# Motor protection for the IE3 revolution

What the ErP directive means for switching and protection systems for electric motors


**White Paper**
Jan Nowak
1st edition 2015

Powering Business Worldwide

# The current ErP Directive is resulting in electric motors with increasingly high energy efficiency levels, all of which has an impact on the design of these motors and the protection systems used for them

**Introduction**

In the field of industrial production, electric motors make up the lion's share – about two thirds, specifically – of the total electric power consumed by the sector. In fact, the German Federal Environment Agency calculates that the use of more efficient drive control and motor technologies could lower consumption by approximately 27 billion kilowatt-hours by 2020 in Germany alone, eliminating around 16 million metric tons of $CO_2$ emissions in the process[1].

The European Union has also recognized this enormous potential, leading it to start its own initiatives designed to promote more environmentally friendly product designs. The core of this new approach is Directive 2009/125/EC for "energy-related products," more commonly known as the ErP Directive[2]. This directive establishes a framework for defining ecodesign requirements – within the EC – for products relevant to energy consumption. It also specifies a series of criteria that these products must meet before they can be operated within Europe.

In turn, there are specific regulations for each of the various individual product groups covered by the ErP Directive. Within this context, the one that is relevant to motors and drives is Commission Regulation (EC) No. 640/2009[3] for electric motors. This regulation requires the industrial sector to gradually and constantly increase the efficiency of the motors it uses, with the result being that the use of premium efficiency IE3 motors (or IE2 motors combined with speed control systems) is about to become mandatory. This, of course, is not without its consequences: In order to be able to reach increasingly higher levels of energy efficiency, the standard asynchronous motors governed by the regulation have had to undergo a series of design changes. And this not only has had a wide-ranging impact on the motors themselves, but also on the components used with them, including the corresponding motor protection systems.

Of course, this gives way to a number of questions: What exactly do these IE3 motor design changes mean for the design of motor protection systems? What kinds of risks do these changes entail for users? What does a user need to keep in mind when selecting switchgear for IE3 motors? What kinds of motor protection solutions that meet the requirements posed by current developments are available on the market? This white paper provides answers to these and other questions, and is intended to help users be able to keep switching and protecting their systems safely in the age of IE3 motors.

Background behind the current ErP Directive, and its contents in relation to electric motors

One of the European Union's environmental policy targets is to significantly cut its greenhouse gas emissions and energy consumption levels by 2020. As part of its "20/30-20-20" strategy, the EU is committed to achieve the following by 2020:

- Reduce greenhouse gas emissions by up to 30%
- Increase the share of renewable energy to 20%
- Boost energy efficiency by 20% in general

The legal basis for these targets is the EuP Directive, which was passed on July 6th, 2005 (2005/32/EC)[4] and sets forth requirements for the environmentally friendly design of energy-using products. An amended version of this directive (2009/125/EC) came into force on October 21st, 2009, and expanded the aforementioned requirements to include the environmentally friendly design of energy-related products (hence the name "ErP"). In Germany, the directive has been implemented with the Energiebetriebene-Produkte-Gesetz (EBPG – the German Energy-Using Products Act), which is more commonly referred to as the Ecodesign Directive.[5]

ErP Directive 2009/125/EC establishes a framework for defining ecodesign requirements – within the EC – for energy-related products. These products include, for instance, electric motor systems and HVAC applications such as tankless heaters, electric water heaters, commercial refrigerators and freezers, air-conditioning systems, pumps, fans, and compressors.

1 German Federal Environment Agency, Press Release No. 53/2009, Energy efficiency in electric motors, 2009 http://www.umweltbundesamt.de/en/press/pressinformation/energy-efficiency-in-electric-motors
2 Directive 2009/125/EC establishing a framework for the setting of ecodesign requirements for energy-related products
3 Commission Regulation (EC) No. 640/2009 of 22 July 2009 implementing Directive 2005/32/EC of the European Parliament and of the Council with regard to ecodesign requirements for electric motors
4 Directive 2005/32/EC establishing a framework for the setting of ecodesign requirements for energy-using products
5 ZVEI, Electric Motors and Variable Speed Drives – Standards and legal requirements for the energy efficiency of low-voltage three-phase motors 2013

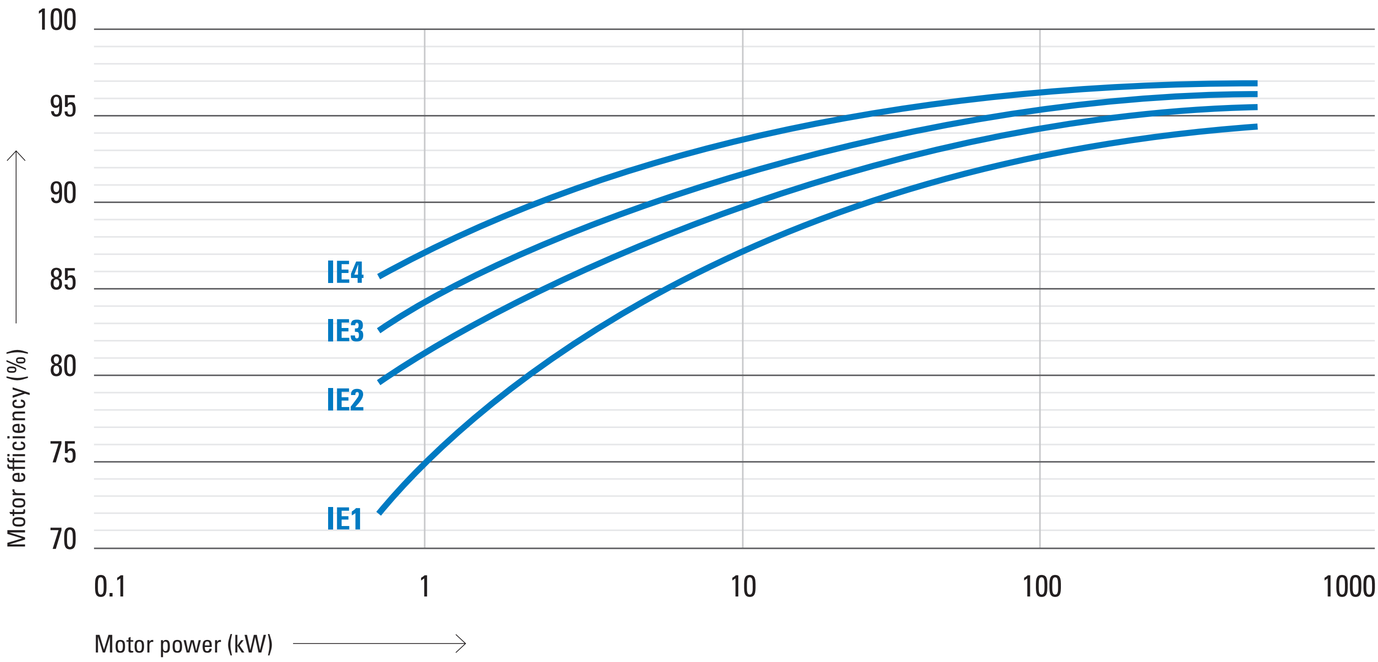
Meanwhile, Regulation (EC) No. 640/2009 sets forth mandatory minimum efficiency levels for a wide variety of rated output powers for low-voltage, three-phase asynchronous motors. This type of motor is widespread in the commerce and industry sectors, and in 2005 accounted for approximately 90% of all electric motor power consumption in the EU's 27 member states[6]. As part of the regulation, the EFF classes defined by the European Committee of Manufacturers of Electrical Machines and Power Electronics (CEMEP), which had been voluntarily adopted by the industry, were replaced with the IE classes defined in standard IEC 60034-30[7] for induction motors. These classes are as follows: IE1 (standard efficiency), IE2 (high efficiency), and IE3 (premium efficiency). Moreover, new specifications for energy efficiency class IE4 (super premium efficiency) were officially incorporated into the draft for standard IEC 60034-30-1 in June 2014.

Efficiency in the IE standard is calculated using a new method (defined in IEC 60034-2-1:2007) and is illustrated in the following graph:

The motor regulation's scope of application will be expanded in the next few years, with the goal being to save even more energy in industrial motor and drive systems. As of this writing, the regulatory framework for standard asynchronous motors is as follows:

Regulation (EC) No. 640/2009, Article 3 (excerpt)[8]

- "From 16 June 2011, motors shall not be less efficient than the IE2 efficiency level..."
- From 1 January 2015: motors with a rated output of 7.5-375 kW shall not be less efficient than the IE3 efficiency levelor shall meet the IE2 efficiency level and be equipped with an electronic speed control.
- From 1 January 2017: all motors with a rated output of 0.75-375 kW shall not be less efficient than the IE3 efficiency level or shall meet the IE2 efficiency level and be equipped with an electronic speed control.




| Class | Classification speed [1/min] | Continuos duty torque [Nm] | Classification power [kW] | Nominal efficiency [%] | Energy loss [W] | as per IE1 |
|---|---|---|---|---|---|---|
| IE1 | 1.500 | 35 | 5.5 | 87.4 | 693 | |
| IE2 | 1.500 | 35 | 5.5 | 87.7 | 676.5 | -2.4% |
| IE3 | 1.500 | 35 | 5.5 | 89.6 | 572 | -21.2% |
| IE4 | 1.500 | 35 | 5.5 | 92.0 | 440 | -57.5% |

IEC 60034-30

*Fig.1: Efficiency curves (IE code) for standard asynchronous motors, valid worldwide. Source: IEC 60034-30*

6 German Federal Environment Agency, Press Release No. 53/2009, Energy efficiency in electric motors, 2009
7 IEC 60034-30: 2008, standard defining efficiency classes for low-voltage motors

8 ZVEI, Electric Motors and Variable Speed Drives – Standards and legal requirements for the energy efficiency of low-voltage three-phase motors 2013

The regulation applies to all single-speed, three-phase 50 Hz or 50/60 Hz squirrel cage induction motors with the following characteristics: 2 to 6 poles, a $U_N$ rated voltage of up to 1000 V, a PN rated operating voltage between 0.75 kW and 375 kW, rated for continuous duty operation.

Moreover, the following motors are exempt from the regulation: brake motors, motors for potentially explosive atmospheres, motors designed to operate wholly immersed in a liquid, and motors completely integrated into a product (e.g., a machine) that makes it impossible to measure the motors' efficiency exactly. The original version[9] contained additional exemptions, but these were heavily limited in updated Regulation (EC) 4/2014[10], which came into effect on July 27th, 2014. More specifically, the following exemption limits were changed, widening the regulation's scope of application:

- Altitudes exceeding 1,000 m were changed to altitudes exceeding 4,000 m
- Ambient temperatures exceeding +40 °C were changed to ambient temperatures exceeding +60 °C
- Ambient temperatures of less than -15 °C were changed to ambient temperatures of less than -30 °C (for all motors) or less than 0 °C for water-cooled motors
- Coolant temperatures at the inlet to a product of less than 5 °C or exceeding 25 °C were changed to temperatures of less than 0 °C or exceeding 32 °C.

**A comparison of international energy efficiency guidelines and regulations**

The stricter limits and requirements in the motor regulation are increasing the pressure on companies to switch to more energy-efficient motors and drive systems. And the phenomenon is not limited to Europe: Governments and associations all around the world are making efforts to promote the use of efficient electric motors in the industrial sector.

As shown in figure 2, minimum efficiency standards have already been in place for years in the USA (IE2 since 2004 and IE3 since 2010), where IE2 high efficiency motors already have a market share of well over 50% and even more efficient IE3 motors have already passed the 20% threshold. In Germany and Europe, the percentage of IE3 motors is still far behind at 10%, meaning that there is still a lot of potential in the field.[11] Meanwhile, the IE2 standard became mandatory in China in 2011, and the Chinese government is already working on implementing IE3. For the German machine and system building industry, which relies considerably on exports, this means that the subject of energy efficiency in motors and drive systems needs to be tackled effectively if the industry wishes to continue being globally successful today and in the future.

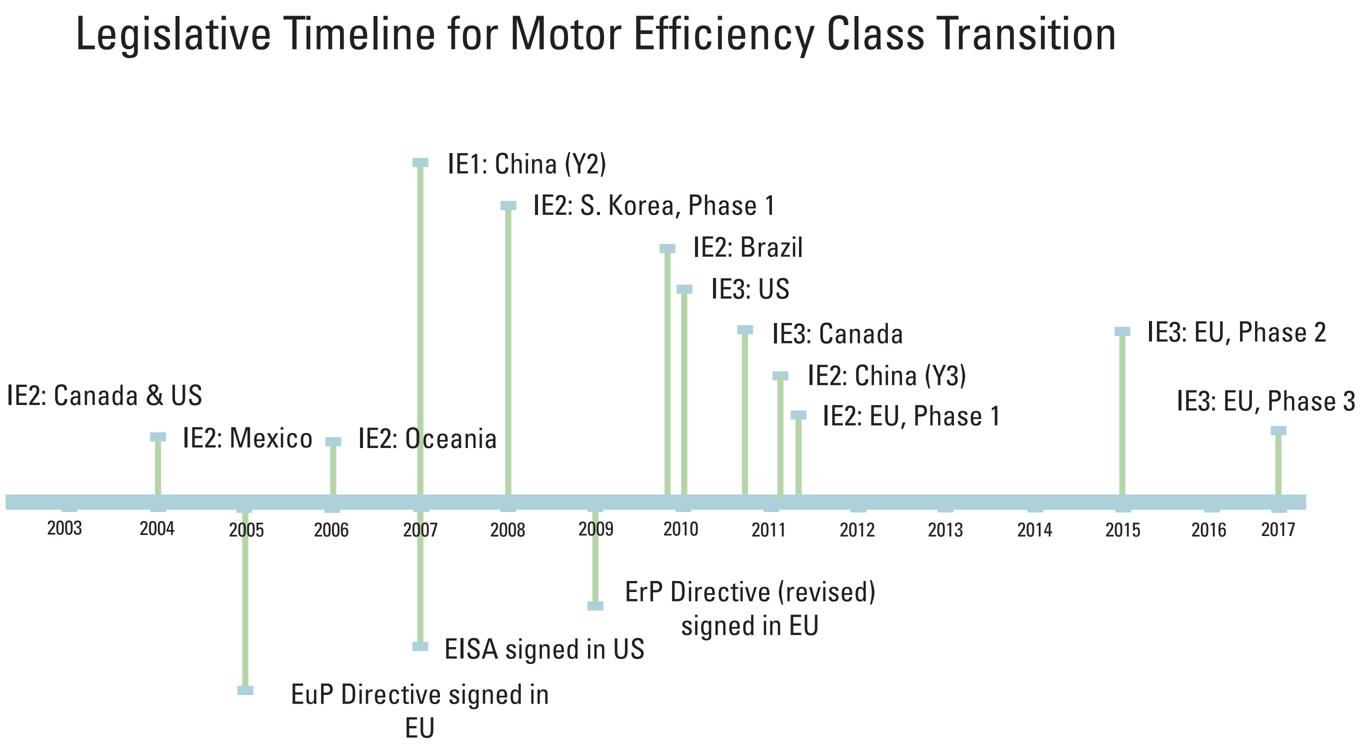



*Fig. 2: International timeline for the implementation of energy efficiency classes for standard asynchronous motors. Source: IMS Research*

9 See Commission Regulation (EC) No. 640/2009 of 22 July 2009
10 Commission Regulation (EU) No. 4/2014 of 6 January 2014 amending Regulation (EC) No. 640/2009 implementing Directive 2005/32/EC of the European Parliament and of the Council with regard to ecodesign requirements for electric motors

11 Deutsche Energie Agentur GmbH (dena), Dipl.-Ing. Günther Volz, Ratgeber „Elektrische Motoren in Industrie und Gewerbe: Energieeffizienz und Ökodesign-Richtlinie" [„Electric Motors in the Industrial and Commercial Sector: Energy Efficiency and Ecodesign Directive, available in German only"], 2010

**Repercussions on motor design resulting from the change to IE3**

The requirements set forth in the ErP Directive and the motor regulation are forcing electric motor manufacturers to make design changes to their products (see figure 3). In turn, these changes are also affecting motors' electrical characteristics: Thicker magnet wires in the stator, as well as thicker rotor bars and shorting rings, increase resistance. An optimized lamination cross-section reduces stray-load losses. Higher-quality lamination material reduces hysteresis losses.

All these changes mean that high-efficiency motors have higher inductance levels, which stems from the fact that the corresponding copper losses ($P_V = I^2R$) are smaller. This, in turn, causes the motors' starting currents to be higher. The end result of all this is that the corresponding switchgear, such as contactors and motor-protective circuit-breakers, need to be modified as well.

For starters, the aforementioned higher starting currents can result in nuisance tripping though no fault or short circuit has occurred. In addition, the contactor can experience contact bounce, which will exert an additional thermal load on the device and, in extreme cases, result in the contacts sticking. If the contacts melt, this can result in expensive machine downtimes and expensive servicing. And, in addition, it will shorten the contactor's service life.

**Impact of higher starting currents on protective devices**

The aforementioned changes to the design of high-efficiency motors, as well as the potential risks that they entail for users, mean that protective device manufacturers need to check their devices under the new conditions and make any necessary adjustments. This is absolutely indispensable, as users will be expecting safe and reliable solutions that meet the requirements for motor-protective devices in the age of IE3 premium efficiency motors by January 1st, 2015 at the very latest.

**Study of the behavior of switchgear when starting IE3 motors with DOL starting**

As one of the world's leading experts in safe motor driving, switching, and protection, Eaton recently conducted a study to closely examine the behavior of motor-protective devices in real-life tests. To check how the design changes on IE3 motors would affect its protective devices, the company carried out tests using IE3 motors from various well-known manufacturers. Following is an example showing the results obtained with three different high-efficiency makes:

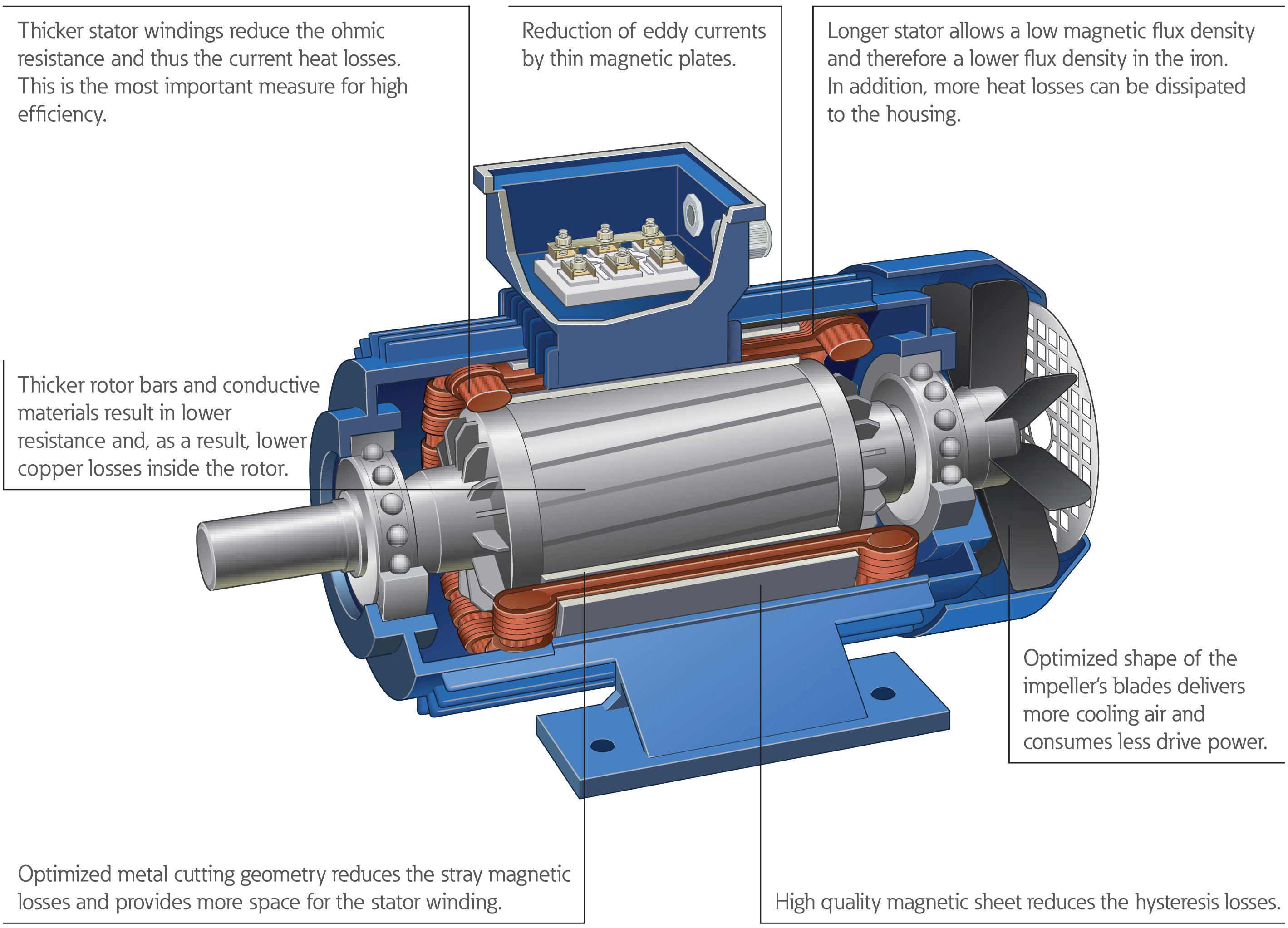



*Fig. 3: Due to changes in their electrical characteristics, high-efficiency motors have higher inductances, resulting in higher inrush currents. Source: Eaton*

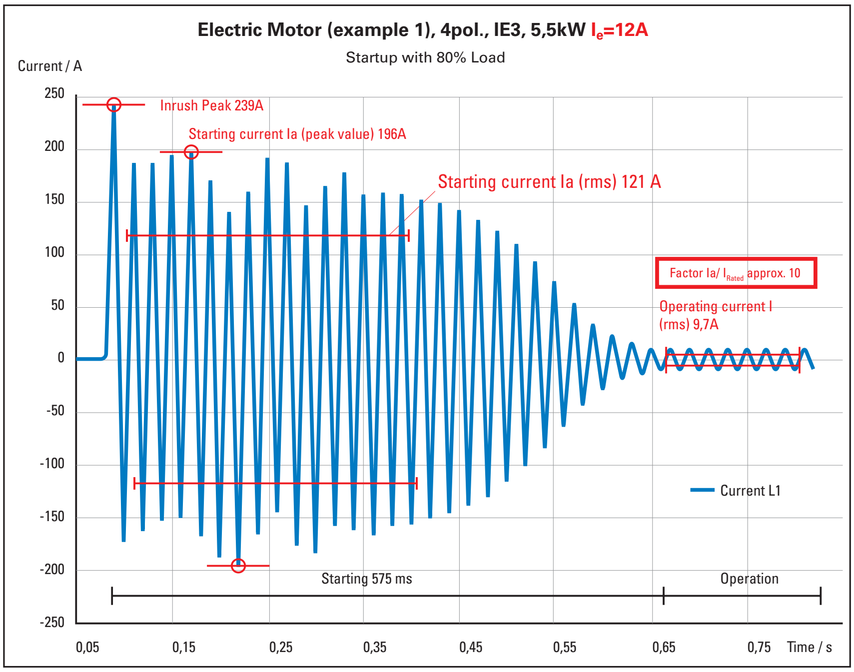



Fig. 4:
*Startup behavior of a 5.5 kW IE3 electric motor (make 1) with Irated = 12 A – RMS starting current Ia was ten times higher than the rated operating current. Source: Eaton*

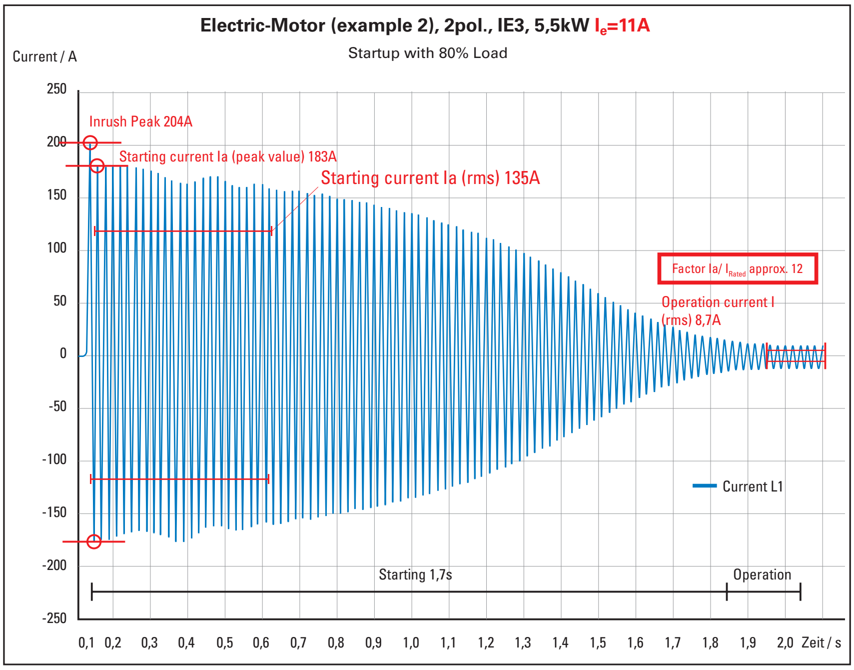



Fig. 5:
*Startup behavior of a 5.5 kW IE3 electric motor (make 2) with Irated = 11 A – RMS starting current Ia was twelve times higher than the rated operating current. Source: Eaton*

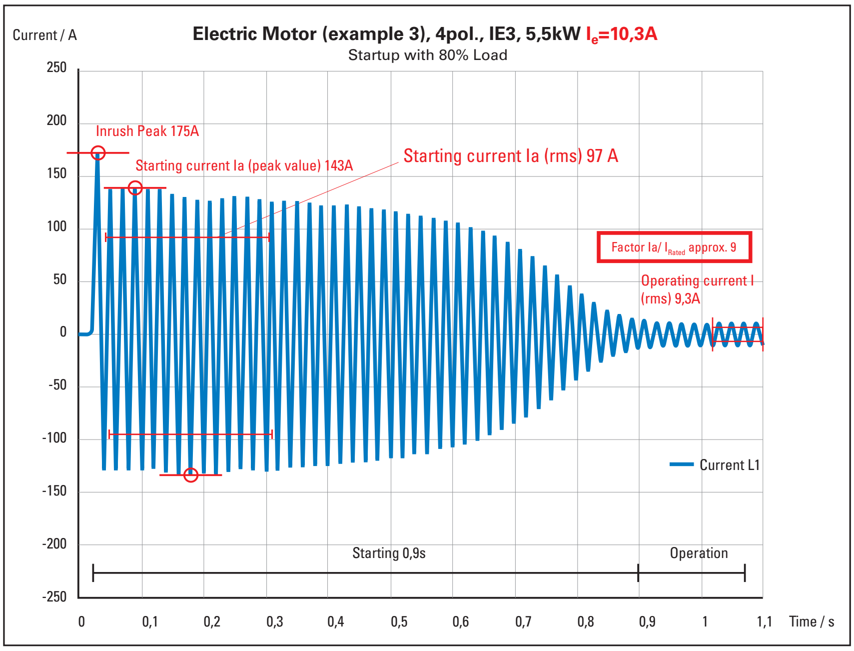



Fig. 6:
*Starting behavior of a 5.5 kW IE3 electric motor (make 3) with Irated = 10.3 A – RMS starting current Ia was nine times higher than the rated operating current. Source: Eaton*

The following starting factors were calculated for the IE3 electric motors tested during the study:

| Electric motor | | Make 1 | Make 2 | Make 3 | Result |
|---|---|---|---|---|---|
| Efficiency class | | **IE3** | **IE3** | **IE3** | IE3 |
| Power | kW | 5.5 | 5.5 | 5.5 | 5.5 |
| Rated operational current $I_n$ | A | 12 | 11 | 10.3 | 12 |
| **Measured values** | | | | | |
| Starting peak (maximum value) | A | 240 | 204 | 172 | |
| Starting peak (RMS) | A | **170** | **144** | **122** | |
| Starting current $I_a$ (maximum value) | A | 200 | 193 | 141 | |
| Starting current $I_a$ (RMS) | A | **124** | **135** | **96** | |
| Load current $I_n$ (RMS) | A | | | 10.8 | |
| **Factors** | | | | | |
| Starting peak (maximum value) | | 20.0 | 18.5 | 16.7 | 20 |
| Starting peak (RMS) | | **14.1** | **13.1** | **11.8** | **14** |
| Starting current $I_a$ (maximum value) | [ - ] | 16.7 | 17.5 | 13.7 | 17 |
| Starting current $I_a$ (RMS) | | **10.3** | **12.3** | **9.3** | **12** |

*Fig. 7: Comparison between the startup behavior of the tested 5.5 kW IE3 electric motors. Source: Eaton*

A comparison between the study's results and the technical specifications for the tested models revealed that the starting currents measured during the real-life tests were higher than those specified by the manufacturers. Moreover, the tests showed that the starting currents of the IE3 motors were significantly higher than those of IE2 motors – in fact, they were even 1.25 times higher than the starting currents of IE1 motors.

The higher starting currents characterizing IE3 motors have also led the responsible committees to start discussing making a change to an important standard: IEC/EN 60947. The change would consist of increasing the required minimum starting factors for protective devices. Standard IEC/EN 60 947 describes design characteristics, functional properties, and tests for low-voltage switchgear and controlgear, and its contents are reproduced in German regulation VDE 0660.

### Challenges for switching and protective device manufacturers

The developments that have been outlined above are forcing switching devices manufacturers to review and optimize their existing product portfolio. Accordingly, Eaton took advantage of its study to test both contactors for DOL starting on public and private power supply systems and contactors for star-delta startup to check whether they were IE3-ready, making sure to test them in combination with soft starters and variable frequency drives as well. In addition, the study was also used to test the performance of mechanical and electrical motor-protective circuit-breakers.

Following is a description of the impact that higher starting currents had on the various switching and protective devices, as well as possible solutions.

- Contactors: The tests revealed that contactors need to be optimized for the higher starting currents of IE3 motors where necessary. One possible solution is to increase the contact pressure force. In this case, the challenge is to find and ensure an ideal balance between a drive output that continues to be low enough (energy efficiency) and an increased contact pressure force (safety) so that the higher starting currents of high-efficiency motors will not pose a problem either.

- Mechanical and electronic motor-protective circuit-breakers: Despite the higher starting currents, there was no nuisance tripping during the tests. However, magnetic release tolerances must be taken into account within the inrush peak current range, as nuisance tripping may occur due to these tolerances. The solution: In order to prevent nuisance stripping when a motor is being started, the short-circuit release's response threshold should be increased. Depending on the current range in question, this can be done by using a stronger spring or by setting a higher latch position for the electromechanical release's spring. On the other hand, it can also be done by shifting the characteristic curve of the electronic short-circuit release (trip block) upwards. This can be done by making modifications to the transformer, using a thicker secondary winding, or by making modifications to the electronic hardware (bypass resistor) and/or software (trip characteristic).

### Practical tip: What should users keep in mind when selecting protective devices?

Most of the changes brought about by the implementation of IE3 motors are the sole concern of electric motor and switchgear manufacturers. However, users also need to keep certain things in mind when attempting to select the right protective devices: For example, the aforementioned magnetic release tolerances within the inrush peak current range, as these tolerances can reach percentages of up to 20%. In order to be sure that the trip characteristic and the motor characteristic will not touch each other despite the higher starting currents (which would result in nuisance tripping), the two of them must be balanced in advance as required for the specific application at hand. Tools such as Eaton's Curve Select program can prove to be invaluable within this context.

Moreover, users should make sure that the switchgear and motor-protective devices used in applications with high-efficiency motors are truly IE3-ready. This is absolutely indispensable, as the safety and reliability of the machines and systems used will otherwise be at stake. Accordingly, it is important to be very careful when selecting protective device suppliers and only use products that have been demonstrated to meet the new requirements. Eaton comes to the rescue here as well, with its practical "Motor Starter Configurator" tool featuring a filter function that enables users to be absolutely sure that their products are IE3-ready. Put simply, this makes it child's play to find the right motor starter solution for any application.

Finally, users should use branded products exclusively. The reason for this is that only well-known manufacturers can be reasonably expected to have performed sufficient testing to ensure that their products are IE3-ready. In addition, it is recommended to only choose contactors and motor-protective circuit-breakers intended for use with IE3 applications when selecting motor protection products. This is particularly important, as the contactor relays and special contactors found in applications such as heating and lighting systems and motors with lower switching frequencies do not have a sufficiently large contact pressure force, meaning that they are not suitable for starting IE3 motors. Selection tools, such as the ones provided by Eaton, are the perfect way to avoid making a serious mistake here.

**Conclusion**

For more than 100 years, one of Eaton's core competencies has been developing quality switchgear, including contactors, motors starters, and even its new PowerXL DE1 variable speed starters (VSS) and PowerXL variable frequency drives. As one of the world's leading switchgear manufacturers, the power management company has not only tested its range of products thoroughly in order to ensure that they are suitable for use with IE3 premium efficiency motors, but has also taken all the necessary actions in order to guarantee this.

**Higher trip limits:** After exhaustive testing, Eaton has optimized its DIL contactors and its PKZ and PKE motor-protective circuit-breakers as required for the new challenges that IE3 motorspose. In order to guarantee maximum levels of reliability and safety, the motor protection solution experts have increased the response threshold for short-circuit releases, as the previous starting factor of 8 (inrush peak current to operating current), as currently specified in DIN EN 60947-4-1, was not sufficient for IE3 motors. In fact, Eaton has raised the starting factor of its products to values of 12 to 15.5 to err on the side of caution and be able to guarantee that its devices will be future-proof. Moreover, the company has perfected a delicate balancing act with its contactors, which have a hold-in power that is as low as possible in order to optimize energy efficiency while still being able to safely switch the higher starting currents that characterize IE3 motors.

**Clear identification:** Both the contactors in the DIL series and the motor-protective circuit-breakers in the PKZ and PKE product lines are already perfect choices for safely operating IE3 motors. And in order to enable users to easily identify these devices so that they can select their products more easily, the company is using a label (see figure 9) that clearly indicates that these products are "IE3-ready." This way, users can rest assured knowing that there will not be any nasty surprises waiting around the corner. In addition, the label is particularly important due to the fact that the machine-building industry has operations worldwide – this, combined with how different parts of the world are implementing higher-efficiency motors gradually at different times, makes it very likely that inventories will have both non-IE3-ready and IE3-ready devices at one point or another. This is where the label can help avoid the costly mistake of using completely unsuitable components in order to start IE3 motors.

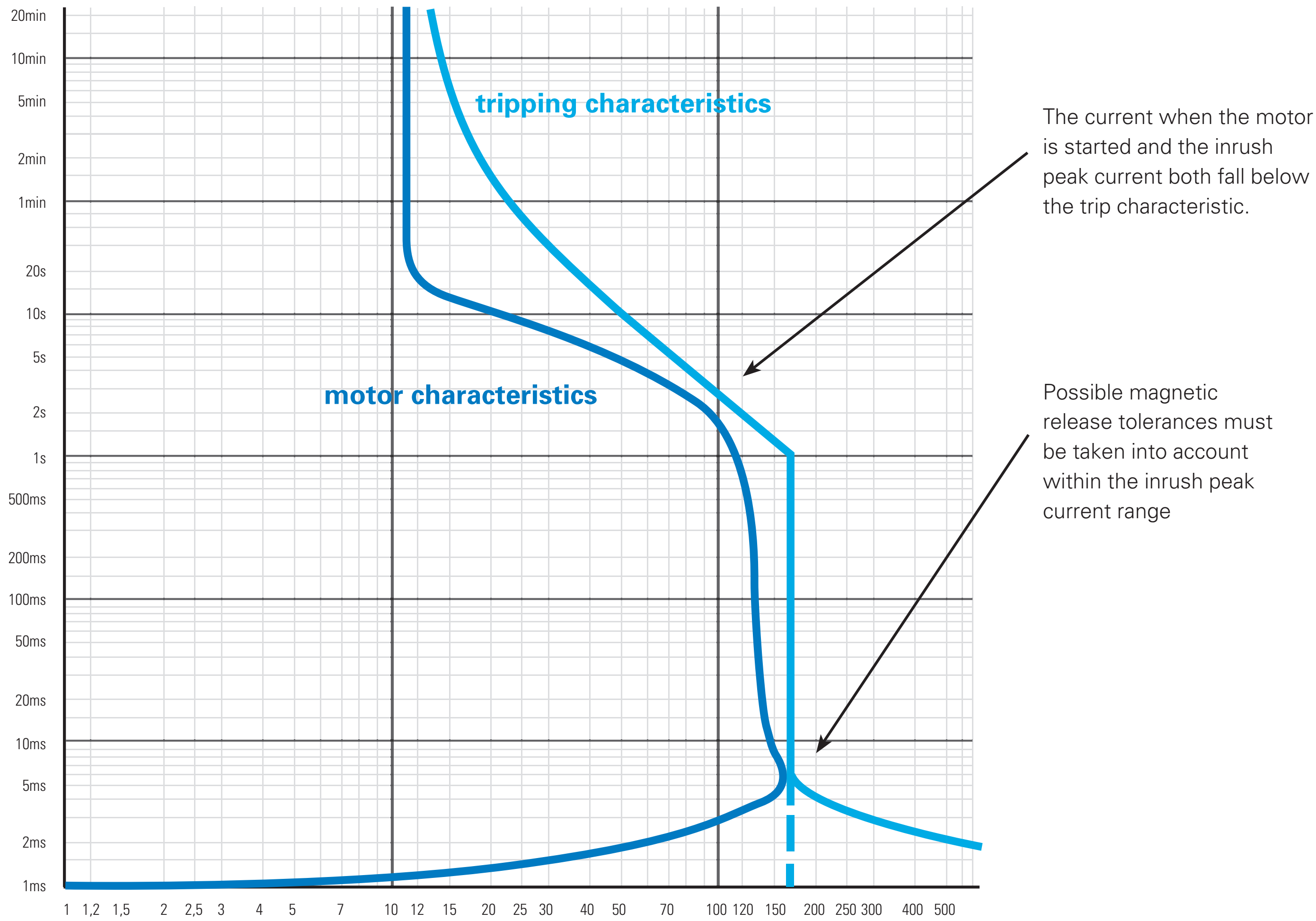



*Fig. 8: Trip behavior of a mechanical motor-protective circuit-breaker during a test run with a 5.5 kW IE3-electric motor. Source: Eaton*


*Fig. 9: DIL contactors and PKZ and PKE motor-protective circuit-breakers are IE3-ready. Source: Eaton*

**A global solution for everything:** Eaton is one of the first manufacturers to offer a solution that is demonstrated to cover both IE2 and IE3 motors – worldwide. In other words, using Eaton products ensures that users do not have to worry about figuring out which products should be used with which energy efficiency classes, effectively simplifying life despite the new directive. On top of this, the fact that a single product line covers both IE2 and IE3 applications eliminates the need for extra engineering and warehousing work.

**Future-proof:** A draft standard for updating DIN EN 60947-4-1 for IE3 motors is currently being worked on. This is why Eaton's protective devices are designed as future-proof units that are guaranteed to meet any new requirements added to the relevant standards. This also means that users do not have to worry about extra engineering complexities, as Eaton has already taken care of all the development work for them.

DIL ....

PKE ....

PKZM .....

**Bibliography:**


- German Federal Environment Agency, Press Release No. 53/2009, Energy efficiency in electric motors, 2009 http://www.umweltbundesamt.de/en/press/pressinformation/energy-efficiency-in-electric-motors
- Directive 2009/125/EC establishing a framework for the setting of ecodesign requirements for energy-related products
- Commission Regulation (EC) No. 640/2009 of 22 July 2009 implementing Directive 2005/32/EC of the European Parliament and of the Council with regard to ecodesign requirements for electric motors
- Directive 2005/32/EC establishing a framework for the setting of ecodesign requirements for energy-using products
- ZVEI, Electric Motors and Variable Speed Drives – Standards and legal requirements for the energy efficiency of low-voltage three-phase motors, 2013
- German Federal Environment Agency, Press Release No. 53/2009, Energy efficiency in electric motors, 2009
- Commission Regulation (EU) No. 4/2014 of 6 January 2014 amending Regulation (EC) No. 640/2009 implementing Directive 2005/32/EC of the European Parliament and of the Council with regard to ecodesign requirements for electric motors
- Deutsche Energie Agentur GmbH (dena), Dipl.-Ing. Günther Volz, Ratgeber „Elektrische Motoren in Industrie und Gewerbe: Energieeffizienz und Ökodesign-Richtlinie", 2010 Deutsche Energie Agentur GmbH (dena), Dipl.-Ing. Günther Volz, Ratgeber „Elektrische Motoren in Industrie und Gewerbe: Energieeffizienz und Ökodesign-Richtlinie", 2010 [„Electric Motors in the Industrial and Commercial Sector: Energy Efficiency and Ecodesign Directive, available in German only]
- DIN EN 60947-1:2011-10; VDE 0660-100:2011-10, Low-voltage switchgear and controlgear – Part 1: General rules (IEC 60947-1:2007 + A1:2010); German version EN 60947-1:2007 + A1:2011
- IEC 60034-30: 2008, standard defining efficiency classes for low-voltage motors
- Eaton, Günter Baujan, Ralf Thar, Jan Nowak, "The New ErP Directive: Protecting and Switching IE3 Motors" Study, 2014

IE3

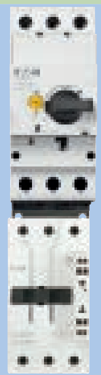
PKZM0 ...+DIL M7 to DIL M15

| Motor data AC-3 380V 400V 415V P (kW) | Rated operational current 400V $I_e$ (A) | Rated short-circuit current 380-415V $I_q$ (kA) | Motor-protective circuit-breaker | Contactor coordination type "1" | Contactor coordination type "2" |
|---|---|---|---|---|---|
| 0.06 | 0.21 | 150/50* | PKZM0-0,25 | DILM7-... | DILM7-... |
| 0.09 | 0.31 | 150/50* | PKZM0-0,4 | DILM7-... | DILM7-... |
| 0.12 | 0.41 | 150/50* | PKZM0-0,63 | DILM7-... | DILM7-... |
| 0.18 | 0.6 | 150/50* | PKZM0-0,63 | DILM7-... | DILM7-... |
| 0.25 | 0.8 | 150/50* | PKZM0-1 | DILM7-... | DILM7-... |
| 0.37 | 1.1 | 150/50* | PKZM0-1,6 | DILM7-... | DILM7-... |
| 0.55 | 1.5 | 150/50* | PKZM0-1,6 | DILM7-... | DILM7-... |

PKZM0 ...+DIL M17 to DIL M32

| Motor data AC-3 380V 400V 415V P (kW) | Rated operational current 400V $I_e$ (A) | Rated short-circuit current 380-415V $I_q$ (kA) | Motor-protective circuit-breaker | Contactor coordination type "1" | Contactor coordination type "2" |
|---|---|---|---|---|---|
| 0.75 | 1.9 | 150/50* | PKZM0-2,5 | DILM7-... | DILM7-... |
| 1.1 | 2.6 | 150/50* | PKZM0-4 | DILM7-... | DILM7-... |
| 1.5 | 3.6 | 150/50* | PKZM0-4 | DILM7-... | DILM7-... |
| 2.2 | 5 | 150/50* | PKZM0-6,3 | DILM7-... | DILM7-... |
| 3 | 6.6 | 150/50* | PKZM0-10 | DILM7-... | DILM17-... |
| 4 | 8.5 | 150/50* | PKZM0-10 | DILM9-... | DILM17-... |
| 5.5 | 11.3 | 50 | PKZM0-12 | DILM12-... | DILM17-... |

PKZM4 ...+DIL M17 to DIL M65



| Motor data AC-3 380V 400V 415V P (kW) | Rated operational current 400V $I_e$ (A) | Rated short-circuit current 380-415V $I_q$ (kA) | Motor-protective circuit-breaker | Contactor coordination type "1" | Contactor coordination type "2" |
|---|---|---|---|---|---|
| 7.5 | 15.2 | 50 | PKZM0-16 | DILM17-... | DILM17-... |
| 11 | 21.7 | 50 | PKZM0-25 | DILM25-... | DILM25-... |
| 15 | 29.3 | 50 | PKZM0-32 | DILM32-... | DILM32-... |
| 18.5 | 36 | 50 | PKZM4-40 | DILM40 | DILM40 |
| 22 | 41 | 50 | PKZM4-50 | DILM50 | DILM50 |
| 30 | 55 | 50 | PKZM4-58 | DILM65 | DILM65 |
| 34 | 63 | 50 | PKZM4-63 | DILM65 | DILM65 |

NZM...+DIL M72 to DIL M500

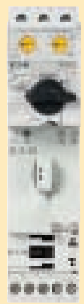
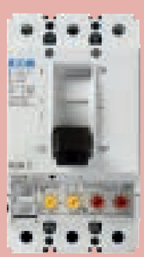
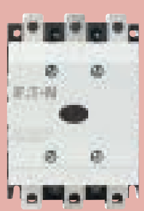
| Motor data AC-3 380V 400V 415V P (kW) | Rated operational current 400V $I_e$ (A) | Rated short-circuit current 380-415V $I_q$ (kA) | Motor-protective circuit-breaker | Contactor coordination type "1" | Contactor coordination type "2" |
|---|---|---|---|---|---|
| 37 | 68 | 50 | NZMN1-M80 | DILM80 | DILM80 |
| 45 | 81 | 50 | NZMN1-M100 | DILM95 | DILM95 |
| 55 | 99 | 50 | NZMN1-M100 | DILM115 | DILM115 |
| 75 | 134 | 50 | NZMN2-M160 | DILM150 | DILM150 |
| 90 | 161 | 50 | NZMN2-M200 | DILM185A | DILM185A |
| 110 | 196 | 50 | NZMN2-M200 | DILM225A | DILM225A |
| 132 | 231 | 50 | NZMN3-ME350 | DILM250 | DILM250 |
| 160 | 279 | 50 | NZMN3-ME350 | DILM300A | DILM300A |
| 200 | 349 | 50 | NZMN3-ME350 | DILM400 | DILM400 |
| 250 | 437 | 50 | NZMN3-ME450 | DILM500 | DILM500 |

* Type 2 coordination

# Motor-starter combinations

with Electronic Overload Release

IE3

| Series | | Motor data: AC-3 380V 400V 415V P (kW) | Rated operational current 400V $I_e$ (A) | Rated short-circuit current 380-415V $I_q$ (kA) | Motor-protective circuit-breaker | Contactor coordination type "1" | Contactor coordination type "2" |
|---|---|---|---|---|---|---|---|
| PKE …+DIL M7 to DIL M12 |  | 0.06 | 0.21 | 100 | PKE12/XTU-1,2 | DILM7-… | DILM17-… |
| | | 0.09 | 0.31 | 100 | PKE12/XTU-1,2 | DILM7-… | DILM17-… |
| | | 0.12 | 0.41 | 100 | PKE12/XTU-1,2 | DILM7-… | DILM17-… |
| | | 0.18 | 0.6 | 100 | PKE12/XTU-1,2 | DILM7-… | DILM17-… |
| | | 0.25 | 0.8 | 100 | PKE12/XTU-1,2 | DILM7-… | DILM17-… |
| | | 0.37 | 1.1 | 100 | PKE12/XTU-1,2 | DILM7-… | DILM17-… |
| | | 0.55 | 1.5 | 100 | PKE12/XTU-4 | DILM7-… | DILM17-… |
| PKE …+DIL M17 to DIL M32 |  | 0.75 | 1.9 | 100 | PKE12/XTU-4 | DILM7-… | DILM17-… |
| | | 1.1 | 2.6 | 100 | PKE12/XTU-4 | DILM7-… | DILM17-… |
| | | 1.5 | 3.6 | 100 | PKE12/XTU-4 | DILM7-… | DILM17-… |
| | | 2.2 | 5 | 100 | PKE12/XTU-12 | DILM7-… | DILM17-… |
| | | 3 | 6.6 | 100 | PKE12/XTU-12 | DILM7-… | DILM17-… |
| | | 4 | 8.5 | 100 | PKE12/XTU-12 | DILM9-… | DILM17-… |
| | | 5.5 | 11.3 | 100 | PKE12/XTU-12 | DILM12-… | DILM17-… |
| PKE 65 …+DIL M40 to DIL M65 |  | 7.5 | 15.2 | 100 | PKE32/XTU-32 | DILM17-… | DILM17-… |
| | | 11 | 21.7 | 100 | PKE32/XTU-32 | DILM25-… | DILM25-… |
| | | 15 | 29.3 | 100 | PKE32/XTU-32 | DILM32-… | DILM32-… |
| | | 18.5 | 36 | 80 | PKE65/XTUW-65 | DILM40 | DILM40 |
| | | 22 | 41 | 80 | PKE65/XTUW-65 | DILM50 | DILM50 |
| | | 30 | 55 | 80 | PKE65/XTUW-65 | DILM65 | DILM65 |
| | | 34 | 63 | 80 | PKE65/XTUW-65 | DILM65 | DILM65 |
| NZM…ME…+DIL M80 to DIL M500 |  | 37 | 68 | 100 | NZMH2-ME90 | DILM80 | DILM80 |
| | | 45 | 81 | 100 | NZMH2-ME90 | DILM95 | DILM95 |
| | | 55 | 99 | 100 | NZMH2-ME140 | DILM115 | DILM115 |
| | | 75 | 134 | 100 | NZMH2-ME140 | DILM150 | DILM150 |
| | | 90 | 161 | 100 | NZMH2-ME220 | DILM185A | DILM185A |
| |  | 110 | 196 | 100 | NZMH2-ME220 | DILM225A | DILM225A |
| | | 132 | 231 | 100 | NZMH3-ME350 | DILM250 | DILM250 |
| | | 160 | 279 | 100 | NZMH3-ME350 | DILM300A | DILM300A |
| | | 200 | 349 | 100 | NZMH3-ME350 | DILM400 | DILM400 |
| | | 250 | 437 | 100 | NZMH3-ME450 | DILM500 | DILM500 |

Eaton is dedicated to ensuring that reliable, efficient and safe power is available when it's needed most. With unparalleled knowledge of electrical power management across industries, experts at Eaton deliver customized, integrated solutions to solve our customers' most critical challenges.

Our focus is on delivering the right solution for the application. But, decision makers demand more than just innovative products. They turn to Eaton for an unwavering commitment to personal support that makes customer success a top priority. For more information, **visit www.eaton.eu/electrical.**

**To contact an Eaton salesperson or local distributor/agent, please visit www.eaton.eu/electrical/customersupport**

Powering Business Worldwide

**Eaton Industries GmbH**
Hein-Moeller-Str. 7–11
D-53115 Bonn/Germany


Printed in Germany 03/15
Publication No.: WP042001EN
ip May 2015
Article No.: 179526

4 015081 746101