COMMISSION REGULATION (EU) 2019/1781

of 1 October 2019

laying down ecodesign requirements for electric motors and variable speed drives pursuant to Directive 2009/125/EC of the European Parliament and of the Council, amending Regulation (EC) No 641/2009 with regard to ecodesign requirements for glandless standalone circulators and glandless circulators integrated in products and repealing Commission Regulation (EC) No 640/2009

(Text with EEA relevance)

THE EUROPEAN COMMISSION,

Having regard to Article 114 of the Treaty on the Functioning of the European Union,

Having regard to Directive 2009/125/EC of the European Parliament and of the Council of 21 October 2009 establishing a framework for the setting of ecodesign requirements for energy-related products ([1]), and in particular Article 15(1) thereof,

Whereas:

(1) Pursuant to Directive 2009/125/EC, the Commission should set ecodesign requirements for energy-related products which account for significant volumes of sales and trade in the Union and which have a significant environmental impact and present significant potential for improvement through design in terms of their environmental impact, without entailing excessive costs.

(2) The Communication from the Commission COM(2016)773 ([2]) (ecodesign working plan established by the Commission in application of Article 16(1) of Directive 2009/125/EC sets out the working priorities under the ecodesign and energy labelling framework for the period 2016-2019. The ecodesign working plan identifies the energy-related product groups to be considered as priorities for the undertaking of preparatory studies and eventual adoption of implementing measures, as well as the review of Commission Regulation (EC) No 640/2009 ([3]).

(3) Measures from the Working Plan have an estimated potential to deliver a total in excess of 260 TWh of annual final energy savings in 2030, which is equivalent to reducing greenhouse gas emissions by approximately 100 million tonnes per year in 2030. Electric motors is one of the product groups listed in the Working Plan, with an estimated 10 TWh of annual final energy savings in 2030.

(4) The Commission established ecodesign requirements for electric motors in Regulation (EC) No 640/2009 and pursuant to that Regulation, the Commission shall review that Regulation in the light of technological progress on both motors and drives.

(5) Pursuant to Article 7 of Regulation (EC) No 640/2009, the Commission has reviewed Regulation (EC) No 640/2009 and analysed the technical, environmental and economic aspects of electric motors and drives. The review was carried out in close cooperation with stakeholders and interested parties from the Union and third countries. Its results were made public and presented to the Consultation Forum established pursuant to Article 18 of Directive 2009/125/EC.

(6) The review study shows that electric motor driven systems use about half the electricity produced in the Union. It is estimated that electric motors converted 1 425 TWh of electricity into mechanical energy and heat in 2015, corresponding to 560 Mt of CO_2-equivalent emissions. This value is expected to rise to around 1 470 TWh by 2020 and to about 1 500 TWh by 2030.

([1]) OJ L 285, 31.10.2009, p. 10.
([2]) Communication from the Commission. Ecodesign working plan 2016-2019, COM(2016) 773 final, 30.11.2016.
([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 (OJ L 191, 23.7.2009, p. 26).

(7) The review also shows that variable speed drives are placed on the Union's market in large quantities, helping to control motor speed and increase energy efficiency of motor systems, with their use-phase energy consumption being the most significant environmental aspect of all life cycle phases. In 2015, variable speed drives converted about 265 TWh of electricity from the grid into electricity with a frequency suited for the driven application; this corresponds to 105 Mt of CO_2 emissions. This value is expected to rise to around 380 TWh by 2020 and to about 570 TWh by 2030.

(8) The review indicates that Regulation (EC) No 640/2009 would save 57 TWh annually by 2020 and 102 TWh annually by 2030. As the provisions of that Regulation are being maintained, these savings will also continue to materialise.

(9) There is significant additional scope for improving these motor driven systems' energy efficiency cost-effectively. One cost-effective way to do so is by making motors more energy-efficient, including motors not covered by Regulation (EC) No 640/2009, and using energy-efficient variable speed drives. This implies that ecodesign requirements for electric motors should be adjusted and ecodesign requirements set for variable speed drives, to realise their full potential for cost-effective energy efficiency.

(10) Ecodesign requirements should also include product information requirements that will help potential buyers make the most appropriate decision and make it easier for Member States to perform market surveillance.

(11) Many motors are integrated in other products. To maximise cost-efficient energy saving, this Regulation should apply to such motors, provided that their efficiency can be tested separately.

(12) The environmental aspect of products in the scope of this Regulation that have been identified as significant for the purposes of this Regulation is energy consumption in the use phase.

(13) Electric motors are used in many different types of products, such as pumps, fans or machine tools, and under many different operating conditions. The energy use of motor-driven systems can be reduced if motors in variable speed and load applications are equipped with variable speed drives, but also if these drives have their own minimum energy efficiency requirements. In fixed speed (constant load) applications, a variable speed drive induces additional costs and energy losses. The use of a variable speed drive should not, therefore, be mandatory under this Regulation.

(14) Improvements in the electricity consumption of electric motors and variable speed drives should be achieved by applying existing, non-proprietary and cost-effective technologies that can reduce the total combined costs of purchasing and operating them.

(15) Ecodesign requirements should harmonise energy efficiency requirements for electric motors and variable speed drives throughout the Union, thus contributing to the smooth operation of the internal market and helping to improve these products' environmental performance.

(16) Manufacturers should have enough time to redesign or adapt their products where needed. The timing should be such as to minimise negative impact on the functionalities of electric motors or variable speed drives. It should also take account of cost implications for manufacturers, including small and medium-sized enterprises, while ensuring that the objectives pursued by this Regulation are achieved in good time.

(17) The inclusion of motors not covered by Regulation (EC) No 640/2009, notably smaller and larger motors, in conjunction with updated minimum energy efficiency requirements that are in line with international standards and technological progress, and together with the inclusion of variable speed drives, should increase the market penetration of electric motors and variable speed drives with an improved life-cycle environmental impact. This should result in additional estimated net electricity savings of 10 TWh per year, and should reduce net greenhouse gas emissions by 3 Mt CO_2 equivalent annually by 2030, compared with the situation that would prevail if no additional measures were taken.

(18) Although the environmental impacts of medium voltage motors are relevant, for the time being no classification exists for the energy efficiency of electric motors with a rated voltage above 1 000 V. Once such a classification is developed, the possibility of setting minimum requirements for medium voltage motors should be reassessed.

(19) Although the environmental impacts of submersible motors are relevant, there is, at the present time, no test standard that defines energy efficiency classes for these motors. Once such a test standard and classification is developed, the possibility of setting minimum requirements for submersible motors should be reassessed.

(20) The Commission communication on the circular economy ([4]) and the Communication on the ecodesign working plan ([5]) underline the importance of using the ecodesign framework to support the move towards a more resource efficient and circular economy. This Regulation should therefore, in order to cut the costs of repairing products containing motors that were placed on the market before the entry into force of the Regulation, or to avoid scrapping them early if they cannot be repaired, provide that motors supplied as spare parts be exempted for a given period. This is meant to avoid the problem that arises if it is impossible to replace a non-compliant motor by a compliant one without disproportionate costs to the end-user. If such motors are intended for the repair of products for which specific availability of spare parts provisions covering motors have been set in other ecodesign regulations, such specific provisions have precedence over the spare parts provisions in this Regulation.

(21) In particular situations, for instance, where safety, functionality or disproportionate costs are at stake, certain motors or variable speed drives (VSDs) should be exempted from efficiency requirements. However, this Regulation should nonetheless cover such products as regards product information requirements, such as information concerning disassembly, recycling or disposal at end-of-life, or other information useful for market surveillance purposes.

(22) The relevant product parameters should be determined using reliable, accurate and reproducible methods. These methods should take into account the recognised state-of-the-art methods including, where available, harmonised standards adopted by the European standardisation organisations, as listed in Annex I to Regulation (EU) No 1025/2012 of the European Parliament and of the Council ([6]).

(23) An appropriate standard to determine the specific duty types S1, S3 or S6 is IEC 60034-1:2017. Appropriate standards to determine Ex eb increased safety motors and other explosion-protected motors are IEC/EN 60079-7:2015, IEC/EN 60079-31:2014 or IEC/EN 60079-1:2014.

(24) In accordance with Article 8(2) of Directive 2009/125/EC, this Regulation should specify the applicable conformity assessment procedures.

(25) Compliance of products should be demonstrated either when the product is placed on the market or when it is put into service, not both.

(26) To facilitate compliance checks, manufacturers, importers or authorised representatives should provide the information in the technical documentation referred to in Annexes IV and V to Directive 2009/125/EC, insofar as that information relates to the requirements laid down in this Regulation.

(27) To improve the effectiveness of this Regulation and to protect consumers, products that automatically alter their performance in test conditions to improve the declared parameters should be prohibited from being placed on the market or put into service.

(28) To facilitate verification testing, market surveillance authorities should be allowed to test, or witness the testing of, larger motors at premises such as those of the manufacturer.

(29) In addition to the legally binding requirements laid down in this Regulation, benchmarks for best available technologies should be identified to make information on product's environmental performance over their life-cycle subject to this Regulation widely available and easily accessible in accordance with Directive 2009/125/EC, Annex I, part 3, point (2).

([4]) COM(2015) 614 final of 2.12.2015.
([5]) COM(2016) 773 final of 30.11.2016.
([6]) Regulation (EU) No 1025/2012 of the European Parliament and of the Council of 25 October 2012 on European standardisation, amending Council Directives 89/686/EEC and 93/15/EEC and Directives 94/9/EC, 94/25/EC, 95/16/EC, 97/23/EC, 98/34/EC, 2004/22/EC, 2007/23/EC, 2009/23/EC and 2009/105/EC of the European Parliament and of the Council and repealing Council Decision 87/95/EEC and Decision No 1673/2006/EC of the European Parliament and of the Council (OJ L 316, 14.11.2012, p. 12).

(30) A review of this Regulation should assess the appropriateness and effectiveness of its provisions in achieving its goals. The timing of the review should be sufficient for all provisions to be implemented and show an effect on the market.

(31) Regulation (EC) No 640/2009 should therefore be repealed.

(32) Ecodesign requirements on circulators integrated in boilers are set out in Commission Regulation (EC) No 641/2009 ([7]). To ensure that installed boilers with a defective circulator can be repaired within their technical lifetime, the exemption in that regulation for circulators provided as a spare part for existing boilers should be extended.

(33) The measures provided for in this Regulation are in accordance with the opinion of the Committee established by Article 19(1) of Directive 2009/125/EC,

HAS ADOPTED THIS REGULATION:

Article 1

Subject matter

This Regulation establishes ecodesign requirements for the placing on the market or the putting into service of electric motors and variable speed drives, including where they are integrated in other products.

Article 2

Scope

(1) This Regulation applies to the following products:

(a) induction electric motors without brushes, commutators, slip rings or electrical connections to the rotor, rated for operation on a 50 Hz, 60 Hz or 50/60 Hz sinusoidal voltage, that:

(i) have two, four, six or eight poles;

(ii) have a rated voltage U_N above 50 V and up to and including 1 000 V;

(iii) have a rated power output P_N from 0,12 kW up to and including 1 000 kW;

(iv) are rated on the basis of continuous duty operation; and

(v) are rated for direct on-line operation;

(b) variable speed drives with 3 phases input that:

(i) are rated for operating with one motor refered to in point (a), within the 0,12 kW-1 000 kW motor rated output range;

(ii) have a rated voltage above 100 V and up to and including 1 000 V AC;

(iii) have only one AC voltage output.

(2) The requirements in section 1, and points (1), (2), (5) to (11), and (13) of section 2 of Annex I shall not apply to the following motors:

(a) motors completely integrated into a product (for example into a gear, pump, fan or compressor) and whose energy performance cannot be tested independently from the product, even with the provision of a temporary end-shield and drive-end bearing; the motor must share common components (apart from connectors such as bolts) with the driven unit (for example, a shaft or housing) and shall not be designed in such a way that the motor can be separated in its entirety from the driven unit and operate independently. The process of separation shall have the consequence of rendering the motor inoperative;

(b) motors with an integrated variable speed drive (compact drives) whose energy performance cannot be tested independently from the variable speed drive;

([7]) Commission Regulation (EC) No 641/2009 of 22 July 2009 implementing Directive 2005/32/EC of the European Parliament and of the Council with regard to ecodesign requirements for glandless standalone circulators and glandless circulators integrated in products (OJ L 191, 23.7.2009, p. 35).

(c) motors with an integrated brake which forms an integral part of the inner motor construction and can neither be removed nor powered by a separate power source during the testing of the motor efficiency;

(d) motors specifically designed and specified to operate exclusively:

(i) at altitudes exceeding 4 000 metres above sea-level;

(ii) where ambient air temperatures exceed 60 °C;

(iii) in maximum operating temperature above 400 °C;

(iv) where ambient air temperatures are less than – 30 °C; or

(v) where the water coolant temperature at the inlet to a product is below 0 °C or above 32 °C;

(e) motors specifically designed and specified to operate wholly immersed in a liquid;

(f) motors specifically qualified for the safety of nuclear installations, as defined in Article 3 of Council Directive 2009/71/Euratom ([8]);

(g) explosion-protected motors specifically designed and certified for mining, as defined in Annex I, point 1 of Directive 2014/34/EU of the European Parliament and of the Council ([9]);

(h) motors in cordless or battery-operated equipment;

(i) motors in hand-held equipment whose weight is supported by hand during operation;

(j) motors in hand-guided mobile equipment moved while in operation;

(k) motors with mechanical commutators;

(l) Totally Enclosed Non-Ventilated (TENV) motors;

(m) motors placed on the market before 1 July 2029 as substitutes for identical motors integrated in products placed on the market before 1 July 2022, and specifically marketed as such;

(n) multi-speed motors, i.e. motors with multiple windings or with a switchable winding, providing a different number of poles and speeds;

(o) motors designed specifically for the traction of electric vehicles.

(3) The requirements in section 3, and points (1), (2), and (5) to (10) of section 4 of Annex I shall not apply to the following VSDs:

(a) VSDs integrated into a product and whose energy performance cannot be tested independently from the product, that is to say that an attempt to do so would render the VSD or the product inoperative;

(b) VSDs qualified specifically for the safety of nuclear installations, as defined Article 3 of Directive 2009/71/Euratom;

(c) regenerative drives;

(d) drives with sinusoidal input current.

Article 3

Definitions

For the purposes of this Regulation, the following definitions shall apply:

(1) 'electric motor' or 'motor' means a device that converts electrical input power into mechanical output power in the form of a rotation with a rotational speed and torque that depends on factors including the frequency of the supply voltage and number of poles of the motor;

([8]) Council Directive 2009/71/Euratom of 25 June 2009 establishing a Community framework for the nuclear safety of nuclear installations (OJ L 172, 2.7.2009, p. 18).

([9]) Directive 2014/34/EU of the European Parliament and of the Council of 26 February 2014 on the harmonisation of the laws of the Member States relating to equipment and protective systems intended for use in potentially explosive atmospheres (OJ L 96, 29.3.2014, p. 309).

(2) 'variable speed drive' (VSD) means an electronic power converter that continuously adapts the electrical power supplied to a single motor to control the motor's mechanical power output according to the torque-speed characteristic of the load driven by the motor, by adjusting the power supply to a variable frequency and voltage supplied to the motor. It includes all electronics connected between the mains and the motor including extensions such as protection devices, transformers and auxiliaries;

(3) 'energy efficiency' of a motor means the ratio of its mechanical output power to the electrical active input power;

(4) 'pole' means a north or a south pole produced by the rotating magnetic field of the motor, whose total number of poles determines its base speed;

(5) 'continuous duty operation' means capable of continuous operation at rated power with a temperature rise within the specified insulation temperature class, specified as specific duty types S1, S3 >=80 % or S6 >=80 % as defined in standards;

(6) 'phase' means the type of configuration of the mains;

(7) 'mains' or 'electric mains' means the electricity supply from the grid;

(8) 'motor with mechanical commutators' means a motor in which a mechanical device reverses the direction of the current;

(9) 'cordless or battery operated equipment' means an appliance deriving its energy from batteries enabling the appliance to perform its intended function without a supply connection;

(10) 'hand-held equipment' means a portable appliance intended to be held in the hand during normal use;

(11) 'hand-guided equipment' means a non-road mobile appliance that is moved and guided by the user during normal use;

(12) 'totally enclosed non-ventilated (TENV) motor' means a motor designed and specified to operate without a fan, and which dissipates heat predominantly through natural ventilation or radiation on the totally enclosed motor surface;

(13) 'regenerative drive' means a VSD that is able to regenerate energy from the load to the mains, i.e. that induces a 180° +/- 20° phase shift of the input current to the input voltage when the load motor is braking;

(14) 'drive with sinusoidal input current' means a VSD with a sinusoidal waveform of the input current, characterised by a Total Harmonic Content below 10 %;

(15) 'brake motor' means a motor equipped with an electromechanical brake unit operating directly on the motor shaft without couplings;

(16) 'Ex eb increased safety motor' means a motor intended for use in explosive atmospheres and certified 'Ex eb', as defined in standards;

(17) 'other explosion-protected motor' means a motor intended for use in explosive atmospheres and certified 'Ex ec', 'Ex tb', 'Ex tc', 'Ex db', or 'Ex dc' as defined in standards;

(18) 'test load' of a VSD means the electrical device used for testing purposes that determines the output current and the output displacement factor cos phi;

(19) 'equivalent model' means a model which has the same technical characteristics relevant for the technical information to be provided, but which is placed on the market or put into service by the same manufacturer, importer or authorised representative as another model with a different model identifier;

(20) 'model identifier' means the code, usually alphanumeric, which distinguishes a specific product model from other models with the same trade mark or the same manufacturer's, importer's or authorised representative's name;

(21) 'witnessed testing' means actively observing the physical testing of the product under investigation by another party, to draw conclusions on the validity of the test and the test results. This may include conclusions on the compliance of testing and calculations methods used with applicable standards and legislation;

(22) 'factory acceptance test' means a test on an ordered product where the customer uses witnessed testing to verify the product's full accordance with contractual requirements, before they are accepted or put into service.

Article 4

Ecodesign requirements

The ecodesign requirements set out in Annex I shall apply from the dates indicated therein.

Article 5

Conformity assessment

1. The conformity assessment procedure referred to in Article 8 of Directive 2009/125/EC shall be the internal design control system set out in Annex IV of that Directive or the management system set out in Annex V of that Directive.

2. For the purposes of the conformity assessment pursuant to Article 8 of Directive 2009/125/EC, the technical documentation of motors shall contain a copy of the product information provided in accordance with point 2 of Annex I to this Regulation, and the details and results of calculations set out in Annex II to this Regulation.

3. For the purposes of the conformity assessment pursuant to Article 8 of Directive 2009/125/EC, the technical documentation of VSDs shall contain a copy of the product information provided in accordance with point 4 of Annex I to this Regulation, and the details and results of calculations set out in Annex II to this Regulation.

4. Where the information included in the technical documentation for a particular model has been obtained:

(a) from a model that has the same technical characteristics relevant for the technical information to be provided but is produced by a different manufacturer; or

(b) by calculation on the basis of design or extrapolation from another model of the same or a different manufacturer, or both,

the technical documentation shall include the details of such calculation, the assessment undertaken by the manufacturer to verify the accuracy of the calculation and, where appropriate, the declaration of identity between the models of different manufacturers.

The technical documentation shall include a list of all equivalent models, including the model identifiers.

Article 6

Verification procedure for market surveillance purposes

Member States shall apply the verification procedure laid down in Annex III when performing the market surveillance checks referred to in point 2 of Article 3 of Directive 2009/125/EC.

Article 7

Circumvention and software updates

The manufacturer, importer or authorised representative shall not place on the market products designed to be able to detect they are being tested (e.g. by recognising the test conditions or test cycle), and to react specifically by automatically altering their performance during the test with the aim of reaching a more favourable level for any of the parameters specified in this Regulation or declared by the manufacturer, importer or authorised representative in the technical documentation or included in any of the documentation provided.

The energy consumption of the product and any of the other declared parameters shall not deteriorate after a software or firmware update when measured with the same test standard originally used for the declaration of conformity, except with explicit consent of the end-user prior to the update. No deterioration of performance shall occur as result of rejecting the update.

A software update shall never have the effect of changing the product's performance in a way that makes it non-compliant with the ecodesign requirements applicable for the declaration of conformity.

Article 8

Benchmarks

The benchmarks for the best-performing motors and variable speed drives available at the time of adopting this Regulation are set out in Annex IV.

Article 9

Review

The Commission shall review this Regulation in the light of technological progress and shall present the results of this assessment, including, if appropriate, a draft revision proposal, to the Consultation Forum no later than 14 November 2023.

This review shall in particular address the appropriateness of:

(1) setting additional resource efficiency requirements for products in accordance with the objectives of the circular economy, including identification and reuse of rare earth in permanent magnet motors;

(2) the level of verification tolerances;

(3) setting stricter requirements for motors and variable speed drives;

(4) setting minimum energy efficiency requirements for motors with a rated voltage above 1000 V;

(5) setting requirements for combinations of motors and VSDs placed on the market together, as well as integrated variable speed drives (compact drives);

(6) the exemptions set out in Articles 2(2) and (3);

(7) adding other types of motors to the scope, including permanent magnet motors.

Article 10

Repeal

Regulation (EC) No 640/2009 is repealed as from 1 July 2021.

Article 11

Amendment to Regulation (EC) No 641/2009

(1) Article 1, point 2(b) is replaced by:

'(b) circulators to be integrated in products and placed on the market no later than 1 January 2022 as replacement for identical circulators integrated in products placed on the market no later than 1 August 2015 and specifically marketed as such, except as regards the product information requirements of Annex I, point 2(1)(e).'

(2) Annex I, point 2(1)(e) is replaced by:

'(e) for circulators to be integrated in products and placed on the market no later than 1 January 2022 as replacement for identical circulators integrated in products placed on the market no later than 1 August 2015, the replacement circulator or its packaging shall clearly indicate the product(s) for which it is intended.'

Article 12

Entry into force and application

This Regulation shall enter into force on the twentieth day following that of its publication in the *Official Journal of the European Union*.

It shall apply from 1 July 2021. However, the first paragraph of Article 7 and Article 11, shall apply from 14 November 2019.

This Regulation shall be binding in its entirety and directly applicable in all Member States.

Done at Brussels, 1 October 2019.

For the Commission
The President
Jean-Claude JUNCKER

ANNEX I

ECODESIGN REQUIREMENTS FOR MOTORS AND VARIABLE SPEED DRIVES

1. ENERGY EFFICIENCY REQUIREMENTS FOR MOTORS

Energy efficiency requirements for motors shall apply according to the following timetable:

(a) from 1 July 2021:

(i) the energy efficiency of three-phase motors with a rated output equal to or above 0,75 kW and equal to or below 1 000 kW, with 2, 4, 6 or 8 poles, which are not Ex eb increased safety motors, shall correspond to at least the IE3 efficiency level set out in Table 2;

(ii) the energy efficiency of three-phase motors with a rated output equal to or above 0,12 kW and below 0,75 kW, with 2, 4, 6 or 8 poles, which are not Ex eb increased safety motors, shall correspond to at least the IE2 efficiency level set out in Table 1;

(b) from 1 July 2023:

(i) the energy efficiency of Ex eb increased safety motors with a rated output equal to or above 0,12 kW and equal to or below 1 000 kW, with 2, 4, 6 or 8 poles, and single-phase motors with a rated output equal to or above 0,12 kW shall correspond to at least the IE2 efficiency level set out in Table 1;

(ii) the energy efficiency of three-phase motors which are not brake motors, Ex eb increased safety motors, or other explosion-protected motors, with a rated output equal to or above 75 kW and equal to or below 200 kW, with 2, 4, or 6 poles, shall correspond to at least the IE4 efficiency level set out in Table 3.

Energy efficiency for motors, expressed in International Energy efficiency classes (IE), is set out in Tables 1, 2 and 3, for different values of the motor rated output power P_N. IE classes are determined at rated output power (P_N), rated voltage (U_N), based on the 50 Hz operation and 25 °C ambient reference temperature.

Table 1

Minimum efficiencies η_n for IE2 efficiency level at 50 Hz (%)

Rated output power P_N [kW]	Number of poles			
	2	4	6	8
0,12	53,6	59,1	50,6	39,8
0,18	60,4	64,7	56,6	45,9
0,20	61,9	65,9	58,2	47,4
0,25	64,8	68,5	61,6	50,6
0,37	69,5	72,7	67,6	56,1
0,40	70,4	73,5	68,8	57,2
0,55	74,1	77,1	73,1	61,7
0,75	77,4	79,6	75,9	66,2
1,1	79,6	81,4	78,1	70,8
1,5	81,3	82,8	79,8	74,1
2,2	83,2	84,3	81,8	77,6
3	84,6	85,5	83,3	80,0
4	85,8	86,6	84,6	81,9
5,5	87,0	87,7	86,0	83,8
7,5	88,1	88,7	87,2	85,3

Rated output power P_N [kW]	Number of poles			
	2	4	6	8
11	89,4	89,8	88,7	86,9
15	90,3	90,6	89,7	88,0
18,5	90,9	91,2	90,4	88,6
22	91,3	91,6	90,9	89,1
30	92,0	92,3	91,7	89,8
37	92,5	92,7	92,2	90,3
45	92,9	93,1	92,7	90,7
55	93,2	93,5	93,1	91,0
75	93,8	94,0	93,7	91,6
90	94,1	94,2	94,0	91,9
110	94,3	94,5	94,3	92,3
132	94,6	94,7	94,6	92,6
160	94,8	94,9	94,8	93,0
200 up to 1 000	95,0	95,1	95,0	93,5

Table 2

Minimum efficiencies η_n for IE3 efficiency level at 50 Hz (%)

Rated output power P_N [kW]	Number of poles			
	2	4	6	8
0,12	60,8	64,8	57,7	50,7
0,18	65,9	69,9	63,9	58,7
0,20	67,2	71,1	65,4	60,6
0,25	69,7	73,5	68,6	64,1
0,37	73,8	77,3	73,5	69,3
0,40	74,6	78,0	74,4	70,1
0,55	77,8	80,8	77,2	73,0
0,75	80,7	82,5	78,9	75,0
1,1	82,7	84,1	81,0	77,7
1,5	84,2	85,3	82,5	79,7
2,2	85,9	86,7	84,3	81,9
3	87,1	87,7	85,6	83,5
4	88,1	88,6	86,8	84,8
5,5	89,2	89,6	88,0	86,2
7,5	90,1	90,4	89,1	87,3
11	91,2	91,4	90,3	88,6

Rated output power P_N [kW]	Number of poles			
	2	4	6	8
15	91,9	92,1	91,2	89,6
18,5	92,4	92,6	91,7	90,1
22	92,7	93,0	92,2	90,6
30	93,3	93,6	92,9	91,3
37	93,7	93,9	93,3	91,8
45	94,0	94,2	93,7	92,2
55	94,3	94,6	94,1	92,5
75	94,7	95,0	94,6	93,1
90	95,0	95,2	94,9	93,4
110	95,2	95,4	95,1	93,7
132	95,4	95,6	95,4	94,0
160	95,6	95,8	95,6	94,3
200 up to 1 000	95,8	96,0	95,8	94,6

Table 3

Minimum efficiencies η_n for IE4 efficiency level 50 Hz (%)

Rated output power P_N [kW]	Number of poles			
	2	4	6	8
0,12	66,5	69,8	64,9	62,3
0,18	70,8	74,7	70,1	67,2
0,20	71,9	75,8	71,4	68,4
0,25	74,3	77,9	74,1	70,8
0,37	78,1	81,1	78,0	74,3
0,40	78,9	81,7	78,7	74,9
0,55	81,5	83,9	80,9	77,0
0,75	83,5	85,7	82,7	78,4
1,1	85,2	87,2	84,5	80,8
1,5	86,5	88,2	85,9	82,6
2,2	88,0	89,5	87,4	84,5
3	89,1	90,4	88,6	85,9
4	90,0	91,1	89,5	87,1
5,5	90,9	91,9	90,5	88,3
7,5	91,7	92,6	91,3	89,3
11	92,6	93,3	92,3	90,4
15	93,3	93,9	92,9	91,2
18,5	93,7	94,2	93,4	91,7
22	94,0	94,5	93,7	92,1

Rated output power P_N [kW]	Number of poles			
	2	4	6	8
30	94,5	94,9	94,2	92,7
37	94,8	95,2	94,5	93,1
45	95,0	95,4	94,8	93,4
55	95,3	95,7	95,1	93,7
75	95,6	96,0	95,4	94,2
90	95,8	96,1	95,6	94,4
110	96,0	96,3	95,8	94,7
132	96,2	96,4	96,0	94,9
160	96,3	96,6	96,2	95,1
200 up to 249	96,5	96,7	96,3	95,4
250 up to 314	96,5	96,7	96,5	95,4
315 up to 1 000	96,5	96,7	96,6	95,4

To determine the minimum efficiency of 50 Hz motors with rated power outputs P_N of between 0,12 and 200 kW not provided in Tables 1, 2 and 3, the following formula shall be used:

$$\eta_n = A \times [log_{10}(P_N/1\text{kW})]^3 + B \times [log_{10}(P_N/1\text{kW})]^2 + C \times log_{10}(P_N/1kW) + D$$

A, B, C and D are interpolation coefficients to be determined according to Tables 4 and 5.

Table 4

Interpolation coefficients for motors with rated power output P from 0,12 kW up to 0,55 kW

IE code	Coefficients	2 poles	4 poles	6 poles	8 poles
IE2	A	22,4864	17,2751	-15,9218	6,4855
	B	27,7603	23,978	-30,258	9,4748
	C	37,8091	35,5822	16,6861	36,852
	D	82,458	84,9935	79,1838	70,762
IE3	A	6,8532	7,6356	-17,361	-0,5896
	B	6,2006	4,8236	-44,538	-25,526
	C	25,1317	21,0903	-3,0554	4,2884
	D	84,0392	86,0998	79,1318	75,831
IE4	A	-8,8538	8,432	-13,0355	-4,9735
	B	-20,3352	2,6888	-36,9497	-21,453
	C	8,9002	14,6236	-4,3621	2,6653
	D	85,0641	87,6153	82,0009	79,055

Between 0,55 kW and 0,75 kW, a linear interpolation shall be performed on the obtained minimum efficiencies for 0,55 kW and 0,75 kW.

Table 5

Interpolation coefficients for motors with rated power output P from 0,75 kW up to 200 kW

IE code	Coefficients	2 poles	4 poles	6 poles	8 poles
IE2	A	0,2972	0,0278	0,0148	2,1311
	B	-3,3454	-1,9247	-2,4978	-12,029
	C	13,0651	10,4395	13,247	26,719
	D	79,077	80,9761	77,5603	69,735
IE3	A	0,3569	0,0773	0,1252	0,7189
	B	-3,3076	-1,8951	-2,613	-5,1678
	C	11,6108	9,2984	11,9963	15,705
	D	82,2503	83,7025	80,4769	77,074
IE4	A	0,34	0,2412	0,3598	0,6556
	B	-3,0479	-2,3608	-3,2107	-4,7229
	C	10,293	8,446	10,7933	13,977
	D	84,8208	86,8321	84,107	80,247

Losses are determined in accordance with Annex II.

2. PRODUCT INFORMATION REQUIREMENTS FOR MOTORS

The product information requirements set out in points (1) to (13) below shall be visibly displayed on:

(a) the technical data sheet or user manual supplied with the motor;

(b) the technical documentation for the purposes of conformity assessment pursuant to Article 5;

(c) free access websites of the manufacturer of the motor, its authorised representative or the importer, and;

(d) the technical data sheet supplied with products in which the motor is incorporated.

As regards to the technical documentation, the information shall be provided in the order as set out in points (1) to (13). The exact wording used in the list does not need to be repeated. The information may be displayed using clearly understandable graphs figures or symbols rather than text.

From 1 July 2021:

(1) rated efficiency (η_N) at the full, 75 % and 50 % rated load and voltage (U_N), determined based on the 50 Hz operation and 25 °C ambient reference temperature, rounded to one decimal place;

(2) efficiency level: 'IE2' 'IE3' or 'IE4', as determined in the first section of this Annex;

(3) manufacturer's name or trade mark, commercial registration number and address;

(4) product's model identifier;

(5) number of poles of the motor;

(6) the rated power output(s) P_N or range of rated power output (kW);

(7) the rated input frequency(s) of the motor (Hz);

(8) the rated voltage(s) or range of rated voltage (V);

(9) the rated speed(s) or range of rated speed (rpm);

(10) whether single-phase or three-phase;

(11) information on the range of operating conditions for which the motor is designed:

  (a) altitudes above sea-level;

  (b) minimum and maximum ambient air temperatures including for motors with air cooling;

(c) water coolant temperature at the inlet to the product, where applicable;

(d) maximum operating temperature;

(e) potentially explosive atmospheres;

(12) if the motor is considered exempt from efficiency requirement in accordance with Article 2(2) of this Regulation, the specific reason why it is considered exempt.

From 1 July 2022:

(13) The power losses expressed in percentage (%) of the rated output power at the following different operating points for speed versus torque: (25;25) (25;100) (50;25) (50;50) (50;100) (90;50) (90;100) determined based on 25 °C ambient reference temperature, rounded to one decimal place; if the motor is not suited for operation at any of the operating points for speed versus torque above, then 'N.A.' or 'Not Applicable' should be indicated for such points.

The information referred to in points (1) and (2) as well as the year of manufacture shall be durably marked on or near the rating plate of the motor. Where the size of the rating plate makes it impossible to mark all the information referred to in point (1) only the rated efficiency at full rated load and voltage shall be marked.

The information listed in points (1) to (13) does not need to be published on free access websites for tailor-made motors with a special mechanical and electrical design manufactured on the basis of a specific client request if this information is included in the commercial offers provided to the clients.

Manufacturers shall provide information in the technical data sheet or user manual supplied with the motor on any specific precautions that must be taken when motors are assembled, installed, maintained or used with variable speed drives.

For motors exempt from the efficiency requirements in accordance with point 2(m) of Article 2 of this Regulation, the motor or its packaging and the documentation must clearly indicate 'Motor to be used exclusively as spare part for' and the product(s) for which it is intended.

For 50/60 Hz and 60 Hz motors, the information set out in points (1) and (2) above may be provided for the 60 Hz operation in addition to the values at 50 Hz, with clear indication of the applicable frequencies.

Losses are determined in accordance with Annex II.

3. EFFICIENCY REQUIREMENTS FOR VARIABLE SPEED DRIVES

Efficiency requirements for variable speed drives shall apply as follows:

From 1 July 2021, the power losses of variable speed drives rated for operating with motors with a rated output power equal to or above 0,12 kW and equal to or below 1 000 kW shall not exceed the maximum power losses corresponding to the IE2 efficiency level.

Energy efficiency for VSDs, expressed in International Energy efficiency classes (IE), is determined based on the power losses as follows:

The maximum power losses of the IE2 class are 25 % lower than the reference value referred to in Table 6.

Table 6

Reference VSD losses and test load displacement factor for the IE class determination of VSDs

Apparent output power of VSD (kVA)	Rated power of Motor (kW) (indicative)	Reference power losses (kW), at 90 % rated motor stator frequency and 100 % rated torque-producing current	Test load displacement factor cos phi (+/- 0,08)
0,278	0,12	0,100	0,73
0,381	0,18	0,104	0,73
0,500	0,25	0,109	0,73
0,697	0,37	0,117	0,73
0,977	0,55	0,129	0,73
1,29	0,75	0,142	0,79

Apparent output power of VSD (kVA)	Rated power of Motor (kW) (indicative)	Reference power losses (kW), at 90 % rated motor stator frequency and 100 % rated torque-producing current	Test load displacement factor cos phi (+/- 0,08)
1,71	1,1	0,163	0,79
2,29	1,5	0,188	0,79
3,3	2,2	0,237	0,79
4,44	3	0,299	0,79
5,85	4	0,374	0,79
7,94	5,5	0,477	0,85
9,95	7,5	0,581	0,85
14,4	11	0,781	0,85
19,5	15	1,01	0,85
23,9	18,5	1,21	0,85
28,3	22	1,41	0,85
38,2	30	1,86	0,85
47	37	2,25	0,85
56,9	45	2,70	0,86
68,4	55	3,24	0,86
92,8	75	4,35	0,86
111	90	5,17	0,86
135	110	5,55	0,86
162	132	6,65	0,86
196	160	8,02	0,86
245	200	10,0	0,87
302	250	12,4	0,87
381	315	15,6	0,87
429	355	17,5	0,87
483	400	19,8	0,87
604	500	24,7	0,87
677	560	27,6	0,87
761	630	31,1	0,87
858	710	35,0	0,87
967	800	39,4	0,87
1 088	900	44,3	0,87
1 209	1 000	49,3	0,87

If the apparent output power of a VSD is between two values in Table 6, the higher power loss value and the lower value of the test load displacement factor shall be used for the IE class determination.

Losses are determined in accordance with Annex II.

4. PRODUCT INFORMATION REQUIREMENTS FOR VARIABLE SPEED DRIVES

From 1 July 2021, the product information on variable speed drives set out in points (1) to (11) shall be visibly displayed on:

(a) the technical data sheet or user manual supplied with the VSD;

(b) the technical documentation for the purposes of conformity assessment pursuant to Article 5;

(c) free access websites of the manufacturer, its authorised representative or the importer and;

(d) the technical data sheet supplied with products in which the VSD is incorporated.

As regards to the technical documentation, the information shall be provided in the order as listed in points (1) to (11). The exact wording used in the list does not need to be repeated. It may be displayed using clearly understandable graphs figures or symbols rather than text:

(1) power losses in % of the rated apparent output power at the following different operating points for relative motor stator frequency versus relative torque-producing current (0;25) (0;50) (0;100) (50;25) (50;50) (50;100) (90;50) (90;100), as well as standby losses, generated when the VSD is powered up but is not providing current to the load, rounded to one decimal place;

(2) efficiency level: 'IE2' as determined in the third section of this annex;

(3) manufacturer's name or trade mark, commercial registration number and address;

(4) product's model identifier;

(5) apparent output power or range of apparent output power (kVA);

(6) indicative motor rated power output(s) P_N or range of rated power output (kW);

(7) rated output current (A);

(8) maximum operating temperature (°C);

(9) rated supply frequency(s) (Hz);

(10) rated supply voltage(s) or range of rated supply voltage (V);

(11) if the VSD is considered exempt from the efficiency requirements in accordance with Article 2(3) of this Regulation the specific reason why it is considered exempt.

The information listed above in points (1) to (11) does not need to be published on free access websites for tailor-made VSDs with special electrical design manufactured on the basis of a specific client request if this information is included in the commercial offers provided to the clients.

The information referred to in points (1) and (2) as well as the year of manufacture shall be durably marked on or near the rating plate of the VSD. Where the size of the rating plate makes it impossible to mark all the information referred to in point (1) only the rated efficiency at (90;100) shall be marked.

Losses are determined in accordance with Annex II.

ANNEX II

MEASUREMENT METHODS AND CALCULATIONS

For the purposes of compliance and verification of compliance with the requirements of this Regulation, measurements and calculations shall be made using harmonised standards the reference numbers of which have been published for this purpose in the *Official Journal of the European Union*, or other reliable, accurate and reproducible methods, which take into account the generally recognised state-of-the-art, and in line with the following provisions:

1. **FOR MOTORS**

The difference between the output mechanical power and the input electrical power is due to losses occurring in the motor. Total losses shall be determined using the following methods, based on a 25 °C reference ambient temperature:

— Single-phase motors: Direct measurement: Input-Output;

— Three-phase motors: Summation of losses: Residual losses.

For 60 Hz motors, equivalent values of the rated output power (P_N) and rated voltage (U_N) for the 50 Hz operation shall be calculated based on the values applicable at 60 Hz.

2. **FOR VARIABLE SPEED DRIVES**

For the determination of the IE class, the power losses of VSDs shall be determined at 100 % rated torque-producing current and 90 % rated motor stator frequency.

The losses shall be determined according to one of the following methods:

— the input-output method; or

— the calorimetric method.

The test switching frequency shall be 4 kHz until 111 kVA (90 kW) and 2 kHz above, or at the default factory settings as defined by the manufacturer.

It is acceptable to measure VSD losses at a frequency of up to 12 Hz instead of zero.

Manufacturers or their authorised representatives can also use the single loss determination method. Calculations have to be performed with respect to component manufacturer's data with typical values of power semiconductors at the actual VSD operating temperature or at the maximum operating temperature specified in the datasheet. When no component manufacturer data is available, losses shall be determined by measurement. Combination of calculated and measured losses are allowed. The different individual losses are calculated or measured separately and the total losses are determined as the sum of all individual losses.

ANNEX III

VERIFICATION PROCEDURE FOR MARKET SURVEILLANCE PURPOSES

The verification tolerances defined in this Annex relate only to the verification of the measured parameters by Member State authorities and shall not be used by the manufacturer, importer or authorised representative as an allowed tolerance to establish the values in the technical documentation or in interpreting these values with a view to achieving compliance or to communicate better performance by any means.

Where a model has been designed to be able to detect it is being tested (e.g. by recognising the test conditions or test cycle), and to react specifically by automatically altering its performance during the test with the objective of reaching a more favourable level for any of the parameters specified in this Regulation or included in the technical documentation or included in any of the documentation provided, the model and all equivalent models shall be considered not compliant.

When verifying that a product model complies with the requirements laid down in this Regulation pursuant to Article 3(2) of Directive 2009/125/EC the authorities of the Member States shall apply the following procedure for the requirements referred to in Annex I.

(1) The Member State authorities shall verify one single unit of the model.

(2) The model shall be considered to comply with the applicable requirements if:

(a) the values given in the technical documentation pursuant to point 2 of Annex IV to Directive 2009/125/EC (declared values) and where applicable the values used to calculate these values are not more favourable for the manufacturer, importer or authorised representative than the results of the corresponding measurements carried out pursuant to point (g) thereof; and

(b) the declared values meet any requirements laid down in this Regulation and any required product information published by the manufacturer, importer or authorised representative does not contain values that are more favourable for the manufacturer, importer or authorised representative than the declared values; and

(c) when the Member State authorities test the unit of the model, the determined values (the values of the relevant parameters as measured in testing and the values calculated from these measurements) comply with the respective verification tolerances as set out in Table 7.

(3) If the results referred to in points (2)(a) or (2)(b) are not achieved the model and all equivalent models shall be considered not to comply with this Regulation.

(4) If the result referred to in point (2)(c) is not achieved;

(a) for models that are produced in quantities of less than five per year including equivalent models, the model and all equivalent models shall be considered not to comply with this Regulation;

(b) for models that are produced in quantities of five or more per year including equivalent models, the Member State authorities shall select three additional units of the same model for testing. As an alternative, the three additional units selected may be one or more of equivalent models.

(5) The model shall be considered to comply with the applicable requirements if for these three units the arithmetical mean of the determined values complies with the respective verification tolerances given in Table 7.

(6) If the result referred to in point (5) is not achieved the model and all equivalent models shall be considered not to comply with this Regulation.

(7) The Member State authorities shall provide all relevant information to the authorities of the other Member States and to the Commission without delay after a decision is taken on the non-compliance of the model according to points (3) or (6).

The Member State authorities shall use the measurement and calculation methods set out in Annex II.

Given the weight and size limitations for the transportation of motors with a rated power output of 375 to 1 000 kW Member States authorities may decide to undertake the verification procedure at the premises of manufacturers, authorised representatives or importers before the products are put into service. The Member State authority can do this verification using its own testing equipment.

If factory acceptance tests are planned for such motors, which will test parameters laid down in Annex I of this Regulation, the Member State authorities may decide to use witnessed testing during these factory acceptance tests to gather test results which can be used to verify compliance of the motor under investigation. The authorities may request a manufacturer, authorised representative or importer to disclose information on any planned factory acceptance tests relevant for witnessed testing.

In the cases mentioned in the two paragraphs above, the Member States authorities only need to verify one single unit of the model. If the result referred to in point 2(c) is not achieved, the model and all equivalent models shall be considered not to comply with this regulation.

The Member State authorities shall only apply the tolerances set out in Table 7 and shall only use the procedure described in points (1) to (7) for the requirements referred to in this Annex. For the parameters in Table 7, no other tolerances such as those set out in harmonised standards or in any other measurement method shall be applied.

Table 7

Verification tolerances

Parameters	*Verification tolerances*
Total losses (1-η) for motors with a rated output equal to or above 0,12 kW and equal to or below 150 kW.	The determined value (*) shall not exceed the value (1-η) calculated based on the declared η by more than 15 %.
Total losses (1-η) for motors with a rated output of above 150 kW and equal to or below 1 000 kW.	The determined value (*) shall not exceed the value (1-η) calculated based on the declared η by more than 10 %.
Total losses for variable speed drives.	The determined value (*) shall not exceed the declared value by more than 10 %.

(*) In the case of three additional units tested as prescribed in point 4(b), the determined value means the arithmetical mean of the values determined for these three additional units.

ANNEX IV

BENCHMARKS

At the time of adoption of this Regulation the best available technology on the market for the environmental aspects that were considered significant and are quantifiable is indicated below.

For motors the IE4 level was identified as the best available technology. Motors with losses that are 20 % lower exist but within limited availability and not in all power ranges covered by this Regulation and not in the form of induction motors.

For variable speed drives, the best available technology on the market corresponds to 20 % of the reference power losses referred to in Table 6. By utilising silicon carbide technologies (SiC MOFSET), semiconductor losses could be further reduced by about 50 % compared to a conventional solution.