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ANNEXES 1 to 4

ANNEXES

to the

COMMISSION REGULATION

implementing Directive 2009/125/EC of the European Parliament and of the Council with regard to ecodesign requirements for electric motors and variable speed drives

repealing Commission Regulation (EC) No 640/2009 with regard to ecodesign requirements for electric motors

ANNEX I
ECODESIGN REQUIREMENTS FOR MOTORS AND VSDS

1. EFFICIENCY REQUIREMENTS FOR MOTORS

Efficiency requirements for motors shall apply in accordance with the following timetable:

(a) from 30 June 2020:

(i) the energy efficiency of three-phase motors with a rated output of equal or above 0,75 kW and equal or below 1000 kW, and having 2, 4 or 6 poles, which are not brake motors or increased safety motors, shall correspond at least to the IE3 efficiency level as set out in Table 2 below.

(b) from 1 January 2022:

(i) the energy efficiency of three-phase motors with a rated output of equal or above 0,12 kW and below 0,75 kW, single phase motors with a rated output of equal or above 0,12 kW and increased safety motors of equal or above 0,12 kW and equal or below 1000 kW shall correspond at least to the IE2 efficiency level as set out in Table 1 below;

(ii) the energy efficiency of three-phase motors with a rated output of equal or above 0,75 kW and equal or below 1000 kW which are not increased safety motors, shall correspond at least to the IE3 efficiency level.

The energy efficiency for motors, expressed in IE efficiency levels, is set out in Tables 1, 2 and 3. The energy efficiency of motors rated for both 50 Hz and 60 Hz operation shall be determined based on the 50 Hz operation.

Table 1: Minimum efficiencies η_n for IE2 efficiency level (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
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 (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
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
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

The losses corresponding to minimal efficiencies for the IE5 level are 20 % lower than the losses corresponding to the minimal efficiencies for IE4 presented in Table 3.

To determine the minimal 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:

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

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 0,74 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

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

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 documentation and user manuals supplied with the motor;

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

(c) the technical documentation and user manuals supplied with products in which the motor is incorporated.

The information shall be provided in the order as presented in points (1) to (13). 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) rated efficiency (η_N) at the full, 75 % and 50 % rated load and voltage (U_N);

(2) efficiency level: 'IE2', 'IE3', 'IE4' or , 'IE5';

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

(4) product's model number;

(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) information relevant for disassembly, recycling or disposal at end-of-life;

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

(a) altitudes above sea-level;

(b) ambient air temperatures, including for motors with air cooling;

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

(d) maximum operating temperature;

(e) potentially explosive atmospheres;

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

(13) in case the motor is considered exempt of efficiency requirement as per Article 4(2) of this Regulation: the specific reason why it is considered exempt.

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 above 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.

Manufacturers shall provide information in the technical documentation and user manuals supplied with the motor on any specific precautions that must be taken when motors are assembled, installed, maintained or used with variable speed drives, including information on how to minimise electrical and magnetic fields from variable speed drives.

For motors exempt of efficiency requirement as per Article 4(2)(13) 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.

3. EFFICIENCY REQUIREMENTS FOR VSDS

Efficiency requirements for VSDs shall apply in accordance with the following timetable:

(1) from 30 June 2020:

(i) the power losses of variable speed drives rated for operating with motors with a rated output of equal or above 0,75 and equal or below 1000 kW shall not exceed the maximum power losses corresponding to the IE1 efficiency level.

(2) from 1 January 2022:

(i) the power losses of variable speed drives rated for operating with motors with a rated output of equal or above 0,75 and equal or below 220 kW shall not exceed the maximum power losses corresponding to the IE2 efficiency level;

(ii) the power losses of variable speed drives rated for operating with motors with a rated output above 220 kW and equal or below 1000 kW shall not exceed the maximum power losses corresponding to the IE1 efficiency level.

The maximum power losses for different efficiency classes (IE) of variable speed drives are set out in Table 6.

Table 6 – Maximum power losses for IE class determination of VSDs

Apparent output power of VSD (kVA)	Rated power of Motor (kW)	Maximum VSD Power Losses at rated torque producing current and 90 % rated motor stator frequency (kW)	
		IE1	IE2
1,29	0,75	0,178	0,107
1,71	1,1	0,204	0,122
2,29	1,5	0,235	0,141
3,3	2,2	0,296	0,178
4,44	3	0,374	0,224
5,85	4	0,468	0,281
7,94	5,5	0,596	0,358
9,95	7,5	0,726	0,436
14,4	11	0,976	0,586
19,5	15	1,26	0,758
23,9	18,5	1,51	0,908
28,3	22	1,76	1,06
38,2	30	2,33	1,40
47	37	2,81	1,69
56,9	45	3,38	2,03
68,4	55	4,05	2,43
92,8	75	5,44	3,26
111	90	6,46	3,88
135	110	6,94	4,16
162	132	8,31	4,99
196	160	10,0	6,02
245	200	12,5	7,50
302	250	15,5	9,30
381	315	19,5	11,7
429	355	21,9	13,1
483	400	24,8	14,9
604	500	30,9	18,5
677	560	34,5	20,7
761	630	38,9	23,3
858	710	43,8	26,3
967	800	49,3	29,6

1088	900	55,4	33,2
1209	1000	61,6	37,0

The maximum power losses of the IE3 class are 25 % lower than those of the IE2 class. The maximum power losses of the IE4 class are 25 % lower than those of the IE3 class.

If the rated power output of a VSD is between two values in Table 6, the higher power loss value shall be used for the IE class determination.

The values in Table 6 shall be multiplied by a factor of 1.35 when assessing the IE class for a variable speed drive with a rated input voltage below 200 V.

4. PRODUCT INFORMATION REQUIREMENTS FOR VSDS

The product information on variable speed drives set out in points (1) to (9) below shall be visibly displayed on:

(a) the technical documentation and user manuals supplied with the VSD;

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

(c) the technical documentation and user manuals supplied with products in which the VSD is incorporated.

The information shall be provided in the order as presented in points (1) to (9). 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) manufacturer's name or trade mark, commercial registration number and place of manufacture;

(2) product's model number;

(3) power losses (W) at the following different operating points for speed versus torque (0;25), (0;50), (0;100), (50;25), (50;50), (50;100), (90;50), (90;100);

(4) efficiency level: 'IE1', 'IE2', 'IE3' or 'IE4';

(5) the rated supply frequency(s) (Hz);

(6) the rated supply voltage(s) or range of rated supply voltage (V);

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

(8) information relevant for disassembly, recycling or disposal at end-of-life;

(9) in case the VSD is considered exempt from the efficiency requirements as per Article 4(3) of this Regulation, the specific reason why it is considered exempt.

The information listed above 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.

For VSDs exempt of efficiency requirement as per Article 4(3)(3) of this Regulation, the VSD or its packaging and the documentation must clearly indicate "Variable Speed Drive to be used exclusively as spare part for" and the product(s) for which it is intended.

ANNEX II
MEASUREMENT METHODS

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 energy efficiency is the ratio of mechanical output power to the electrical input power. The efficiency of the motor shall be determined at rated output power (P_N), rated voltage (U_N), and at 50 Hz based on 25 °C ambient temperature.

The difference between the output mechanical power and the input electrical power is due to losses occurring in the motor. The determination of total losses shall be carried out by one of the following methods:

– measurement of total losses; or

– determination of separate losses for summation.

2. FOR VARIABLE SPEED DRIVES

The power losses of VSDs shall be determined at 100 % rated torque producing current and 90 % rated motor stator frequency, according to one of the following methods:

– single component loss determination;

– input-output method; or

– calorimetric method.

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 or importer 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.

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

(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 or importer than the results of the corresponding measurements carried out pursuant to paragraph (g) thereof; and

(b) the declared values meet any requirements laid down in this Regulation, and any required product information published by the manufacturer or importer does not contain values that are more favourable for the manufacturer or importer 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), including the total losses (1-η) as decisive criterion for the efficiency, comply with the respective verification tolerances as given in Table 7.

(3) If the results referred to in points 2(a) or (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, the model shall be considered not to comply with this Regulation;

(b) for models that are produced in quantities of five or more per year, the Member State authorities shall select three additional units of the same model for testing. As an alternative, one or more of the three additional units selected may be of an equivalent model. The model shall be considered to comply with the applicable requirements if, for these three units, the arithmetical mean of the determined values, including the total losses (1-η) as decisive criterion for the efficiency, complies with the respective verification tolerances given in Table 7.

(5) If the result referred to in point 4(b) is not achieved, the model and all equivalent models shall be considered not to comply with this Regulation.

(6) 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 being taken on the non-compliance of the model according to points 3, 4(a) and 5.

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

Given the weight and size limitations in the transportation of motors and variable speed drives 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 or importers, before the products are put into service.

The Member State authorities shall only apply the verification tolerances that are set out in Table 7 and shall only use the procedure described in points 1 to 6 for the requirements referred to in this Annex. 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 of equal or above 0,12 kW and equal or below 150 kW.	The determined value shall not exceed the value 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 or below 1 000 kW.	The determined value shall not exceed the value 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 5 %.

ANNEX IV
INDICATIVE 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 best available technology. IE5 motors exist, but within limited availability and not in all power ranges covered by the present Regulation and not in the form of induction motors.

For variable speed drives the IE4 level was identified as the best available technology, assumed to correspond to losses equal or lower than 56.3 % of the IE2 maximum losses, although there is not yet an internationally agreed standard that defines the IE4 level.