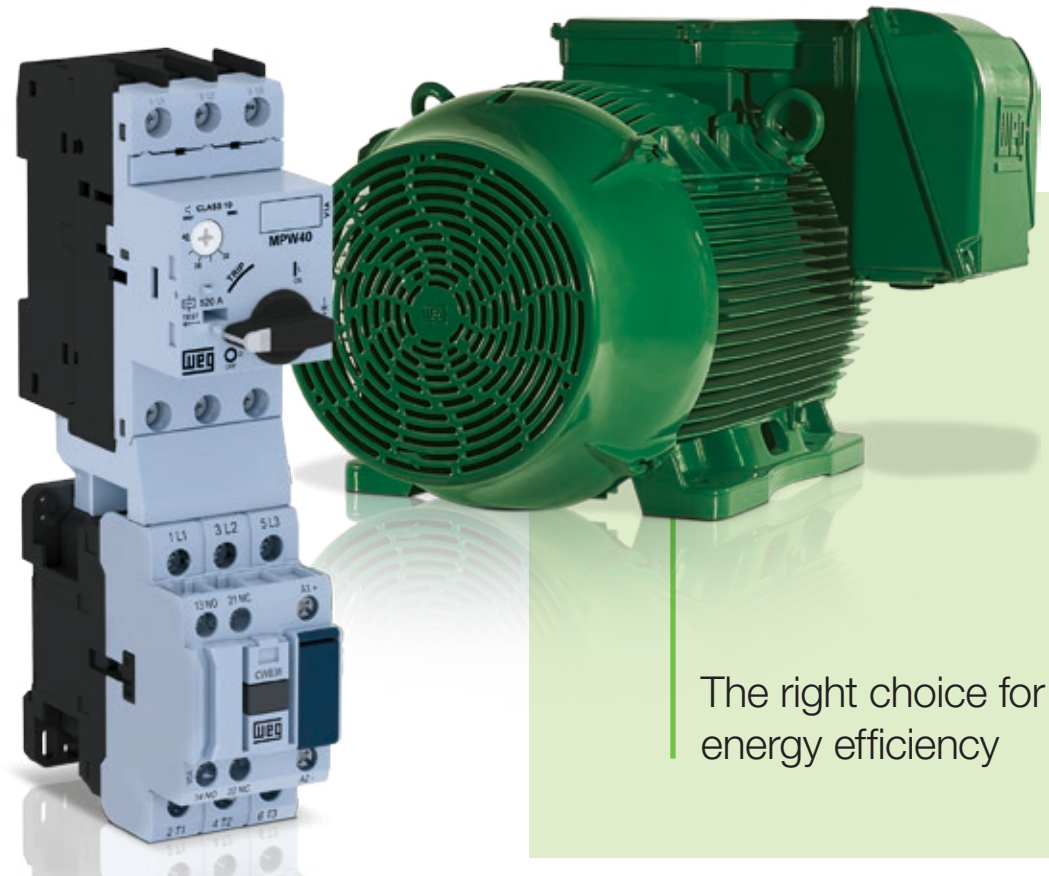
Motors | Automation | Energy | Transmission & Distribution | Coatings



WEG Control and Protection Components

Technical Bulletin - WEG: Conform to IE3 Motors.
European directive 640/2009/EC and implications on low voltage motor control and protections components.





The right choice for energy efficiency

IE3 CONFORM

WEG: IE3-conform motor control and protection components



The most recent change of the European directive 640/2009/EC, which went into force in January 2015, affects manufacturers and users of electric motors and switching and protection components. According to the new regulation, motors with rated outputs from 7.5 to 375 kW must not be less efficient than the IE3 efficiency level or may still be IE2 efficiency level if equipped with variable speed drives.

For WEG the pursuit for means to lower the cost of energy and care for the environment has been a concern and commitment for many years. ***This new regulation only emphasizes how ahead of our time we have always been.*** WEG has been producing premium and super premium efficiency electric motors (IE3 and IE4) for over fifteen years. The company is aware that behind the increase in efficiency lie important optimizations in motor designs with possible impacts on switching and protection components.

Company experts list the use of cores with thinner silicon steel laminations, greater silicon concentration and windings with increased copper mass as the main optimizations. Improvements also include reduced air-gaps and a more efficient cooling system.

With the higher efficiency, it is common for IE3 motors to present higher inrush and starting currents in comparison to IE2 motors. Thus, one question arises: ***"Is it necessary to use a derating factor when WEG switching and protection components are sized for IE3 motors"?*** The answer to this is simple and objective: WEG's line of components has been developed and improved alongside IE3 motors, therefore, it is suitable for such purpose and no derating factor is necessary, or, in short, ***WEG components are IE3-conform.***

Due to all recent changes in standards and directives and their implications, some uncertainty is natural. WEG strives to fulfill the trust and confidence that ever receives from users and therefore, provides this technical bulletin in order reassure them. If on one hand the use of premium efficiency motors is mandatory, ***the choice of switching and protection components for IE3 motors is the users' decision.*** The following pages are meant to guide users through such selection, ensuring them that WEG switching and protection components are IE3-conform.



Focused on sustainability and improving life quality, several regulations and directives have been established, aiming at cutting down power consumption and CO_2 emission. Directive 2009/125/EC for Energy Related Products, also known as ErP directive, was created in order to obtain reduction and conscious consumption of electric energy.

It defines the ***"ecological concept requirements of the products relating to energy"***. The directive focuses on encouraging the improvement of electrical equipment to be more efficient and to reduce environmental impacts, once electric energy consumption should keep significantly growing in the next twenty years, as mentioned on the ErP directive itself.

Governments worldwide, especially in the European Union, have increased their attention on the industry's carbon footprint in general, and the energy use of motors in particular. Because electric motors account for as much as 70% of industry's energy usage, this attention is very well-deserved.

As stated by the German Federal Environment Agency in report 53/2009 regarding the "Energy Efficiency in Electric Motors", the forecast for energy consumption by electric motors of the 27 member countries of the European Union may reach 135 billion kWh in 2020.

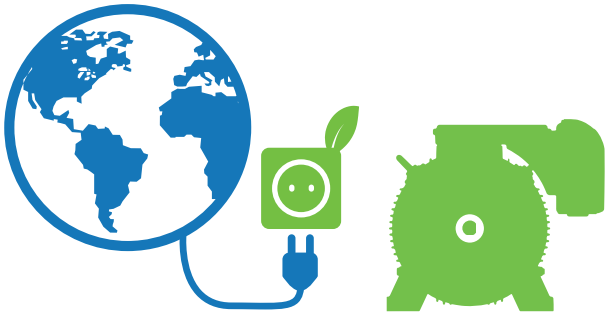
However, this should not be seen as a negative. It simply means that by choosing the right electric motors and switching and protection components, users can make a dramatic difference to their carbon footprint. And even better, by reducing carbon footprint with more efficient motors, users also reduce energy bills and increase profitability.

The German Agency also points out that the use of high-efficiency motors may generate savings of up to 27 billion kWh, and emission reduction of about 16 million tons of CO_2 in 2020, taking into account Germany only.
In view of this context, the IEC 60034-30-1 (Rotating Electrical Machines: Efficiency Classes of line operated AC motors - IE code) was reviewed in 2014 so as to define new efficiency classes for induction motors.

New Motor Classification

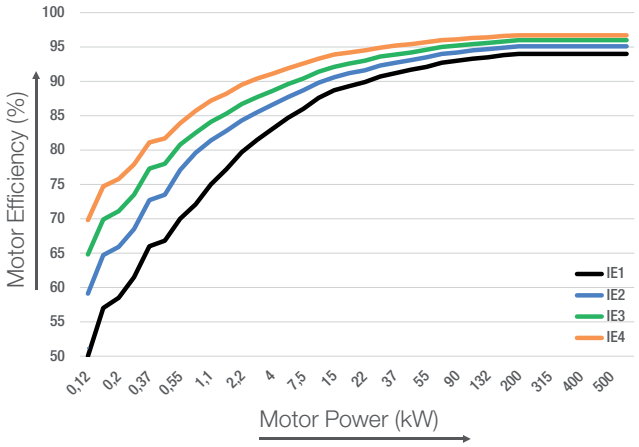
IEC 60034-30-1 classifies electric motors as follows:

IE1	Standard Efficiency
IE2	High Efficiency
IE3	Premium Efficiency
IE4	Super Premium Efficiency



The IE (International Efficiency) classification for motors complying with IEC 60034-1 or IEC 60079-0 (explosive atmospheres) classifies motors according to their efficiency and output. The following picture presents the relationship between efficiency and output for the new IE classification.

Efficiency Curves for Asynchronous Motors, According to IE Classification



Source: IEC 60034-30-1

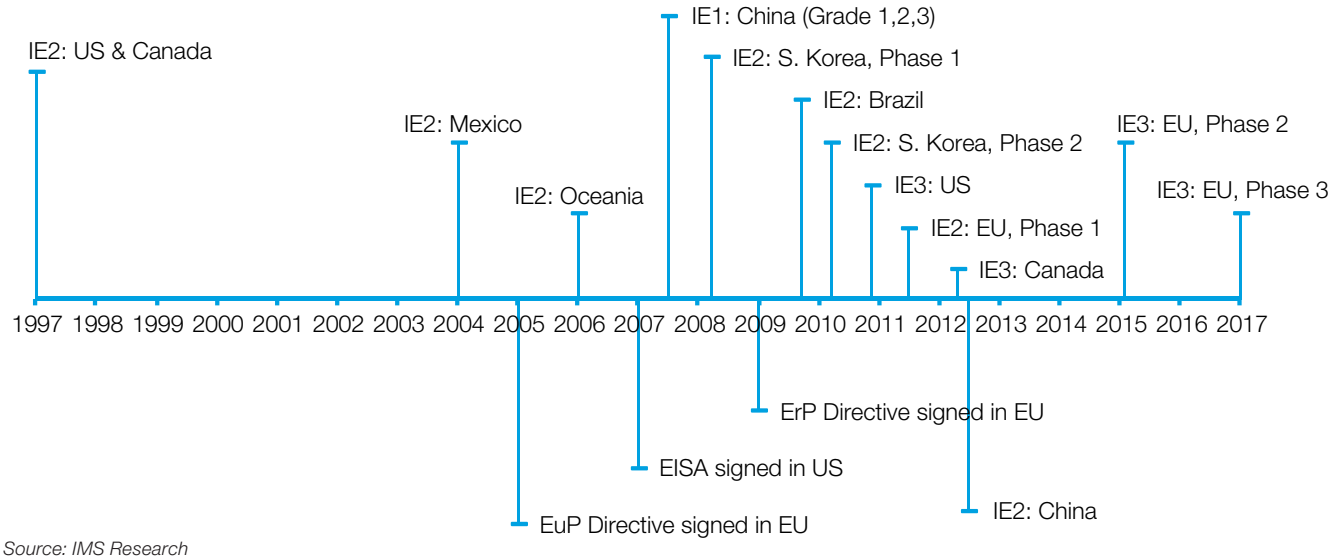
The "Energy Independence and Security Act 2007" establishes energy efficiency levels for NEMA motors, used in North America since 2010, as being NEMA premium efficiency, which in turn is equivalent to the IE classification as follows:

IE classification	NEMA classification
IE1	EFF2
IE2	EFF1
IE3	-
IE4	-

As shown in the following picture, the first attempt to regulate motor efficiency took place in 1997 in the USA and Canada. Later, the first European standard was published in 2005. Yet the intensification of the use of such classification began in mid-2010 with the launch of IE3 motors. According to EU Regulation 640/2009, as of 2015 the use of motors with efficiency below IE3 is not allowed in countries of the European Union, represented in the chart as IE3 Phase 2. The use of IE2 motors is still allowed only if equipped with variable speed drives.

EU Regulation 640/2009 establishes the implementation of motors as follows:
- As of January 2015, only IE3 motors will be allowed for outputs between 7.5 to 375 kW (Phase 2)
- As of January 2017, motors between 0.75 to 7.5 kW will also follow the same rule, that is, only classification IE3 will be allowed

Timeline for Motor Efficiency Class Transitions Around the World



Source: IMS Research

Which Motors Fall Into the New Classification?

The new standard encompasses a range of motors (0.12 kW - 1,000 kW) that is wider than the range of 7.5 to 375 kW of the new EU Regulation 640/2009. It also defines several technical requirements for operation and application. The following chart contains a summary of IEC 60034-30-1 motors that are part of the new regulation.

Motors according to IEC 60034-30-1	
Scope	Single-speed electric motors that are rated for operation on a sinusoidal voltage supply
	Motors capable of continuous operation at their rated power with a temperature rise within the specified insulation temperature class
Poles	2, 4, 6 or 8
Rated power (P_N)	0.12 kW - 1,000 kW
Rated voltage (U_N)	50 V - 1,000 V
Degree of protection	All
Ambient temperature	-20 °C to +60 °C
Altitude	<4,000 m above sea level

Motors excluded from IEC 60034-30-1
Single-speed motors with 10 or more poles or multi-speed motors
Motors completely integrated into a machine (for example pump, fan and compressor) that cannot be practically tested separately from the machine
Brake motors, when the motor cannot be supplied and tested separately
Motor with mechanical commutators (such as DC motors)

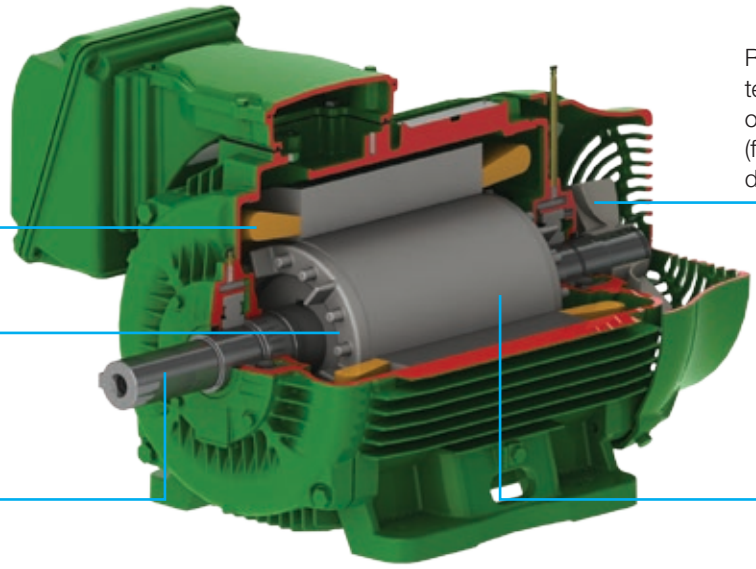
Impacts on the Design of Motors

The new requirements of ErP directive related to the requirement of a ***higher efficiency*** in compliance with standard IEC 60034-30-1 have made manufacturers adjust their motor designs. The increased mass of copper on the stator, use of cores with thinner silicon laminations and with greater silicon concentration, optimized air-gaps, greater amount of conductor material on the rotor, improvements on cooling systems, among others, are among the necessary changes to increase the motor efficiency.

Such modifications provide IE3 motors with ***greater inductances than standard motors***. Moreover, the copper losses are smaller, which make the starting currents of this kind of motors to be above conventional motors (IE1 and IE2). As a consequence of the increase in the starting current, motor switching and protection components, like circuit breakers and contactors, must be prepared to meet the demands of this new behavior. The increase of starting currents may generate undesired tripping on motor-protective circuit breakers due to the actuation of its short circuit release mechanism. That may happen because their magnetic characteristics make them sensitive to instantaneous current values.

In the case of contactors, the high starting currents may produce excessive heating. Contact welding is only expected in more extreme cases on contactors that have high contact bouncing levels and when the rated thermal current value (Ith) is exceeded by much. ***In short, in order to meet the demands of this new efficiency class, users need robust products that guarantee smooth operation of motors while ensuring the safety of the installation.***

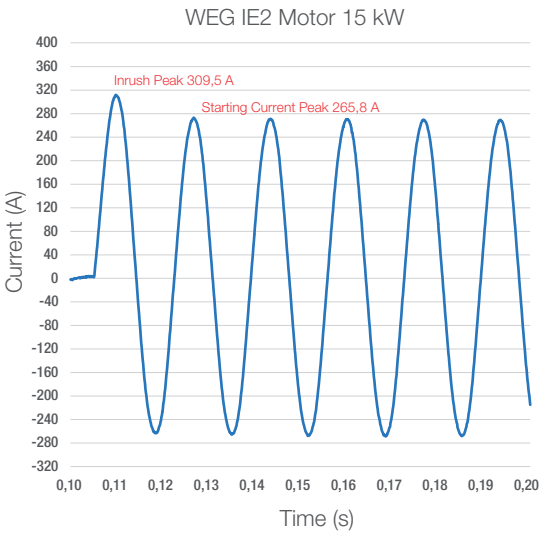
Crop-View of a WEG W22 Premium Efficiency Motor



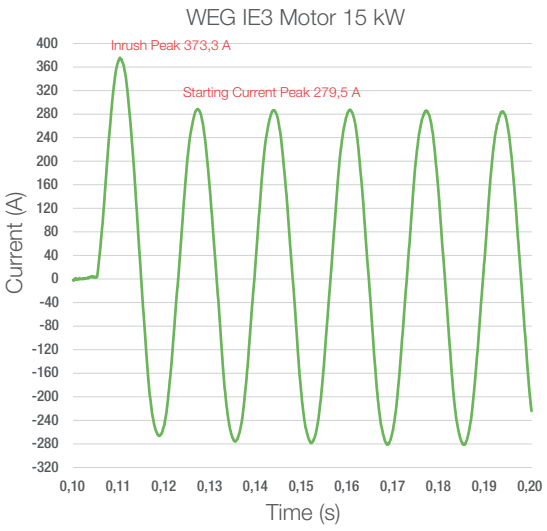
The Behavior of IE3 Motors

In order to ensure the perfect operation of the whole line of switching and protection components, WEG carried out a thorough study with products of the main global electric motor manufacturers. In this study, IE2 motors were compared to IE3 motors so as to know better, and quantify effects of the starting current. As an example, the following pictures show the behavior of the starting current under locked rotor condition of two WEG motors with the same power output, but different efficiency classifications, IE2 and IE3.

Locked-Rotor Behavior of 15 kW IE2 Motor. Source: WEG



Locked-Rotor Behavior of 15 kW IE3 Motor. Source: WEG



Based on the curves previously shown, some factors can be calculated to help the comprehension of the main differences between IE2 and IE3 motors regarding the switching and protection components.

Efficiency level		IE2	IE3	
Motor nameplate data				
Output power	kW	15	15	
Full load current In (RMS)	A	30.2	29.5	
Power factor		0.83	0.84	
Efficiency	%	91.3	92.3	
Test results				IE3/IE2
Inrush current (peak value)	A	309.5	373.3	1.21
Starting current (peak value)	A	265.8	279.5	1.05
Starting current (RMS)	A	187.9	197.6	1.05
Comparison factors				IE3/IE2
Inrush current (peak value) / full load current (RMS)		10.2	12.7	1.23
Starting current (RMS) / full load current (RMS)		6.2	6.7	1.08

When comparing the test results, it is noticeable that the starting current is 5% higher and the inrush (peak value) is 21% higher on the IE3 motor. The ratio between the peak of the inrush current and the rms value of the full load current of the motor is very important factor because it is related to the multiple of the short circuit release on motor-protective circuit breakers. The value of this ratio is 12.7 on the IE3 motor, that is, 23% higher than the one found on the IE2 motor.

The short circuit release of WEG motor-protective circuit breakers is calibrated at 13 times the upper limit of its current range. When this factor (13) is multiplied by $\sqrt{2}$, the value 18.4 is obtained which represents the peak value of the current of the short circuit release. Comparing now to the value of 12.7 (ratio between the peak of the inrush current and the rms value of the full load current of the IE3 motor) it is clear that even when switching IE3 motors, the undesirable tripping will not occur. The increase on starting currents of IE3 motors are concerning the normative committees which are evaluating the possibility to adequate the relevant standards, such as IEC 60947, which establish the construction and test requirements for low voltage switching and protection devices.



If the Motor Changed, did the Switching and Protection Components Change Too?

As one of the largest manufacturers of electric motors in the world, WEG has already been studying and producing premium and super premium efficiency motors for years. With the changes in regulations, several modifications were implemented in its motors, and the same holds true for the line of switching and protection components. In the past years, the behavior of IE3 motors of several manufacturers have been studied, and hundreds of hours of engineering have been employed in the improvement of products so that they can always operate in a coordinate and safe way.

Is Complying with IEC 60947-1, IEC 60947-2 and IEC 60947-4-1 Standards Enough?

The IEC 60947 (Low-voltage switchgear and Controlgear) standard, which defines the values for currents to be tested, does not take into account inrush values as high as those found on IE3 motors, and thus it was necessary to carry out a much more thorough investigation. In order to ensure that such new characteristics be continuously assessed, WEG employs special test inductors in the development and routine tests of its products. Those inductors, exclusively developed for such purpose, allow simulating inrush current characteristics of premium efficiency motors in the test of motor-protective circuit breakers, contactors and overload relays. Finally, in order to ensure the perfect operation of WEG components together with IE3 motors, all test sequences of IEC60947 were redesigned, taking into account the specific characteristics of those motors.

Compliance with Performance Requirements - Test Sequences - IEC 60947-4-1

Test sequence 1	Test sequence 2	Test sequence 3	Test sequence 4 (applicable to contactors only)	Test sequence 5	Acceptance criteria
1) Verification of temperature rise 2) Verification of operation and operating limits 3) Verification of dielectric properties	1) Verification of rated making and breaking capacities, change-over ability and reversibility, where applicable 2) Verification of conventional operational performance	1) Performance under short-circuit conditions	1) Verification of ability to withstand overload currents	1) Verification of mechanical properties of terminals 2) Verification of degrees of protection of enclosed contactors and starters	There shall be no failure in any of the tests

After All, What has Changed on WEG Products?



Motor-Protective Circuit Breakers

The motor-protective circuit breaker is definitely the component ***most affected by higher starting currents and inrushes of premium efficiency motors*** due to its sensibility to transients and instantaneous values of current. In 2010, the whole line of WEG circuit breakers was ***evaluated and adjusted***. In that occasion those components underwent improvements to suit new demands, when the multiple of the short circuit release was changed from 12 to 13 times the rms value of the rated current.

In the sequence, exhaustive tests has been carried out with a comprehensive number of IE3 motors of different manufacturers driven by WEG motor-protective circuit breaker and no undesired tripping occurred, which confirms that the modification done in 2010 was consistent with the behavior of motors of the new efficiency classification. Thus, ***since 2010, the whole line of WEG circuit breakers is IE3-conform***.



Contactors

The whole line of WEG contactors is conforming to IE3 motor applications. This accomplishment results from the fact that, in order to withstand higher inrush currents, WEG contactors have undergone several optimizations in the past five years - efforts that were even increased in the CWB contactor line. Since the inrush is a transient phenomenon that only occurs in the first semi-cycle of the current, the most important and effective improvement was the ***reduction of contact bouncing levels during switch-on***.

The contact bouncing reduction was achieved by reducing the kinetic energy of the contacts. In order to do so, several components were improved so as to make lighter the whole movable assembly of the contactor (movable core, plastic contact carrier, contact springs and contact bridges). It was also necessary to employ copper alloys with special hardness, optimize the design of cores and coils so as to increase the magnetic forces and, in some cases, even increase contact spring forces. All optimizations were carried out with ***the commitment to obtaining the desired improvements without reducing mechanical and electrical lifespan or increasing contactor's coil consumption***.





Overload Relays

Overload relays are devices designed to simulate the heat produced on motors and that, unlike motor-protective circuit breakers, are not sensitive to instantaneous currents. That makes WEG solid-state and thermal overload relays be conform to IE3 motor applications. The working principles of overload relays depend basically on the square of the current and on its duration (I^2t) that is known as the let-through energy.

On thermal overload relays, the motor heating is simulated by passing motor current directly or indirectly through bimetal strips. The heat generated by joule effect (i^2t) bends the bimetallic strips and, depending on the current set on the relay, a trip mechanism is activated. On solid-state overload relays, the motor current is measured by current transformers and then converted into an electronic signal. The hypothetical thermal energy generated by this current is mathematically calculated by a microprocessor that, based on the parameter settings, defines whether a trip mechanism is activated or not.

Regardless of the construction technology of the overload relay, whether thermal or solid-state, the inrush current is an extremely brief transient phenomenon and the thermal energy it generates is virtually negligible, therefore, it is not enough to cause a tripping. In addition, the current ranges of WEG overload relays have been ***carefully evaluated and there has been no need of changes***, because the currently available limits properly fulfill the complete range of currents of commercial IE3 motors.

Always One Step Ahead

It is WEG philosophy to pursue quality and innovation leadership and it is clear that focusing on the future requires a constant willingness to innovate and change.
By thinking on future energy efficiency classes, the company is constantly evaluating and testing its Control and Protection components with motors of different manufacturers. Therefore, keeping WEG products able to apply with motors in accordance with the market regulations.

In a few words, WEG provides a complete and reliable line of IE3-conform Control and Protection components.



Lowering the cost of energy

WEG: IE3-Conform Motor Control and Protection Components

CONTACTORS

- CWM LINE
- CWB LINE
- CWC LINE

MOTOR-PROTECTIVE CIRCUIT BREAKERS

- MPW LINE

OVERLOAD RELAYS

- RW LINE
- RW_E LINE





How to Identify WEG IE3-Conform Products

In order to ensure greater safety and convenience to users at the moment of selecting the motor switching and protection components, WEG motor-protective circuit breakers, contactors and overload relays will receive the logo “IE3-conform” on their packages.



References

DIRECTIVE 2009/125/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 21 October 2009 establishing a framework for the setting of eco-design 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

German Federal Environment Agency, Press release Nr. 53/2009, Energieeffizienz bei Elektromotoren

IMS Research - Low Voltage Motors & Drives, Global Market Update, Feb. 2013
http://www.e-driveonline.com/conferences/wp-content/uploads/2013/02/NewIMS.pdf

IEC 60034-30-1 - Rotating electrical machines - Part 30-1: Efficiency classes of line operated AC motors (IE code)

IEC 60947-1 - Low-Voltage switchgear and controlgear - Part 1: General Rules

IEC 60947-4-1 - Low-voltage switchgear and controlgear- Part 4-1: Contactors and motor-starters - Electromechanical contactors and motor-starters

WEG - 22 Ways to improve motor efficiency and prolong lifespan
http://ecatalog.weg.net/files/wegnet/WEG-w22-three-phase-motor-22-ways-european-market-50030095-brochure-english.pdf

WEG - Super Premium Efficiency Motors
http://ecatalog.weg.net/files/wegnet/WEG-w22-super-premium-50039723-brochure-english.pdf

CAPIEL - Motor Regulation - Efficient System Design
http://www.capiel.eu/data/Journal_CAPIEL_MOTEUR-2_EN.pdf

WEG - Global Energy Programs - Energy Efficiency Legislation 2015 and beyond
http://ecatalog.weg.net/files/wegnet/WEG-motor-global-energy-efficiency-legislations-2015-and-beyond-energyeffleg-training-english.pdf