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ANNEXES 1 to 5

ANNEXES

to the

COMMISSION REGULATION

**implementing Directive 2009/125/EC of the European Parliament and of the Council
with regard to ecodesign requirements for fans driven by motors with an electric input
power between 125 W and 500 kW and repealing Commission Regulation (EU)
No 327/2011**

ANNEX I

Definitions applicable for the purposes of the Annexes

- (1) ‘measurement category’ means a test, measurement or usage arrangement that defines the inlet and outlet conditions of the fan being tested;
- (2) ‘measurement category A’ means an arrangement where the fan is measured with free inlet and outlet conditions, and a partition between inlet and outlet zone;
- (3) ‘measurement category B’ means an arrangement where the fan is measured with free inlet and with a duct fitted to its outlet, and a partition between inlet and outlet zone;
- (4) ‘measurement category C’ means an arrangement where the fan is measured with a duct fitted to its inlet and free outlet conditions, and a partition between inlet and outlet zone;
- (5) ‘measurement category D’ means an arrangement where the fan is measured with a duct fitted to its inlet and outlet, and a partition between inlet and outlet zone;
- (6) ‘measurement category E’ means an arrangement where the fan is measured with free inlet and outlet conditions, and without a partition between inlet and outlet zone;
- (7) ‘efficiency category’ means the fan gas output energy form used to determine the fan energy efficiency, with a distinction between ‘static’ or ‘total’ efficiency depending on whether the fan gas power has been determined with respectively the fan static pressure or fan pressure;
- (8) ‘fan efficiency’ (η) means the ratio of the fan gas power output P_u and the electric input power P_e , both expressed in W and determined at BEP, multiplied with correction factors for power conversion C_p , part load compensation C_c and guard compensation C_{guard} , with a distinction between ‘static’ or ‘total’ efficiency depending on whether the fan gas power P_u has been determined with respectively the fan static pressure or fan pressure;
- (9) ‘fan gas power’ (P_u), in W, means the product of the volume flow rate q_v , in m³/s, and the pressure difference between fan inlet and outlet Δp , in Pa, both determined at BEP, with a distinction between ‘static’ or ‘total’ fan gas power depending on whether the fan gas power has been determined with, respectively, the fan static pressure or fan pressure;
- (10) ‘electric input power’ (P_e), in W, means the electric input power at BEP, measured at main terminals of motor or, when a VSD is present, at VSD input current terminal;
- (11) ‘power conversion correction’ (C_p), means a correction factor for power conversion losses, as determined according to point 3 of Annex III;
- (12) ‘part load compensation’ (C_c) means a correction factor for part load, as determined according to point 5 of Annex III;
- (13) ‘guard compensation’ (C_{guard}) means a correction factor, as determined according to point 5 of Annex III, that may be applied when calculating fan efficiency where the fan is equipped with permanently fitted protective guards that cannot be removed without making the fan inoperable;
- (14) ‘volume flow rate’ (q_v), in m³/s, means the gas volume displaced per unit of time by the fan and is derived from the mass flow rate, typically with standard air with a density ρ at default 1.200 kg/m³;

- (15) ‘total pressure’ (p_{tot}), in Pa, means the pressure calculated from the absolute pressure and the dynamic pressure;
- (16) ‘absolute pressure’ (p), in Pa, means the pressure measured with respect to absolute zero pressure;
- (17) ‘dynamic pressure’ (p_d), in Pa, means the pressure calculated from the velocity and the density;
- (18) ‘fan dynamic pressure’ (p_{fd}), in Pa, means the dynamic pressure of the fan, defined at the fan outlet with the average velocity;
- (19) ‘fan static pressure’ (p_{fs}), in Pa, means the difference between the static pressure at the fan outlet and the stagnation pressure at the fan inlet or, when the compressibility phenomenon is not a factor, the difference between the static pressure at the fan outlet and the total pressure at the fan inlet. It is the omnidirectional force per unit surface area exerted at the fan outlet and is typically assessed by measuring the stagnation pressure in a (cylindrical) hole of appropriate geometry and dimensions, in duct wall or appropriate measurement instrument perpendicular to the direction of the gas flow;
- (20) ‘fan pressure’ (p_f), in Pa, means the difference between the stagnation pressures at the fan outlet and the fan inlet or, when compressibility phenomenon is not a factor, the difference between the total pressures at the fan outlet and the fan inlet. It is the directional force per unit surface area exerted at the fan outlet and is typically assessed by measuring the stagnation pressure in a (cylindrical) hole of appropriate geometry dimensions facing the direction of the gas flow;
- (21) ‘stagnation pressure’ (p_{sg}), in Pa, means the pressure measured at a point in a flowing gas if it were brought to rest via a process where there is no transfer of heat or matter;
- (22) ‘efficiency grade’ means a parameter in the calculation of the minimum energy efficiency of a fan of specific electric input power at its BEP (expressed as parameter ‘ N ’ in the calculation of the fan energy efficiency);
- (23) ‘minimum fan efficiency’ (η_{min}) means the fan efficiency to be achieved in order to meet the requirements, calculated as the outcome of the appropriate equation in Annex II, using the applicable integer N of the efficiency grade and the electric input power P_e of the fan expressed in kW at its BEP;
- (24) ‘jet-fan efficiency’ $\eta_r(T)$ means the fan gas power output derived from the measured thrust of a jet fan divided by the electric input power P_e , multiplied with correction factors for power conversion C_p , part load compensation C_c and guard compensation C_{guard} , in accordance with point 5 of Annex III;
- (25) ‘specific speed’ (σ_{BEP}) means the ratio between volume flow rate and fan pressure as dimensionless characteristic number determined at BEP, in accordance with point 7 of Annex III;
- (26) ‘low noise fan’ means an axial fan with an electric input power of 10 kW or more with a maximum characteristic noise emission value $L \leq 32$ dB(A);
- (27) ‘dual use fan’ means a fan designed for both ventilation under normal conditions and emergency use as set out in Article 1(3), point (b);
- (28) ‘reversible fan’ means a fan capable of reaching at least 80% of the nominal forward air flow in the reverse direction;

- (29) ‘custom fan’ means a fan having a custom design for a specific client and/or contract with respect to one or more of the significant elements, and an operating point or range specified by the client/contract. These fans are only supplied to that client/contract. Details are not presented in catalogues, online media or general selection programmes. The performance details are specific to the application and the client/contract;
- (30) ‘safety critical fan’ means a fan that has been designed, verified, certified and manufactured under the scope of either the Regulation (EU) No 305/2011 or Directive 2014/34 relating to equipment and protective systems intended for use in potentially explosive atmospheres;
- (31) ‘professional repairer’ means an operator or undertaking which provides services of repair and professional maintenance of fans;
- (32) ‘manufacturer-authorized professional repairer’ means a professional repairer authorised by the manufacturer, importer or authorised representative to repair safety critical fans they place on the market.
- (33) ‘wearing parts (sacrificial elements)’ means parts that are intentionally designed to wear to meet the requirements of the intended use. For example, where a fan is used in a abrasive environment the fan can quickly become damaged by the abrasion. Some parts are designed as sacrificial elements to protect other critical areas and are designed to be replaced more frequently;
- (34) ‘proprietary tool’ means a tool that is not commonly available and is specifically designed for a function that cannot be safely and/or reliably achieved by a commonly available tool;
- (35) ‘inherent speed’ means the rotation speed of the fan, when the fan is operated at nominal or rated supply conditions of the motor;
- (36) ‘guarantee’ means any undertaking by the manufacturer, importer or authorised representative to the consumer, to: (a) reimburse the price paid; or (b) replace, repair or handle fans in any way if they do not meet the specifications set out in the guarantee statement or in the relevant advertising.

ANNEX II

Ecodesign requirements for fans

Fans shall comply with the ecodesign requirements set out in points 1 to 5 of this Annex, except for fans integrated into other products which are placed on the market within the first year after the date of application of this Regulation, and provided those fans meet the requirements of Annex I to Regulation (EU) No 327/2011, using the calculation methods in Annex II to that Regulation, and verified by market surveillance authorities in accordance with Annex III to that Regulation.

However, until [10 years from date of application], spare part fans replacing fans placed on the market before [the date of application of this Regulation] shall be exempt from the requirements set out in points 1 to 5, provided that:

- (a) there is no replacement fan that is fit to be integrated into the product in question which is compliant with this Regulation, for example because its size exceeds the available physical space;
- (b) they comply with the information requirements set out in, point 6.

1. MINIMUM FAN EFFICIENCY REQUIREMENTS

With effect from [Two years after entry into force], the following rules shall apply:

1. Fans, except jet fans and cross flow fans, shall have a fan efficiency (η) equal to or larger than the minimum fan efficiency (η_{\min}), which is a function of the electric input power P_e (in kW) and minimum efficiency grade N following the equations:
 - for fans with $P_e < 10$ kW: $\eta_{\min} = 4.56 \text{ LN}(P_e) - 10.5 + N$ [%];
 - for fans with $P_e \geq 10$ kW: $\eta_{\min} = 1.1 \text{ LN}(P_e) - 2.6 + N$ [%].
2. Jet fans shall have a fan efficiency (η_r) equal to or larger than the minimum jet fan efficiency ($\eta_{r,\min}$), which is a function of the electric input power P_e (in kW) and minimum efficiency grade N following the equations:
 - for jet fans with $P_e \geq 750$ W and < 10 kW: $\eta_{r,\min} = 7.32 \text{ LN}(P_e) - 21.4 + N$ [%];
 - for jet fans with $P_e \geq 10$ kW: $\eta_{r,\min} = 1.73 \text{ LN}(P_e) - 8.2 + N$ [%].
3. Cross flow fans shall have a minimum total fan efficiency (B,D) of at least 0.21 (21%) over the full power range.
4. The fan efficiency shall be assessed in accordance with the measurement method in point 3 of Annex III.
5. Except cross flow fans, the values of the minimum efficiency grade N are set out in Table 1 per fan type, efficiency category (static or total) and measurement category (A to E) as appropriate.

Table 1

Minimum efficiency grades

Fan type	Measurement category	Efficiency category (pressure)	Minimum efficiency grades (N) (applicable from [2 years after entry into force])
Axial fans	A, C	static	50
	B, D	total	64
Forward curved <5 kW and backward inclined centrifugal fans	A, C	static	52
	B, D	total	57
Other centrifugal fans	A, C	static	64
	B, D	total	67
Mixed flow fans	A, C	static	$57+7 \cdot (\alpha - 45)/25$
	B, D	total	67
Jet fans ≥ 750 W	E		50

6. The calculation of the minimum efficiency grade N for mixed flow fans involves the fan flow angle α , in degrees rounded to the nearest integer, assessed in accordance with the measurement method in point 4 of Annex III;
7. For fans having the following characteristics, the values of the minimum efficiency grades N set out in Table 1 shall be multiplied by the corresponding factor(s), as applicable:

Fans characteristics	Factor value
Dual use fans designed for both ventilation under normal conditions and emergency use as set out in Article 1,3(b)	0.9
For reversible fans	0.85
Low noise fans	0.9

8. For centrifugal fans with specific speed $\sigma_{BEP} < 0.12$, electric input power $P_e < 10$ kW, measurement category B or D and efficiency category ‘total’ the minimum fan efficiency (η_{min}) is a function of σ_{BEP} as follows: $\eta_{min} = 2.95 * \sigma_{BEP} + 0.2$.

2. PRODUCT INFORMATION REQUIREMENTS ON FANS

1. With effect from [two years after entry into force], the information on fans set out in points 2(a) to (o) shall be visibly displayed on:
 - (a) the technical data sheet or user manual supplied with the fan, unless an internet link or a QR code linking to the free access website referred to in point (c) is supplied with the product;

- (b) the technical documentation for the purposes of conformity assessment pursuant to Article 4;
- (c) free access websites of the manufacturer of the fan, its authorised representative or the importer for a period of at least 20 years after the placing on the market of the last unit of the model concerned.

2. The following information shall be displayed:

- (a) fan type: select one of the following types: axial fan, forward curved centrifugal fan, backward curved centrifugal fan, backward inclined centrifugal fan, centrifugal fan (in case of a centrifugal fan that is not a forward curved, backward curved or backward inclined centrifugal fan), cross flow fan, mixed flow fan, jet fan;
- (b) fan efficiency (η), either as a number rounded to the nearest third decimal, or as a percentage (with symbol ‘%’) rounded to the nearest decimal;
- (c) measurement category used to determine the fan efficiency (A-E);
- (d) efficiency category (static or total), except for jet fans;
- (e) efficiency grade N at BEP;
- (f) the electric input power P_e (in kW), volume flow rate q_v (in m³/h rounded to the nearest integer, or alternatively, when flow rate is ≥ 0.5 m³/s in m³/s rounded to the nearest second decimal), and applicable pressure difference Δp (in Pa, rounded to the nearest integer) at BEP;
- (g) DC voltage lower than 100 V, with answer ‘yes’ or ‘no’;
- (h) list of all the other significant elements supplied with the fan;
- (i) specific speed σ_{BEP} , only for centrifugal fans with specific speed $\sigma_{BEP} < 0.12$, electric input power $P_e < 10$ kW, measurement category B or D and efficiency category ‘total’;
- (j) fan speed in revolutions per minute (rpm, rounded to the nearest integer) at BEP;
- (k) the specific ratio, rounded to the nearest second decimal;
- (l) manufacturer’s name, registered trade name or registered trademark, and the address at which the manufacturer can be contacted;
- (m) the model identifier and, where appropriate, other codes and marks sufficient for the product to be unequivocally and easily identified;
- (n) information relevant for facilitating disassembly, recycling or disposal at end-of-life;
- (o) information relevant to minimise impact on the environment and ensure optimal life expectancy as regards installation, use and maintenance of the fan.

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

The information listed in points (a) to (o) does not need to be published on free access websites for custom fans if this information is included in the commercial offers provided to the clients.

3. The information referred to in points 2(a), 2(b), 2(c) and 2(d) and year of manufacture shall be durably marked on or near the rating plate of the fan.
4. Manufacturers shall provide information in the manual of instruction on specific precautions to be taken when fans are assembled, installed or maintained, including cleaning.

3. INFORMATION REQUIREMENTS ON PARTIAL LOAD OR AT SPECIFIED DUTY

With effect from [Three years after entry into force], the following requirements shall apply:

1. For all fans, except custom fans, jet fans and fans with multiple speed motors:

The partial-load operational performance of the fan shall be provided for fans, except custom fans, jet fans and fans with multiple speed motors. This shall be described by a minimum of three performance curves at different speeds: one at the stated inherent speed, one at a lower speed of between 40 % and 50 % of the inherent speed, plus an additional one in the middle (± 5 %) of the other two. More than three curves can be provided, including at any speeds including ones lower than 40 %.

Performance curves shall comprise a sufficient number of test points to permit the characteristic curve to be plotted over the normal operating range.

The information on the curves can be in digital form such as selection software or online catalogue. However, the values of volume flow, pressure, electric power, fan rotation speed and efficiency shall be provided for the individual test points.

This information shall be available on:

- (a) the technical data sheet or user manual supplied with the fan, unless an internet link or a QR code to that information is supplied with the product;
- (b) the technical documentation for the purposes of conformity assessment pursuant to Article 4;
- (c) the free access websites of the manufacturer of the fan, its authorised representative or the importer.

2. For custom fans:

The performance or performance curve of custom fans at the specified operating point(s) or operating range(s) shall be provided. A performance curve shall comprise a sufficient number of test points to permit the characteristic curve to be plotted over the normal operating range. The values of volume flow, pressure, electric power and efficiency shall be provided for the individual test points.

This information shall be available on:

- (a) the technical data sheet or user manual supplied with the fan, unless an internet link or a QR code to that information is supplied with the product;
- (b) the technical documentation for the purposes of conformity assessment, pursuant to Article 4.

3. For jet fans:

The partial-load operational performance of the fan shall be provided for jet fans. For jet fans with a single speed motor there is no partial load operation, and no partial load information is required.

For jet fans without variable speed drives or not intended to be used with variable speed drives, but fitted with a multiple fixed speed motor, the additional operating point is at the lower speed settings.

For jet fans with a variable speed drive or intended to be used with a variable speed drive the additional data points shall be at 30% and 50% of the inherent speed.

For each operating point, the published data shall include thrust, electric input power, rotational speed and efficiency, as a minimum.

4. For fans with multiple speed motors except jet fans, the curves shall be provided for the motor's inherent and minimum speed available to the customer in the same conditions as set out in points 1 and 2 depending on whether or not the fan is a custom fan.

4. RESOURCE EFFICIENCY REQUIREMENTS

For fans that are specifically designed and marketed exclusively to be integrated in specific energy-related products covered by ecodesign requirements with respect to spare part availability, the specific provisions of the implementing regulation applicable to the product in question shall apply, for the duration specified therein, in place of the requirements set out in this point.

For custom fans for which spare part availability is addressed in the contract, and which are not covered by the previous paragraph, no specific requirements shall apply.

For other fans, the following requirements shall apply from [two years after entry into force]:

1. Availability of spare parts:
 - (a) For all models, units of which are placed on the market as from [date of application of this Regulation], manufacturers, importers or authorised representatives of fans, other than safety critical fans, shall make available to professional repairers at least the following spare parts, if part of the fan, as individual elements or integrated as originally supplied:
 - (1) motors of which the rated power is lower than 10 kW;
 - (2) motor brushes;
 - (3) impellers;
 - (4) stator elements;
 - (5) mechanical drive components;
 - (6) variable speed drives;
 - (7) sensors;
 - (8) wearing parts (sacrificial elements);
 - (9) joints and fixtures required to install these spare parts.
 - (b) For all models, units of which are placed on the market as from [date of application of this Regulation], manufacturers, importers or authorised representatives of safety critical fans shall make available to manufacturer-authorised professional repairers at least the following spare parts, if part of the fan, as individual elements or integrated as originally supplied:
 - (1) motors, of which the rated power is lower than 10 kW;

- (2) motor brushes;
 - (3) impellers,
 - (4) stator elements;
 - (5) mechanical drive components;
 - (6) variable speed drives;
 - (7) sensors;
 - (8) wearing parts (sacrificial elements);
 - (9) joints and fixtures required to install these spare parts.
- (c) Availability of spare parts referred to in points (a) and (b) shall be ensured for a minimum period starting at the latest [two years after date of application of this Regulation] or two years after the placing on the market of the first unit of the model, whichever is the later date, and ending at least 10 years after placing on the market the last unit of the model concerned. For that purpose, the list of spare parts, the procedure for ordering them and the repair instructions shall be publicly available on the free access website of the manufacturer, importer or authorised representative, at least during the same period and starting at the date referred to in this point. For safety critical fans, the free access website access may be restricted by username and password.
- (d) Maximum delivery time of spare parts:
- During the period mentioned in point (c), the manufacturer, importer or authorised representative shall ensure the delivery of the spare parts with the following timeframe:
- (1) as specified in a contract, where a contract exists between the manufacturer and the end user of the fan;
 - (2) if not, as specified in the product information of the fan and made available on free access websites;
 - (3) if not, then 8 weeks after having received the order.

2. Access to repair and maintenance information:

- (a) During the period referred to in point 1(c) the manufacturer, importer or authorised representative shall provide access to the fan repair and maintenance information to professional repairers.
- The manufacturer's, importer's or authorised representative's website shall indicate the process for professional repairers to request access to information. In order to accept such a request, the manufacturers, importers or authorised representatives may only require the professional repairer to demonstrate that:
- (1) the professional repairer has the technical competence to repair fans and complies with the applicable regulations for repairers of electrical equipment in the Member States where it operates. Reference to an official registration system as professional repairer, where such system is in place in the Member States concerned, shall be accepted as proof of compliance with this point;

- (2) the professional repairer is covered by insurance covering liabilities resulting from its activity regardless of whether this is required by the Member State.
 - (b) manufacturers, importers or authorised representatives shall accept or refuse the request referred to in point (a) within 5 working days.
 - (c) manufacturers, importers or authorised representatives may charge reasonable and proportionate fees for access to the repair and maintenance information or for receiving regular updates. A fee is reasonable if it does not discourage access by failing to take into account the extent to which the professional repairer uses the information.
 - (d) once the request is accepted, a professional repairer shall have access to the requested repair and maintenance information within one working day. The information may be provided for an equivalent model or model of the same family, where relevant.
 - (e) The repair and maintenance information shall include:
 - (1) the unequivocal appliance identification;
 - (2) a disassembly map or exploded view allowing to visualise at least the spare parts made available;
 - (3) a technical manual of instructions for repair;
 - (4) a list of necessary repair and test equipment;
 - (5) component and diagnosis information (such as minimum and maximum theoretical values for measurements);
 - (6) wiring and connection diagrams;
 - (7) diagnostic fault and error codes (including manufacturer-specific codes, where applicable);
 - (8) instructions for installation of relevant software and firmware including reset software;
 - (9) information on how to access data records of reported failure incidents stored on the product (where applicable).
3. Requirements for dismantling for material recovery and recycling while avoiding pollution:
- (a) manufacturers, importers or authorised representatives shall ensure that fans are designed in such a way that the materials and components referred to in Annex VII to Directive 2012/19/EU of the European Parliament and of the Council¹ can be removed with the use of commonly available tools.
 - (b) manufacturers, importers and authorised representatives shall fulfil the obligations laid down in Article 15(1) of Directive 2012/19/EU.
 - (c) When manufacturers, importers or authorised representatives of fans make available software and firmware updates, these shall remain available for a

¹ Directive 2012/19/EU of the European Parliament and of the Council of 4 July 2012 on waste electrical and electronic equipment (WEEE) (OJ L 197, 24.7.2012, p. 38).

minimum of 10 years after the placing of the last unit of a model on the market, and these software and firmware updates shall be provided free of charge.

5. MATERIAL EFFICIENCY PRODUCT INFORMATION REQUIREMENTS

From [two years after date of entry into force], user and installer instructions shall be provided in the form of a user manual on free access websites of manufacturers, importers and authorised representatives, and shall include the following information:

- (a) how to access professional repair services (internet webpages, addresses, contact details);
- (b) relevant information for ordering spare parts, directly from the manufacturer or through other channels;
- (c) the minimum period during which spare parts, necessary for the repair of the appliance, are available;
- (d) the minimum duration of the guarantee of the fan in years;
- (e) details of any proprietary tool required for repair;
- (f) instructions of correct installation;
- (g) instructions for maintenance;
- (h) identification of errors, the meaning of the errors and the action required, including identification of errors requiring professional assistance;
- (i) information on any implications of self-repair or non-professional repair for the safety of the user and for the guarantee.

6. PRODUCT INFORMATION REQUIREMENTS FOR SPARE PART FANS

From [two years after date of entry into force], the packaging (or the product itself in the absence of packaging), the technical data sheet or user manual supplied with the fan, and product information available online and in catalogues shall indicate in a clear and visible manner:

“This fan does not meet the performance requirements of Regulation (EU) [reference to this Regulation] and can only be used to replace a corresponding existing fan placed on the market before [date of entry into application of this Regulation] and integrated into a product, to the extent that no compliant fan is fit to be used as a replacement”.

The technical data sheet or user manual supplied with the spare part fan shall provide:

- (a) manufacturer’s name, registered trade name or registered trademark, and the address at which the manufacturer can be contacted;
- (b) the model identifier and, where appropriate, other codes and marks sufficient for the product to be unequivocally and easily identified;
- (c) information relevant for facilitating disassembly, recycling or disposal at end-of-life;
- (d) information relevant to minimise impact on the environment and ensure optimal life expectancy as regards installation, use and maintenance of the fan.

ANNEX III

Measurements and calculations

1. 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 using other reliable, accurate and reproducible methods that take into account the generally recognised state-of-the-art methods. They shall meet the conditions and technical parameters set out in points 2 to 5.

In the absence of existing relevant standards and until the publication of the references of the relevant harmonised standards in the Official Journal, the transitional testing methods set out in Table 2, or other reliable, accurate and reproducible methods, which take into account the generally recognised state-of-the-art methods, shall be used.

2. For the purpose of compliance testing and provided that reliable, accurate and reproducible test- and calculation methods are used, the manufacturer:
 - (a) may remove the elements that are not significant elements as defined in Article 2, point (2);
 - (b) may conduct the tests with the geometrical equivalent of the stator inner surface;
 - (c) may conduct the tests with a scale model and calculate the results for the real-size product if the latter has an impeller diameter above 1 m for jet fans or 0.5 m for other fans;
 - (d) may conduct the tests at customer's or manufacturer's site if the latter has an impeller diameter above 1 m for jet fans or 0.5 m for other fans.

The compliance of fans with multiple speed motors shall be determined at the power and speed corresponding to the highest speed made available to the customer.

The compliance of fans of which the blade pitch angle can be adjusted to fulfil the customer's duty point shall be determined using the pitch configuration made available to the customer.

3. Fan flow angle

The fan flow angle α is calculated as the average value of angles α_1 and α_2 following the formula:

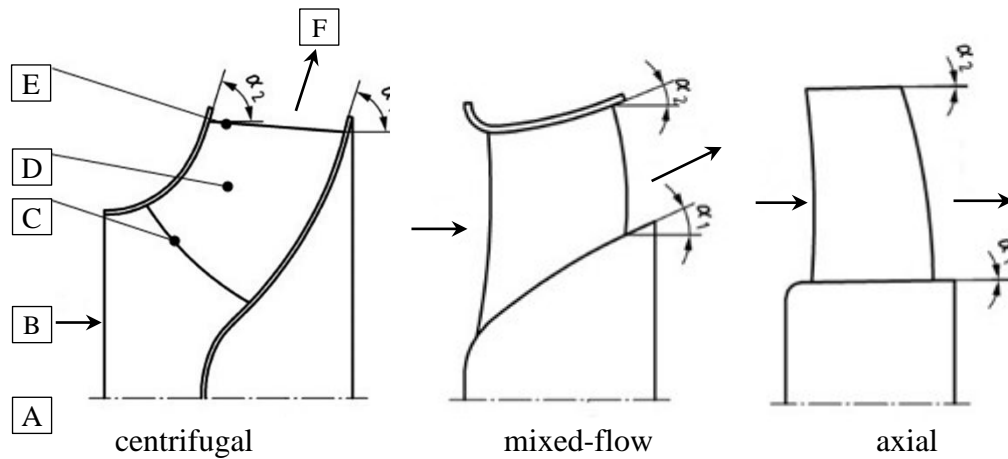
$$\alpha = \frac{\alpha_1 + \alpha_2}{2}$$

where:

α_1 is the angle of the tangent at the hub at the intersection of the blade trailing edge with the hub;

α_2 is the angle of the tangent at the shroud or at the outer diameter of the blade at the intersection of the blade trailing edge with the shroud or with the outer diameter of the blade, given that, if the hub and/or shroud are not axisymmetric, angles α_1 and α_2 are the average values in circumferential direction.

An impeller defined as ‘axial’ if $\alpha < 20^\circ$, ‘mixed-flow’ if $20^\circ \leq \alpha < 70^\circ$ and ‘centrifugal’ if $\alpha \geq 70^\circ$.

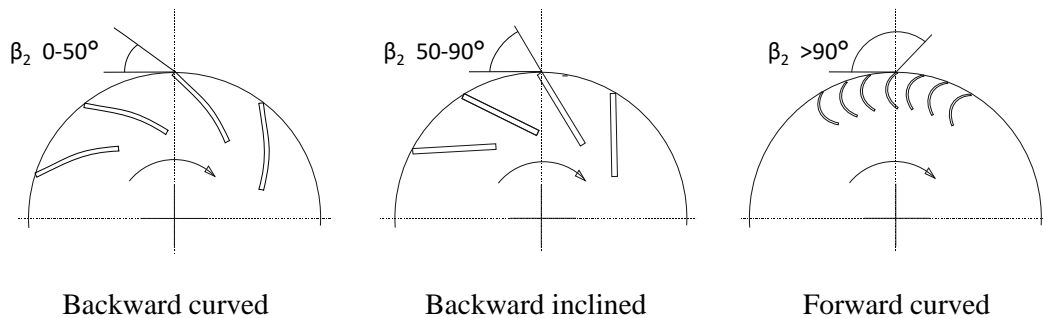


Where:

A = rotation axis; B = inflow; C = leading edge; D = blade; E = trailing edge; F = outflow

4. Centrifugal blade angle

‘Centrifugal blade angle β_2 means the angle between the tangent to the outer circumference of the outer circle, as defined by the trailing edge of the blades, and a line bisecting the trailing edge of the blade. To consider blade designs that have a rapid change of angle at the trailing edge, the angle is the arithmetic mean along 50% of the trailing length of the blade. The trailing edge of the blade is the edge at the tip of the blade at the outlet of the impeller. A centrifugal impeller is defined as ‘backward curved’ if $0^\circ < \beta_2 \leq 50^\circ$, ‘backward inclined’ if $50^\circ < \beta_2 \leq 90^\circ$ and ‘forward-curved’ if $\beta_2 > 90^\circ$.



5. Fan efficiency

5.1. Fans, other than jet fans

The fan efficiency is calculated as follows:

$$\eta = C_p \cdot C_c \cdot C_{\text{guard}} \cdot P_u / P_e$$

where:

C_p is a correction factor for power conversion losses with a value of 0.9 for fans equipped with a DC motor with a rated voltage lower than 100 V when the converter transforming AC into DC is not part of the fan, and 1.0 otherwise;

C_c is a correction factor for part load compensation with one of the following values:

$C_c = 1$ for a fan without a variable speed drive;

$C_c = 1.04$ for a fan with a variable speed drive and $P_e \geq 5$ kW and where this variable speed drive is included in the fan conformity assessment;

$C_c = 1 + 0.0812 (P_e)^{-0.5}$ for a fan with a variable speed drive and $P_e < 5$ kW and where this variable speed drive is included in the fan conformity assessment;

C_{guard} is a correction factor for guard compensation that may be applied when calculating fan efficiency in case the fan is equipped by permanently fitted protective guards that cannot be removed without making the fan inoperable. The value of C_{guard} is:

- 1 for a fan without a protective guard, with removable protective guard, or a protective guard with opening $e > 30$ mm;
- 1.02 for a fan equipped with a protective guard with opening $20 < e \leq 30$ mm;
- 1.06 for a fan equipped with a protective guard with $10 < e \leq 20$ mm;
- 1.09 for a fan equipped with a protective guard with opening $8 < e \leq 10$ mm;
- 1.15 for a fan equipped with a protective guard with opening $e \leq 8$ mm,

where ‘e’ is the dimension of the opening, corresponding to the side of a square opening, the diameter of a round opening and the narrowest dimension of a slot opening, as defined in section 4.2.4.1 of standard EN ISO 13857:2019;

P_u , in W, is the product of the volume flow rate q_v , in m^3/s , and the pressure difference between fan in- and outlet Δp , in Pa, both determined at BEP, following the expression:

$$P_u = q_v \cdot \Delta p,$$

where q_v , in m^3/s , is the gas volume displaced per unit of time by the fan and is derived from the mass flow rate, typically with standard air with a density ρ at default $1.200 \text{ kg}/\text{m}^3$;

P_e , in W, is the electric input power at BEP, measured at main terminals of motor or, when present, variable speed drive.

5.2. Jet-fans

The jet-fan efficiency $\eta_r(T)$ is calculated as:

$$\eta_r(T) = C_p \cdot C_c \cdot C_{\text{guard}} \cdot q_v(T) \cdot \frac{\Delta p(T)}{P_e} = C_p \cdot C_c \cdot C_{\text{guard}} \cdot 0.5 \sqrt{\frac{T_m}{\rho \cdot A_2}} \cdot \frac{T_m}{P_e}$$

where:

$q_v(T)$ is volume flow rate at thrust T, in m³/s;

$\Delta p(T)$ is pressure difference at thrust T, in Pa;

P_e electric input power supplied to the fan, in W;

ρ is the standard air density (1.2 kg/m³);

A_2 is the gross fan outlet area in m²;

T_m is fan thrust measured, in N, assessed according to measurement category E.

C_p , C_c and C_{guard} are correction factors as outlined in section 5.1 above.

6. Characteristic noise emission value L

The characteristic noise emission value C, in dB(A) is defined as

$$L = PWL_{impeller} - 30 \log u_{tip} - 10 \log (0.001 \cdot q_v \cdot p_{fs}) + 5 \log D_{impeller}$$

where:

$PWL_{impeller}$ is impeller sound power level, in dB(A);

u_{tip} is impeller tip speed, in m/s;

q_v is volume flow rate, in m³/s;

p_{fs} is fan static pressure, in Pa;

$D_{impeller}$ is impeller diameter, in m.

7. Specific speed σ_{BEP}

The specific speed σ_{BEP} of centrifugal fans with electric input power $P_e < 10$ kW, measurement category B or D and efficiency category 'total' is defined as:

$$\sigma_{BEP} = n \cdot \frac{2 \cdot \sqrt{\pi \cdot q_{v,BEP}}}{\left(2 \cdot \frac{p_{f,BEP}}{\rho}\right)^{0.75}} \frac{2 \cdot \sqrt{\pi \cdot q_{v,BEP}}}{\left(2 \cdot \frac{p_{f,BEP}}{\rho}\right)^{0.75}}$$

where:

σ_{BEP} is specific speed;

n is fan speed in revolutions per second (rps);

ρ is air density 1.2 kg/m³;

$q_{v,BEP}$ is volume flow rate at BEP, in m³/s;

$p_{f,BEP}$ is fan pressure at BEP, in Pa;

π is the number pi (3.14...).

Table 2

References and qualifying notes for fans

(The source of all references is CEN unless otherwise indicated)

Parameter	Reference/ Title	Notes and short description
	<i>FprEN 17166:2020 Fans – Procedures and methods to</i>	

	<i>determine the energy efficiency for the electric input power range of 125 W up to 500 kW</i>	
Measurement category	§ 4.3 Identification of an appropriate measurement category.	The measurement category means a test, measurement or usage arrangement that defines the inlet and outlet conditions of the fan under test, used to determine the energy efficiency. Categories included are numbered A through E, according to EN ISO 13349:2010 and EN ISO 5801:2017 § 6.2, 6.3, 6.4, 6.5 (categories A though D) and EN ISO 13350:2015 (category E – jet fans).
Efficiency category	§ 3.15.1 and § 3.15.3 Definitions of fan pressure and fan static pressure.	The fan gas output energy form used to determine the fan energy efficiency, defined by fan pressure or fan static pressure.
Efficiency grade	§ 6.1 and § 6.2 Method of comparison between efficiency grades.	Parameter in the calculation of the minimum fan energy efficiency is denoted in this Regulation as ‘N’. In FprEN 17166:2020 the minimum required efficiency grade is denoted N_g .
Fan efficiency	§ 5.5.2.5 Testing of jet fans § 5.5.2.2 to 5.5.2.4 § 5.6 Calculation method for not final assembly.	Jet fan overall efficiency is calculated following EN ISO 13350:2015. For all other fan types in accordance with the provisions of EN ISO 5801:2017. Where scaling is necessary it shall be carried out in accordance with the requirements of ISO 13348:2007 subclause 7.1.6. Full-size testing on-site shall be carried out in accordance with the test and calculation methods in EN ISO 5802:2008/A1:2015. Denoted η in this Regulation. Reference efficiency (η_{ref}) in the standard is defined as the fan efficiency value which is used to

		verify compliance, being either the fan overall efficiency referred to the drive input power, (η_{ed}), or the fan overall efficiency referred to the motor input power (η_e), depending on whether a VSD is used or not.
Volume flow rate q_v	§ 3.18 Volume flow rate	Volume flow rate q_{v1} is the mass flow rate divided by the density at fan inlet: $q_{v1} = q_m / \rho_1$. EN ISO 5801:2017 § 11.2 and Annex A for mass flow rate measurement and calculation, whereby the volume flow rate can be calculated according to § 15.1.8.
Specific speed σ_{BEP}	§ 3.15.1	The ratio between flow rate and fan pressure as dimensionless characteristic number determined at BEP, which can be calculated according to Annex III, 7. The needed fan pressure can be calculated according to FprEN 17166:2020 § 3.15.1.
	<i>EN ISO 5801:2017 Fans – Performance testing using standardised airways</i>	
Pressure difference Δp (in Pa) at BEP	§ 12.8.9 Method of measurement	Describes how to measure pressure difference between fan inlet and outlet, which following the Regulation has to be measured at BEP.
Fan speed (rpm)	§ 7.2 and § 12.3 Rotational speed	
Specific ratio	§ 15.1.6 Fan pressure	The stagnation pressure measured at the fan outlet divided by the stagnation pressure at the fan inlet at nominal flow rate. The specific ratio can be calculated from EN ISO 5801:2017 § 3.35 where it is defined as fan pressure ratio (r), where $r = p_{sg2} / p_{sg1}$.
	<i>IEC/EN 60034-2-1:2014 Rotating electrical machines - Part 2-1: Standard methods for determining losses and</i>	

	<i>efficiency from tests (excluding machines for traction vehicles)</i>	
Electric input power P_e (in kW)	§ 6.1.2 Direct measurement of input (P_1) and output (P_2)	The electric input power at BEP, measured at main terminals of motor or, when present, variable speed drive. EN IEC/60034-2-1:2014 for the electric input power of electric motors fed directly from the grid, EN IEC 61800-9-2:2017 for the electric input of electric motors combined with and fed by a CDM).
	<i>EN 45550 – 45559 series on Energy-related products - Material efficiency aspects for Ecodesign</i>	
Disassembly, recycling or disposal at end-of-life	EN 45553:2020 EN 45555:2019 EN 45558:2019 EN 45559:2019	Disassembly aspects. Assessing the recyclability and recoverability of an energy related product. Critical raw material (CRM) content. Methods for providing information relating to material efficiency.

ANNEX IV

Verification procedure for market surveillance purposes

1. The verification tolerances defined in this Annex relate only to the verification by Member State authorities of the declared values 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.
2. 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 non-compliant.
3. As part of 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, the authorities of the Member States shall apply the following procedure:
 - (a) the Member State authorities shall verify one single unit of the model;
 - (b) the model and all equivalent models shall be considered to comply with the requirements set out in this Regulation if all the following conditions are fulfilled:
 - (i) the declared values given in the technical documentation pursuant to point 2 of Annex IV to Directive 2009/125/EC 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 2(g) of that Annex;
 - (ii) 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;
 - (iii) when the Member State authorities check the unit of the model, it complies with the product information requirements in points 2, 3, 5 and 6 and resource efficiency requirements in point 4 of Annex II, as applicable;
 - (iv) 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 set out in Table 3.
4. Where the results referred to in points 3(b), (i), (ii) and (iii) are not achieved, the model and all equivalent models shall be considered not to comply with this Regulation.
5. Where the result referred to in point 3(b)(iv) 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.
6. The model shall be considered to comply with the applicable requirements if, for the three units referred to in point 5(b), the arithmetical mean of the determined values, complies with the respective verification tolerances set out in Table 3.
7. Where the result referred to in point 5 is not achieved, the model and all equivalent models shall be considered not in compliance with this Regulation.
8. The Member State authorities shall, without delay, provide all relevant information to the authorities of the other Member States and to the Commission through the information and communication referred to in Article 34 of Regulation (EU) 2019/1020 of the European Parliament and of the Council² after a decision is taken on the non-compliance of the model according to points 2, 4 or 7.
9. The Member State authorities shall use the measurement and calculation methods set out in Annex III.
10. The performance curves referred to in point 3 of Annex I shall be verified by checking a minimum of two declared test points for each of the characteristic curves.
11. Given the weight and size limitations for the transportation of fans with electric input power of 250 to 500 kW, Member State 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.
12. If factory acceptance tests are planned for such fans, which will test parameters laid down in Annex II 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 fan 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.
13. In the cases mentioned in points 11 and 12, the Member State authorities only need to verify one single unit of the model. If the result referred to in point 3(b)(v) is not achieved, the model and all equivalent models shall be considered not to comply with this Regulation.
14. When testing fans at part load, the Member State authorities shall use a variable speed drive without filters, with a view to minimising VSD energy losses.
15. The Member State authorities shall only apply the verification tolerances set out in Table 3 and shall only use the procedure described in this Annex for the requirements referred to in this Annex. For the parameters in Table 3, no other

² Regulation (EU) 2019/1020 of the European Parliament and of the Council of 20 June 2019 on market surveillance and compliance of products and amending Directive 2004/42/EC and Regulations (EC) No 765/2008 and (EU) No 305/2011 (OJ L 169, 25.6.2019, p. 1).

tolerances such as those set out in harmonised standards or in any other measurement method shall be applied.

<i>Table 3 — Verification tolerances</i>	
<i>Parameters</i>	<i>Verification tolerances</i>
Fan efficiency (η)	The determined value* shall not be lower than the value representing 93 % of the corresponding declared value at BEP, and not be lower than the value representing 85 % of the corresponding declared value at partial load.
Electric input power (P_e)	The determined value* shall not be higher than the value representing 107 % of the corresponding declared value at BEP, and not be higher than the value representing 110 % of the corresponding declared value at partial load.
Volume flow rate (q_v)	The determined value* shall not differ by more than 5% from the corresponding declared value at BEP, and not more than 10% than the corresponding declared value at partial load.
Pressure difference (Δp)	The determined value* shall not differ by more than 5% from the corresponding declared value at BEP, and not more than 10% than the corresponding declared value at partial load.

* Where three additional units are tested in accordance with point 5(b), the determined value means the arithmetical mean of the values determined for those three additional units.

ANNEX V

Indicative benchmarks

The maximum values relate to the achievable efficiency grade N (minimum efficiency formulas are set out in Annex II) with clean air and no space and/or noise restrictions. The minimum values apply to contaminated air (some dust load) and space, noise and/or other operational restrictions at the limit of what is still in scope according to the exemptions in Article 1.

Table 4

Indicative benchmarks for fans

Fan type	Measurement category	Pressure	N minimum	N maximum
Axial fans	A, C	static	50	75
	B, D	total	64	85
Forward curved <5 kW and backward inclined fans	A, C	static	52	65
	B, D	total	57	70
Forward curved ≥ 5 kW, backward curved fans	A, C	static	64	80
	B, D	total	67	85
Mixed flow fans	A, C	static	$57+7 \cdot (\alpha - 45)/25$	77
	B, D	total	67	85
Jet fans	E		60	

Cross flow fans: 21% efficiency.