraction up to & inc 400ºC	Yes	Yes
Std Motors for Gearboxes	Yes	Yes

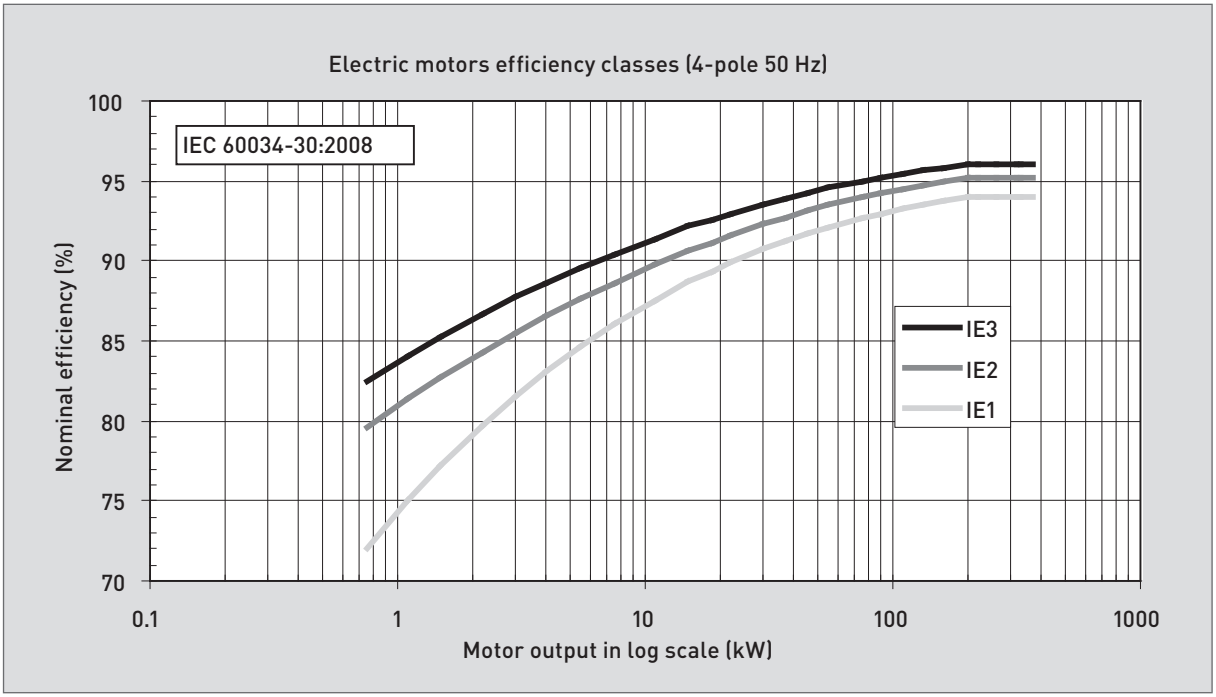
Category	Affected by Eup	Affected by IEC 60034-30
Motors which are fully integrated & cannot be tested separately	No	No
Motors in short-time duty S2 or intermittent duty S3, S4 etc	No	No
Other Special Motors for Drives - Multi Speed etc.	No	No
Motors for Built-in cooling functions	No	No

MEPS

Efficiency levels in Europe

	Efficiencies OLD Version		Efficiencies NEW Version
EFF3	Low Efficiency	-	-
EFF2	Standard Efficiency	IE1	Standard Efficiency
EFF1	High Efficiency	IE2	High Efficiency
-	-	IE3	Premium Efficiency
-	-	IE4	Super Premium Efficiency

New IEC –Efficiency Classes in accordance. with IEC 60034-30



Notes to be aware of:

New Supply

Replacement motors already in circulation e.g. in stock or 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 e.g. by the manufacturer or service centre of the manufacturer, must comply with the new regulations as of the date when the new regulations come into effect.

Motor Repairs

If a motor is repaired without changing the technical properties and the existing nameplate is kept, the old CE label 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 CE label. It must comply with all current regulations including the regulations for the minimum efficiency levels.

Efficiency classes: IEC 60034-30 (2008)

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50Hz

	IE1 – Standard Efficiency			IE2 – High Efficiency			IE3 – Premium Efficiency		
kW	2-pole	4-pole	6-pole	2-pole	4-pole	6-pole	2-pole	4-pole	6-pole
0.75	72.1	72.1	70.0	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	81.5	81.5	79.7	84.6	85.5	83.3	87.1	87.7	85.6
4	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
11	87.6	87.6	86.4	89.4	89.8	88.7	91.2	91.4	90.3
15	88.7	88.7	87.7	90.3	90.6	89.7	91.9	92.1	91.2
18.5	89.3	89.3	88.6	90.9	91.2	90.4	92.4	92.6	91.7
22	89.9	89.9	89.2	91.3	91.6	90.9	92.7	93.0	92.2
30	90.7	90.7	90.2	92.0	92.3	91.7	93.3	93.6	92.9
37	91.2	91.2	90.8	92.5	92.7	92.2	93.7	93.9	93.3
45	91.7	91.7	91.4	92.9	93.1	92.7	94.0	94.2	93.7
55	92.1	92.1	91.9	93.2	93.5	93.1	94.3	94.6	94.1
75	92.7	92.7	92.6	93.8	94.0	93.7	94.7	95.0	94.6
90	93.0	93.0	92.9	94.1	94.2	94.0	95.0	95.2	94.9
110	93.3	93.3	93.3	94.3	94.5	94.3	95.2	95.4	95.1
132	93.5	93.5	93.5	94.6	94.7	94.6	95.4	95.6	95.4
160	93.8	93.8	93.8	94.8	94.9	94.8	95.6	95.8	95.6
200	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	94.0	94.0	94.0	95.0	95.1	95.0	95.8	96.0	95.8
300	94.0	94.0	94.0	95.0	95.1	95.0	95.8	96.0	95.8
330	94.0	94.0	94.0	95.0	95.1	95.0	95.8	96.0	95.8
375	94.0	94.0	94.0	95.0	95.1	95.0	95.8	96.0	95.8

60Hz

	IE1 – Standard Efficiency			IE2 – High Efficiency			IE3 – Premium Efficiency		
hp	2-pole	4-pole	6-pole	2-pole	4-pole	6-pole	2-pole	4-pole	6-pole
1	77.0	78.0	73.0	75.5	82.5	80.0	77.0	85.5	82.5
1.5	78.5	79.0	75.0	82.5	84.0	85.5	84.0	86.5	87.5
2	81.0	81.5	77.0	84.0	84.0	86.5	85.5	86.5	88.5
3	81.5	83.0	78.5	85.5	87.5	87.5	86.5	89.5	89.5
5	84.5	85.0	83.5	87.5	87.5	87.5	88.5	89.5	89.5
7.5	86.0	87.0	85.0	88.5	89.5	89.5	89.5	91.7	91.0
10	87.5	87.5	86.0	89.5	89.5	89.5	90.2	91.7	91.0
15	87.5	88.5	89.0	90.2	91.0	90.2	91.0	92.4	91.7
20	88.5	89.5	89.5	90.2	91.0	90.2	91.0	93.0	91.7
25	89.5	90.5	90.2	91.0	92.4	91.7	91.7	93.6	93.0
30	89.5	91.0	91.0	91.0	92.4	91.7	91.7	93.6	93.0
40	90.2	91.7	91.7	91.7	93.0	93.0	92.4	94.1	94.1
50	91.5	92.4	91.7	92.4	93.0	93.0	93.0	94.5	94.1
60	91.7	93.0	91.7	93.0	93.6	93.6	93.6	95.0	94.5
75	92.4	93.0	92.1	93.0	94.1	93.6	93.6	95.4	94.5
100	93.0	93.2	93.0	93.6	94.5	94.1	94.1	95.4	95.0
125	93.0	93.2	93.0	94.5	94.5	94.1	95.0	95.4	95.0
150	93.0	93.5	94.1	94.5	95.0	95.0	95.0	95.8	95.8
200	94.1	94.5	94.1	95.0	95.0	95.0	95.4	96.2	95.8
250	94.1	94.5	94.1	95.4	95.4	95.0	95.8	96.2	95.8
300	94.1	94.5	94.1	95.4	95.4	95.0	95.8	96.2	95.8
350	94.1	94.5	94.1	95.4	95.4	95.0	95.8	96.2	95.8
400	94.1	94.5	94.1	95.4	95.4	95.0	95.8	96.2	95.8
450	94.1	94.5	94.1	95.4	95.4	95.0	95.8	96.2	95.8
500	94.1	94.5	94.1	95.4	95.4	95.0	95.8	96.2	95.8

Group Products / Technical Information

Products available from Brook Crompton

Brook Crompton have a complete range of IE1 Standard Efficiency,* IE2 High Efficiency and IE3 Premium Efficiency products available. These products will cover the needs of a demanding market. Series 10, a low variant volume solution and 'W' a flexible high variant volume solution.

*still available to non EUP compliant countries.

Product ranges and Efficiency classes

	IE2	IE3
Product Range	0,75-375 kW 2,4,6-pole	0,75-375 kW 2,4,6-pole
Brook Crompton W-Range	80 - 355 frames	80 - 355 frames
Brook Crompton Series 10	80 - 355 frames	On Request

Useful Electrical Formulae

To Find:	For Three Phase:
Amperes Knowing Input kW	$\frac{kW \times 1000}{1.732 \times Volts \times Power\ Factor}$
Amperes Knowing Output Horsepower	$\frac{Horsepower \times 746}{1.732 \times Volts \times Efficiency \times Power\ Factor}$
Amperes Knowing KVA	$\frac{KVA \times 1000}{1.732 \times Volts}$
Input kW	$\frac{Volts \times Amps \times Power\ Factor \times 1.732}{1000}$
KVA	$\frac{Volts \times Amps \times 1.732}{1000}$
Horsepower Output	$\frac{Volts \times Amps \times Efficiency \times Power\ Factor \times 1.732}{746}$
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 = $\frac{Torque\ (lb\text{-}ft) \times RPM}{9550}$

Speed

Synchronous RPM = $\frac{Hertz \times 120}{Poles}$	Percent Slip = $\frac{Synchronous\ RPM - Full\ Load\ RPM \times 1000}{Synchronous\ RPM}$

Ex d/de motors with inverters (VSD's)

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Keep your options open when using Ex d/de motors with inverter drives

Background

In the past motor users have been advised that flameproof Ex d/de motors and inverters need to be tested together when used as a system in a potentially flammable atmosphere. Brook Crompton, explain that this need not be the case if motor certification was undertaken with the objective of using any manufacturer's inverter.

Application - Motor Sizing and Design

The motor is designed to suit the application from the user specified requirements augmented by the actual inverter generated waveform as it is applied to the motor. The motor insulation thickness is primarily set by the type of inverter waveform, the distance from the motor and the incorporation of either over-voltage negating software or devices at the inverter or motor if fitted.

To accommodate world supply voltages and the over-voltages as applied to the motor causes motor manufacturers to establish pre-defined insulation and winding systems. The voltage at the motor primarily sets the insulation thickness and winding layout. The type of insulation material is based on the operating temperature in the slots and overhangs for a given life. In all cases it has to be with a design margin for overload conditions and long life.

The application dictates the required capability – torques, speed range and temperature limitations. Motors of differing size can meet the torque and speed requirements but the correct selection of working temperatures is obtained through the use of proven derating curves. These curves plot torque against speed to achieve a reliable thermal performance within temperature boundaries.

The use of software in motor performance modelling for torques, currents, efficiency and loss distribution can be applied to motor thermal models to predict temperatures throughout the motor. These calculated results provide a parallel route to assist the selection of materials based on forecast temperatures that are calibrated and mirrored by measurements.

The long term testing of motors supplied by alternative waveforms, from a broad range of inverter manufacturers, leads to a reduction in risk. By having derating curves that are proven in practice from many inverter manufacturers makes it is possible to cater for possible inverter change due to replacement later in life.

Motors and Inverters

All electrical equipment for hazardous areas must be installed with great care as potentially flammable or explosive conditions may arise. Depending on the nature of the risk, different motor construction methods can be used e.g. non-sparking 'n', increased safety 'e', and flameproof 'd'. All designs seek to reduce the risk of sparking or abnormally high temperatures being attained.

For small and medium size Category 2 industrial motors (Zone 1), the flameproof construction is often considered the safest and most economical option. This design concept requires a mechanically rugged enclosure to meet certified internal explosive pressures and impact values. There is also a requirement to keep external surface temperatures within a prescribed value according to the temperature classification, e.g. T4 (135°C).

When used in conjunction with a variable speed drive other design requirements must also be met.
An inverter supply can change the motor thermal performance in several ways.

a) Increased running losses due to a non-sinusoidal waveform with increased harmonics, particularly when a higher Pulse Width Modulated switching frequency is employed.
b) Reduced speed operation reduces the cooling effect of the external fan.
c) There is a possibility of running the motor in an under or over-voltage configuration.
d) Changes to inverter settings to those initially tested can affect temperatures.
e) Combinations of all of the above at the same time.

Thermistor Protection

All the above situations manifest themselves as increased temperatures in the motor and hence the external surfaces. Brook Crompton pioneered the development of Ex-certified motors over 80 years ago. They also recognised the benefits of fitting thermistors embedded in the windings. These electronic devices trip at set temperatures and are used to monitor internal heating that would eventually lead to increased external temperatures. Typically a 140°C trip temperature thermistor is used for T4 certification. Brook Crompton has developed this convenient protection concept for Ex d/de motors through testing and evaluation of results using the facilities of BASEEFA at Buxton.

The temperatures attained in a motor must have a design margin to the temperature classification. Under fault

Ex d/de motors with inverters (VSD's)

Keep your options open when using Ex d/de motors with inverter drives

conditions, however they arise, the thermistor protection must operate.

The PTC thermistor (Positive Temperature Coefficient) exhibits a rapidly increasing resistance at the trip temperature, which is used to operate the protective circuit.

To cover the risk of over temperature three thermistors are distributed around the winding and one is embedded in each phase.

The application commissioning for safety need only confirm that the motor thermistor triplet has a low resistance. The test should be with a low voltage/current to prevent damage. The protection circuit should be checked to operate using a short circuit link that is changed to open circuit to simulate the thermistor operation.

From a safety point of view different temperature classifications are covered in motor sizing and choice of trip setting. This is primarily set by the motor thermal behaviour and not generally influenced by the inverter.

Benefits

Providing a motor used with an inverter has the correct class of thermistor triplet embedded and connected to the protection circuit, any make of inverter can be used with a Brook Crompton Ex d/de motor. The protection circuit should disconnect the motor from the supply.

The benefits to the user are: -

1. No limitation on manufacturer. Existing inverter suppliers can be maintained where sites have a preference.
2. Simple concept gives confidence that excessive surface temperatures will be detected.
3. Changes to the inverter parameters to meet local application requirements or operator changes to inverter settings will not prevent certification conditions and safety being maintained.

To satisfy customer requirements thermistors are fitted as standard on frames 200 and above.

ATEX Worker Protection Directives say it is necessary for all sites employing 5 or more employees to carry out a site risk assessment.
This should record hazardous substances and work involving them, potential causes of fire or explosions and possible consequences for employees or the public. The responsibility for site safety rests with local works management.

To help with the above evaluation the Trade Associations GAMBICA and REMA have publish excellent documents.

Conclusion

The matching of a proven motor, using thermal protection, with any inverter is a recommended route to meet the needs of the ATEX Risk Assessment. This procedure is mandatory no matter how selection is achieved. As the motor is in the hazardous area all new applications will require correct sizing using the motor manufacturer's derating curves. Brook Crompton with their engineering expertise in the UK can ensure an optimised result for users and inverter suppliers alike.

References/Terms

1) GAMBICA Trade Association for Industrial, Control, Automation and Laboratory Technology Industries.
2) REMA Rotating Electrical Machines Association Brook Crompton are members of REMA.
3) ATEX ATmosphères EXplosible
4) Zone 1, Category 2
a) Zone 1, Hazard likely to occur in normal operation (>10 < 1000 hours/year)
b) Category 2, Certified by a Notified Body
5) Temperature Classification (Maximum surface temperatures)
a) T1 450°C
b) T2 300°C
c) T3 200°C
d) T4 135°C
e) T5 100°C
f) T6 85°C

6) BASEEFA British Approvals Service for Electrical Equipment in Flammable Atmospheres, EEx nA is certified to an approved standard by BASEEFA.

Dealers Stamp

Brook Crompton
St Thomas' Road Huddersfield
West Yorkshire HD1 3LJ UK
Tel: +44 (0) 1484 557200
Fax: +44 (0) 1484 557201
E-mail: csc@brookcrompton.com
Internet: www.brookcrompton.com

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