WORKING DOCUMENT

DRAFT ECODESIGN REGULATION

Review of Regulation 327/2011

COMMISSION REGULATION (EU) …/…

of XXX

implementing Directive 2009/125/EC of the European Parliament and of the Council with regard to ecodesign requirements for fans and repealing Regulation 327/2011

(Text with EEA relevance)

THE EUROPEAN COMMISSION,

Having regard to 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,

Having regard to Commission Regulation (EU) 327/2011 of 30 March 2011 implementing Directive 2009/125/EC of the European Parlimanet 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[2],

After consulting the Ecodesign Consultation Forum,

Whereas:

(1) Under Directive 2009/125/EC ecodesign requirements should be set by the Commission for energy-related products representing significant volumes of sales and trade, having a significant environmental impact and presenting significant potential for improvement through design in terms of their environmental impact without entailing excessive costs.

(2) Article 16(2)(a) of Directive 2009/125/EC provides, that in accordance with the procedure referred to in Article 19(3) and the criteria set out in Article 15(2), and after consulting the Ecodesign Consultation Forum, the Commission should, as appropriate, introduce implementing measures for products offering a high potential for cost-effective reduction of greenhouse gas emissions, such as for fans.

(3) Clarity and transparency regarding the applicable requirements for different fans needs to be ensured. Regulation 327/2011 is repealed from the date of coming into application of the minimum requirements set out in this Regulation.

(4) Fans driven by motors are an important part of various gas handling products. Minimum energy efficiency requirements have been established for electric motors in Commission Regulation [*number and footnote to be added after publication in OJEU*][3]. They also apply to those motors which are part of a motor-fan system.

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1 OJ L 285, 31.10.2009, p. 10.
2 OJ L 90, 6.4.2011, p. 8.
3 OJ L XX, X.X.201X, p. XX.

However, many fans covered by this Regulation are used in combination with motors not covered by Regulation [*number to be added after publication in OJEU*]

(5) Many fans are integrated in other products without being separately placed on the market or put into service in the meaning of Article 3 of Directive 2009/125/EC. To achieve the full cost-efficient energy saving potential, fans integrated in other products where the efficiency can be tested separately should be subject to the provisions of this Regulation.

(6) The Commission has carried out a preparatory study covering the technical, environmental and economic aspects of fans and variable speed drives typically used in the Union. The study was devised together with stakeholders and interested parties from the Union and third countries, and the results have been made publicly available.

(7) Fans used 262 TWh of electricity for the production of mechanical energy in 2010; this corresponds to corresponding to 108 Mt of CO_2 emissions. Without the requirements set out in Regulation 327/2011 this value was expected to increase to 336 TWh in 2020 and 384 TWh in 2030 corresponding to 128 Mt of CO_2 in 2020 and 130 Mt of CO_2 in 2030.

(8) The measures set out in Regulation 327/2011, once the possible overlap on savings accounting with other measures has been taken into account will result in savings of 28 TWh in 2020 and 52 TWh in 2030, corresponding to 12 Mt of CO_2 in 2020 and 18 Mt of CO_2 in 2030.

(9) The preparatory study shows that fans are placed on the Community market in large quantities, with their use-phase energy consumption being the most significant environmental aspect of all life cycle phases.

(10) It has been concluded that the life-cycle energy consumption and the use-phase electricity consumption of fans can be improved significantly.

(11) The environmental aspect of fans that has been identified as significant for the purposes of this Regulation is energy consumption.

(12) The preparatory study shows that requirements regarding the other ecodesign parameters referred to in Annex I, Part 1 to Directive 2009/125/EC are not necessary in the case of fans.

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

(14) Ecodesign requirements should harmonise power consumption requirements for fans throughout the Community, thus contributing to the functioning of the internal market and to the improvement of the environmental performance of these products.

(15) An appropriate timeframe should be provided for manufacturers to redesign products. The timing should be such that negative impacts on the functionalities of fans, and cost impacts for manufacturers, in particular small and medium-sized enterprises, are taken into account, while ensuring timely achievement of the objectives of this Regulation.

(16) Measurements of the relevant product parameters should be performed through reliable, accurate and reproducible measurement methods, which take into account the recognised state of the art measurement methods including, where available, harmonised standards adopted by the European standardisation organisations, as listed

in Annex I to Regulation (EU) 1025/2012 of the European Parliament and of the Council of 25 October 2012 on European standardisation[4].

(17) Regulation 327/2011 was estimated to save 34 TWh per year by 2020. As the provisions set out in such Regulation are maintained, such savings are also maintained.

(18) This Regulation should increase the market penetration of technologies that improve the life-cycle environmental impact of fans, leading to an estimated life-cycle electricity savings of 10 TWh by 2030, compared to the situation where no additional measures are taken.

(19) In accordance with Article 8(2) of Directive 2009/125/EC, this Regulation specifies which conformity assessment procedures apply.

(20) In order to facilitate compliance checks, manufacturers should provide the information in the technical documentation referred to in Annexes IV and V to Directive 2009/125/EC insofar that information relates to the requirements laid down in this Regulation.

(21) In order to further limit the environmental impact of motors manufacturers should provide relevant information on disassembly, recycling or disposal at end-of-life.

(22) Benchmarks for currently available technologies with high energy efficiency should be identified. This will help to ensure the wide availability and easy accessibility of information, in particular for small and medium-sized enterprises and very small firms, which will further facilitate the integration of best design technologies for reducing energy consumption.

(23) 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 and scope

1. This Regulation establishes ecodesign requirements for the placing on the market or putting into service of fans with an end-use as component or as sub-assembly integrated in other products.

2. This Regulation shall not apply to:

   a) fan-impellers mounted on the shaft of electric motors of 3 kW or less with the sole purpose of cooling the motor itself;

   b) fans integrated in laundry and washer dryers ≤ 3 kW maximum electrical input power;

   c) fans integrated in kitchen hoods < 280 W total maximum electrical input power attributable to the fan(s);

   d) fans with a best energy efficiency point (bep) at 8000 rotations per minute or more;

3. This Regulation shall not apply to fans which are specified to operate exclusively:

[4] OJ L 316, 14.11.2012, p. 12.

a) in potentially explosive atmospheres as defined in Directive 94/9/EC[5] of the European Parliament and of the Council;

b) for emergency use only, at short-time duty of 1 hour or more, with regard to fire safety requirements for temperatures of 300°C and above set out in Regulation (EU) No 305/2011 of the Council and the Parliament[6];

c) in nuclear installations nuclear installations, as defined in Article 3 of Directive 2009/71/EURATOM[7], military or civil defence establishments and wind turbines;

d) where operating temperatures of the gas being moved is higher than 100 °C or lower than – 40 °C;

e) where operating ambient temperature for the motor, if located outside the gas stream, driving the fan is higher than 65 °C or lower than – 30 °C;

f) with a supply voltage > 1 000 V AC or > 1 500 V DC;

g) handling toxic, highly corrosive or flammable gases or vapours as set out in Regulation (EC) No 1272/2008[8] and its adaptations;

h) handling abrasive substances with a hardness of at least 5 Mohs with a concentration of at least 100 mg/m³;

i) handling gases containing bio-hazardous substances of risk groups 2, 3 and 4 as set out in Directive (EC) 2000/54/EC[9];

j) handling gases containing carcinogens or mutagens as set out in Directive 2004/37/EC[10];

k) handling gases with a solid particle concentration of more than 200 mg/m³ and/or particles with an average diameter of 1 mm;

l) handling gases with a compressibility factor, rounded to the nearest 2 decimal places, in the designated pressure and temperature range of the scope that is not equal to 1,00;

m) in cordless or battery operated equipment;

n) in hand-held equipment whose weight is supported by hand during operation;

o) as a replacement for identical fans that are no longer compliant with the minimum requirements in this regulation, for a period of 5 years after the implementation date of the tier whose requirements could not be met by the identical fan to be replaced;

whereby the packaging, the product information, nameplate and the technical documentation must clearly indicate regarding (a) to (n) that the fan shall only be used for the purpose for which it is specified and regarding (o) the product(s) it is intended to replace.

Article 2

5 OJ L 100, 19.4.1994, p. 1
6 OJ L 88, 4.4.2011, p. 5.
7 OJ L 172, 2.7.2009, p. 18.
8 OJ L 353, 31.12.2008, p. 1.
9 OJ L 262, 17.10.2000, p. 21.
10 OJ L 158, 30.4.2004, p. 50.

Definitions

In addition to the definitions set out in Directive 2009/125/EC, the following definitions shall apply:

1. 'Fan' means a configuration of impeller, stator and drive system, intended for the continuous displacement of gas with at its bep an electric input power ≥ 125 W and ≤ 500 kW, a pressure-increase ratio lower than 1.1 and an output air velocity lower than 65 m/s, and which is an axial fan, centrifugal fan, cross flow fan, mixed flow fan or jet fan;
2. 'bep' is the best energy efficiency point for fan operation, as declared by the manufacturer and specified by the applicable fan speed, expressed in rounds per minute (rpm);
3. 'Impeller' means the part of the fan that is imparting energy into the gas flow and is also known as the fan wheel;
4. 'Stator' is the stationary part of the fan which interacts with the air stream passing through the impeller and, within the geometrical air-stream envelope between defined fan inlet- and outlet sections, includes any part that may increase, and excludes any non-fan component that may decrease, the fan efficiency, following manufacturer's instruction;
5. 'Drive system' means electric motor, transmission or direct drive and possibly a variable speed drive;
6. 'Transmission' means a driving arrangement for a fan which is not 'direct drive' as defined above. Such driving arrangements may include transmissions using a belt-drive, gearbox or slipping coupling;
7. 'Direct drive' means a driving arrangement for a fan where the impeller is fixed to the motor shaft, either directly or with a co-axial coupling, and where the impeller speed is identical to the motor's rotational speed;
8. 'Variable speed drive' (VSD) means an electronic power converter, integrated or functioning as one system or as a separate delivery with the motor and the fan, which continuously adapts the electrical power supplied to the motor in order to control its mechanical power output according to the torque-speed characteristic of the load it is driving, including EC (electronically commutated) motors with an internal control, excluding variable voltage controllers where only the supply voltage for the motor is varied;
9. The 'specific pressure ratio' means the stagnation pressure measured at the fan outlet divided by the stagnation pressure at the fan inlet at nominal flow rate;
10. 'Fan flow angle' is the angle between incoming and outgoing gas flow direction of the fan-impeller measured in accordance with Annex V, point 1;
11. 'Axial fan' means a fan with a fan flow angle ≤20°, 'centrifugal fan' means a fan with a flow angle ≥70° and 'mixed flow fan' means a fan with a flow angle >20° and <70°;
12. 'Centrifugal blade angle' means the inclination of a centrifugal fan blade towards or away from its rotation direction measured in accordance with Annex V, point 2;
13. 'forward-curved' means a centrifugal fan with a fan blade angle ≥1°, 'backward-curved' means a centrifugal fan with a fan blade angle ≤−1° and 'radial' means a centrifugal fan with a fan blade angle <1° and > −1°;

14. ‘Cross flow fan’ means a fan in which the gas path through the impeller is in a direction essentially at right angles to its axis both entering and leaving the impeller at its periphery;
15. ‘Jet fan’ means a fan used for producing a jet of air in a space and unconnected to any ducting;
16. ‘Low noise fan’ means a fan with an electric power input of 10 kW or more with a maximum characteristic noise emission value C ≤32 dB(A), as set out in Annex V, point 4;
17. ‘Dual use fan’ means a fan designed for both ventilation under normal conditions and emergency use as set out in Art. 1, 3 (b);
18. ‘Reversible fan’ means a fan capable of reaching at least 80% of the nominal forward air flow in the reverse direction.

Article 3

Ecodesign requirements

1. The ecodesign requirements for fans are set out in Annex II, using definitions in Article 2 and Annex I.
2. The fan minimum energy efficiency requirements of Annex I Section 2 shall apply from 1 January 2020.
3. The product information requirements on fans and how they must be displayed are as set out in Annex III. These requirements shall apply from 1 January 2020.
4. For non-reversible dual use fans designed for both ventilation under normal conditions and emergency use as set out in Art. 1, 3 (b), the values of the applicable efficiency grades set out in Annex I will be multiplied by a factor 0.9.
5. For reversible fans, for dual use or not, the values of the applicable efficiency grades set out in Annex I will be multiplied by a factor 0.85.
6. For low noise fans the values of the applicable efficiency grades set out in Annex I will be multiplied by a factor 0.9.
7. Compliance with ecodesign requirements shall be measured and calculated in accordance with requirements set out in Annex III.

Article 4

Conformity assessment

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 to that Directive or the management system for assessing conformity set out in Annex V to that Directive.

Article 5

Verification procedure for market surveillance purposes

When performing the market surveillance checks referred to in Article 3(2) of Directive 2009/125/EC, the authorities of the Member States shall apply the verification procedure set out in Annex IV to this Regulation.

Article 6

Indicative benchmarks

The indicative benchmarks for the best-performing fans available on the market at the time of entry into force of this Regulation are set out in Annex VI.

Article 7

Revision

The Commission shall review this Regulation no later than 5 years after its entry into force in the light of technological progress. The review will include the assessment of design options that can facilitate re-use and recycling. The results of this review shall be presented to the Ecodesign Consultation Forum.

Article 8

Entry into force

This Regulation repeals Commission Regulation (EU) 327/2010 and shall enter into force on the 20th day following its publication in the Official Journal of the European Union.

Annex I

Definitions

(1) ‘Measurement category’ means a test, measurement or usage arrangement that defines the inlet and outlet conditions of the fan under test;

(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 a duct fitted to its inlet and outlet and a partition between inlet and outlet zone;

(4) ‘Measurement category C’ means an arrangement where the fan is measured with free inlet conditions and a duct fitted to its outlet 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 static or total pressure difference between fan in- and outlet;

(8) ‘Fan efficiency’ (η_f) is the ratio of the fan gas power output P_u and the electric power input P_e, both expressed in W and determined at bep, multiplied with correction factors for power conversion C_p and part load compensation C_c, following the expression:

$$\eta_f = C_p \cdot C_c \cdot P_u / P_e$$

with a distinction between 'static' or 'total' efficiency depending on whether the fan gas power P_u has been determined with respectively the static or total pressure difference between fan in- and outlet;

(9) 'Fan gas power' (P_u), in W, is the product of the fan 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:

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

with a distinction between 'static' or 'total' fan gas power depending on whether the fan gas power has been determined with respectively the static or total pressure difference Δp between fan in- and outlet;

(10) 'Electric power input' P_e, in W, is the electric input power at bep, measured at main terminals of motor or, when present, variable speed drive;

(11) 'Power conversion correction' C_p, is a correction factor for power conversion losses with a default value of 0.9 for fans using DC current with a voltage lower than 100 V;

(12) 'Part load compensation' C_c is a correction factor with one of the following values:

C_c=1 for a motor without a variable speed drive;

C_c=1,04 for a motor with a variable speed drive and $P_e \geq 5$ kW;

$C_c = -0{,}03 \ln(P_e) + 1{,}088$ for a motor with a variable speed drive and $P_e < 5$ kW;

(13) 'Fan flow rate' q_v, in m³/s, is the gas volume displaced per unit of time by the fan and is typically derived from assessment of the fan dynamic pressure difference, air velocity or measured thrust, calculated using the gravitational gas density ρ at default 1.2 kg/m³ and the fan outlet surface area;

(14) 'Fan static pressure' (p_{fs}), in Pa, 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;

(15) 'Fan total pressure' (p_f), in Pa, 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 or, for jet fans, by measuring the reactive thrust force exerted on the fan by the gas flow per unit fan outlet surface area;

(16) 'Stagnation pressure' means the pressure measured at a point in a flowing gas if it were brought to rest via an isentropic process;

(17) 'Efficiency grade' is a parameter in the calculation of the target 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);

(18) 'Minimum fan efficiency' (η_{min}) is the fan efficiency to be achieved in order to meet the requirements, calculated as the outcome of the appropriate equation in Annex II, Table 1, using the applicable integer *N* of the efficiency grade and the electrical power input P_e of the fan expressed in kW at its bep;

(19) 'Test fan' is the fan, as defined in Article 2, whereby for the purpose of compliance testing the manufacturer:

- must add motor- or bearing struts and, except for jet fans, an orifice panel or orifice ring, to which these struts are attached for the benefit of testing;
- may remove the parts and geometry sections, e.g. in case the envelope extends beyond the defined inlet and outlet sections, that are not included in the defined stator;
- may conduct the tests with the geometrical equivalent of the stator inner surface;

- 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;
- 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.

provided that reliable, accurate and reproducible test- and calculation methods are used and modifications, test conditions and calculations are meticulously reported as prescribed in Annex I, section 3.

(20) 'Test gas' is the working fluid for the purpose of compliance testing, and independent of the actual gas used in the fan, is clean air at standard inlet conditions of 20 °C and 101325 Pa;

(21) 'Jet-fan impeller efficiency' η_r(T) is the fan gas power output derived from the measured thrust of a jet fan divided by the mechanical power supplied to the impeller of the fan, in accordance with Annex V, point 3.

Annex II

Ecodesign requirements for fans

Fan energy efficiency requirements

The minimum fan efficiency (η_{min}) values as a function of the electric power input P_e (in kW), efficiency grade N from the equations:

- for fans with Pe<10 kW: $\eta_{min} = 0.0456\ LN(Pe) - 0.105 + N$
- for fans with Pe≥10 kW: $\eta_{min} = 0.011\ LN(Pe) - 0.0206 + N$

as set out in Table 1 below per fan type (axial, mixed flow, centrifugal, cross flow), efficiency category (static, total) and measurement category (A, B, C or D) as appropriate.

The calculation of the efficiency grade N for mixed flow fans involves the fan flow angle α, in degrees rounded to the nearest integer, with reference to the measurement method in Annex III.

Fan type	**Measurement category**	**Pressure**	**N**
Axial	A, C	static	0,50
	B, D	total	0,64
Forward curved and radial <5kW	A, C	static	0,52
	B, D	total	0,57
Forward curved and radial ≥5kW, Backward curved	A, C	static	0,64
	B, D	total	0,67
Mixed flow	A, C	static	0,57+0,07·(α −45)/25
	B, D	total	0,67
Cross flow	B, D	total	0,21

For jet fans the jet-fan impeller efficiency shall be equal or above 0,50.

ANNEX III

Product information requirements

1. Product information requirements on fans

1. The information on fans set out in points 2(1) to 2(14) shall be visibly displayed on:

   a. the technical documentation of fans;

   b. free access websites of manufacturers of fans;

2. The following information shall be displayed:

   (1) applicable fan efficiency (η_f), rounded to the closest value in 3 decimal places, with specification of the type of fan (axial, jet, mixed flow, centrifugal or cross flow) or in the case of a jet fan, the jet-fan impeller efficiency η_r(T) and specifictian 'jet fan';

   (2) measurement category used to determine the energy efficiency (A-E);

   (3) efficiency category (static or total), except for jet fans;

   (4) efficiency grade *N* at bep;

   (5) whether the calculation of fan efficiency assumed use of a VSD and if so, whether the VSD is integrated within the fan or the VSD must be installed with the fan;

   (6) year of manufacture;

   (7) manufacturer's name, registered trade name or registered trade mark, and the address at which the manufacturer can be contacted;;

   (8) product's model number or other codes and marks sufficient for it to be unequivocally and easily identified;

   (9) the electric motor power input P_e (in kW), flow rate q_v (in m^3/h rounded to the closest integer value when <1 m^3/s, else in m^3/s rounded to the closest value in 2 decimal places) and applicable pressure difference Δp (in Pa, rounded to the closest integer value) at bep;

   (10) fan speed in rotations per minute (rpm, rounded to the closest integer value) at bep;

   (11) the 'specific ratio', rounded to the closest value in 2 decimal places;

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

   (13) information relevant to minimise impact on the environment and ensure optimal life expectancy as regards installation, use and maintenance of the fan;

   (14) description of additional items used when determining the fan energy efficiency, such as ducts, that are not described in the measurement category and not supplied with the fan.

3. The information in the technical documentation shall be provided in the order as presented in points 2(1) to 2(14).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.

4. The information referred to in points 2(1), 2(2), 2(3), 2(4) and 2(5) shall be durably marked on or near the rating plate of the fan, where for point 2(5) one of the following forms of words must be used to indicate what is applicable:

   — 'A variable speed drive must be installed with this fan',

   — 'A variable speed drive is integrated within the fan'.

5. Manufacturers shall provide information in the manual of instruction on specific precautions to be taken when fans are assembled, installed or maintained. If provision 2(5) of the product information requirements indicates that a VSD must be installed with the fan, manufacturers shall provide details on the characteristics of the VSD to ensure optimal use after assembly.
6. Manufacturers shall indicate the total weight per fan of the permanent magnets, if any, used in the motor, in kg with 2 digit precision.

ANNEX IV

Verification procedure for market surveillance purposes

When performing the market surveillance checks referred to in Article 3(2) of Directive 2009/125/EC, the authorities of the Member States shall apply the following verification procedure for the requirements set out in Annex I.

1. The authorities of the Member State shall test one single unit.

2. The model shall be considered to comply with the provisions set out in this Regulation if the applicable fan efficiency (η_f) is at least the minimum energy efficiency(η_{min})·0,9 calculated using the formulas and the applicable efficiency grades from Annex II.

3. If the result referred to in point 2 is not achieved:

   — for models that are produced in lower quantities than five per year, the model shall be considered not to comply with this Regulation,

   — for models that are produced in quantities of five or more per year, the market surveillance authority shall randomly test three additional units.

4. The model shall be considered to comply with the provisions set out in this Regulation if the average of the applicable fan efficiency (η_f) of the three units referred to in point 3 is at least the minimum fan efficiency(η_{min})·0,93 using the formulas and the applicable efficiency grades from Annex II.

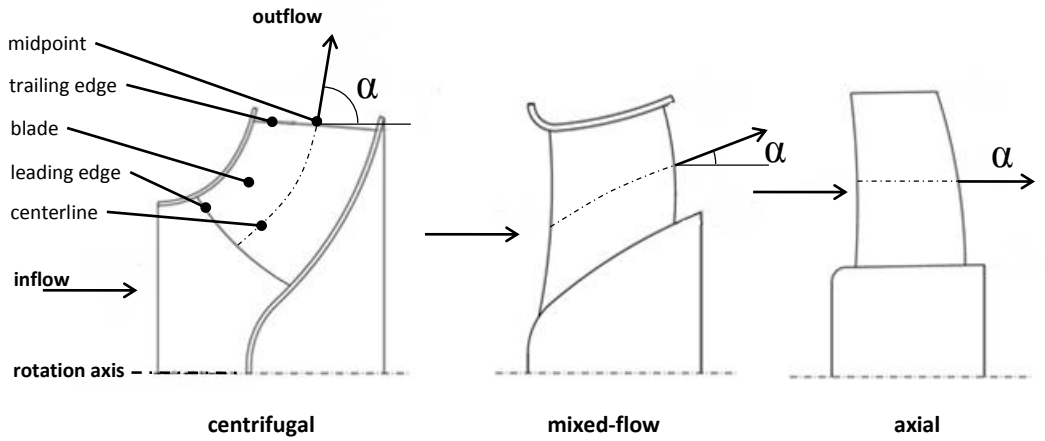
5. If the results referred to in point 4 are not achieved, the model shall be considered not to comply with this Regulation.

ANNEX V

Measurement and calculation methods

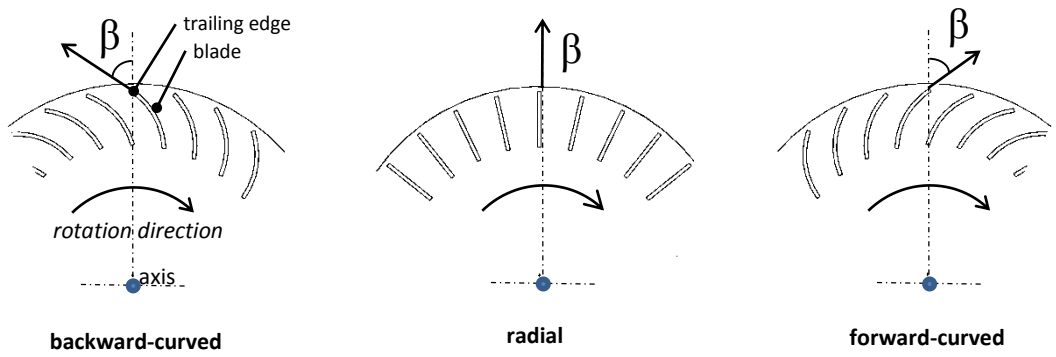
1. Fan flow angle

'Fan flow angle α' means the angle of the center-line of the air-conducting surface of a fan blade, measured at the midpoint of its trailing edge with the center-line of the rotation axis, in a plane through the rotation axis and the midpoint of the trailing edge. A fan is defined as 'axial' if $\alpha \leq 20°$, 'mixed-flow' if $20° < \alpha < 70°$ and 'centrifugal' if $\alpha \geq 70°$.



2. Centrifugal blade angle

'Centrifugal blade angle β' means the angle between the tangent of the air-conducting surface of the blade and the radial through the fan rotation axis, at the midpoint of the blade's trailing edge and in a plane perpendicular to the fan rotation axis. The angle is defined positive when it is inclined in the direction of the rotation of the impeller. A centrifugal fan is defined as 'backward-curved' if $\beta \leq -1°$, 'radial' if $-1° < \beta < 1°$ and 'forward-curved' if $\beta \geq 1°$.



3. Jet fan impeller efficiency

Jet-fan impeller efficiency η_r(T) is calculated as:

$$\eta_r(\mathrm{T}) = q_v(\mathrm{T}) \cdot \Delta p(\mathrm{T}) / P_r = 0{,}5[\ T_m /(\rho \cdot A_2)\ ]^{0,5} \cdot T_m / P_r$$

where:

P_r mechanical power supplied to the impeller of 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 .

4. Characteristic noise emission value C

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

$$C = PWL_{\ \mathrm{impeller}} - 30 \log u_{\ tip} - 10 \log (0{,}001 \cdot q_v \cdot p_{\mathrm{fs}}) + 5 \log D_{impeller}$$

where

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

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

q_v is air flow rate, in m³/s;

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

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

5. Measurement methods

For the purposes of compliance and verification of compliance with the requirements of this Regulation, measurements and calculations must be made using a reliable, accurate and reproducible method, which takes into account the generally recognised state-of-the-art measurement methods, and whose results are deemed to be of low uncertainty, including methods set out in documents the reference numbers of which have been published for that purpose in the *Official Journal of the European Union*.

ANNEX VI

Indicative benchmarks

The maximum values relate to the achievable efficiency grade N in % (see minimum efficiency formulas) 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.

Fan type	**Measurement category**	**Pressure**	**N minimum**	**N maximum**
Axial	A, C	static	0,50	0,75
	B, D	total	0,64	0,85
Forward curved and radial <5kW	A, C	static	0,52	0,65
	B, D	total	0,57	0,70
Forward curved and radial <5kW, Backward curved	A, C	static	0,64	0,80
	B, D	total	0,67	0,85
Mixed flow	A, C	static	$0,57+0,07\cdot(\alpha-45)/25$	0,77
	B, D	total	0,67	0,85
Cross flow	B, D	total	0,13	0,13

An indicative benchmark for jet-fan impeller efficiency is 0,60.