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Fans — Efficiency classification for fans

Ventilateurs — Classification du rendement des ventilateurs

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 12759 was prepared by Technical Committee ISO/TC 117, *Fans*.

Introduction

The last decade has seen not only an escalation in the price, but also an increasing recognition of the finite life of many of the fossil fuels in use. There is also a belief that climatic change is due to an increase in the levels of carbon dioxide in the atmosphere. This has lead to many nations reviewing methods of energy generation and usage.

Therefore, there is a need to promote energy efficiency in order to maintain economic growth. This requires better selection of equipment by users and better design of this equipment by manufacturers.

Fans of all types are used for ventilation and air conditioning, process engineering (drying, pneumatic conveying), combustion air supply and agriculture, etc. Indeed, the energy usage by fans has been calculated as nearly 20 % of worldwide demand.

The fan industry is of a global nature, with a considerable degree of exporting and licensing. To ensure that defined fan performance characteristics are common throughout the world, a series of International Standards has been developed. It is the belief of the industry that there is a need for the recognition of minimum efficiency standards. To encourage their implementation, a classification system is proposed which incorporates a series of efficiency bands. With improvements in technology and manufacturing processes, the minimum efficiency levels can be reviewed and increased over time.

This International Standard can be used by legislators or regulatory bodies for defining future energy saving targets.

Fans — Efficiency classification for fans

1 Scope

This International Standard establishes a classification of fan efficiency for all fan types driven by motors with an electrical input power range from 0,125 kW to 500 kW. This International Standard is applicable to bare shaft and driven fans, as well as fans integrated into products. Fans integrated into products are measured as stand-alone fans.

This International Standard is not applicable to:

a) fans for smoke and emergency smoke extraction;

b) fans for industrial processes;

c) fans for automotive application, trains and planes;

d) fans for potentially explosive atmospheres;

e) box fans, powered roof ventilators and air curtains;

f) jet fans for use in car parks and tunnel ventilation.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 5801:2007, *Industrial fans — Performance testing using standardized airways*

ISO 13348:2007, *Industrial fans — Tolerances, methods of conversion and technical data presentation*

ISO 13349:2010, *Fans — Vocabulary and definitions of categories*

IEC 60034-2-1, *Rotating electrical machines — Part 2-1: Standard methods for determining losses and efficiency from tests (excluding machines for traction vehicles)*

IEC 60034-30, *Rotating electrical machines — Part 30: Efficiency classes of single-speed, three-phase, cage-induction motors*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 13349 and the following apply.

NOTE See, in particular, ISO 13349:2010, Tables 4 and 5, as well as the associated equations in Clause 5 of this International Standard and ISO 5801.

3.1 Fans — General

3.1.1
fan
rotary bladed machine which receives mechanical energy and utilizes it by means of one or more impellers fitted with blades to maintain a continuous flow of air or other gas passing through it and whose work per unit mass does not normally exceed 25 kJ/kg

NOTE 1 Fans are defined according to their installation category, function, fluid path and operating conditions.

NOTE 2 Adapted from ISO 13349:2010, definition 3.1.1.

3.1.2
fan size
maximum impeller tip diameter, D, on which the design of the fan is based

3.1.3
drive
〈transmission and motor/control system〉 device used to power the fan, including motor, mechanical transmission and motor/control system

NOTE 1 Examples of mechanical transmission are belt drive and couplings.

NOTE 2 Examples of a motor or control system are variable frequency controller and electronic commutator.

3.1.4
bare shaft fan
fan without drives, attachments or accessories (appurtenance)

See Figure 1.

NOTE Adapted from ISO 13349:2010, definition 3.1.2.

3.1.5
driven fan
one or more impellers fitted to or connected to a motor, with or without a drive mechanism, a housing and a means of variable speed drive

See Figure 2.

NOTE Adapted from ISO 13349:2010, definition 3.1.3.

3.1.6
air
abbreviated term for the expression “air or other gas”

[ISO 13349:2010, definition 3.2]

3.1.7
standard air
atmospheric air having a density of exactly 1,2 kg/m^3

NOTE 1 Atmospheric air at a temperature of 16 °C, a pressure of 100 000 Pa and a relative humidity of 65 %, has a density of 1,2 kg/m^3, but these conditions do not form part of the definition.

NOTE 2 Adapted from ISO 13349:2010, definition 3.3.

3.2 Fan or test installation categories according to the arrangement of ducting

See Figure 3 and ISO 13349.

3.2.1
installation category A
installation with free inlet and free outlet

3.2.2
installation category B
installation with free inlet and ducted outlet

3.2.3
installation category C
installation with ducted inlet and free outlet

3.2.4
installation category D
installation with ducted inlet and ducted outlet

3.3 Fans — Definitions relating to calculations

3.3.1
average density at fan inlet
ρ_1
fluid density calculated from the absolute pressure and the static temperature

3.3.2
atmospheric pressure
p_a
pressure, measured with respect to absolute zero pressure, which is exerted at a point at rest relative to the air around it

3.3.3
fan pressure
p_f
difference between the stagnation pressure at the fan outlet and the stagnation pressure at the fan inlet

3.3.4
fan static pressure
p_{sf}
conventional quantity defined as the fan pressure minus the fan dynamic pressure at the fan outlet corrected by the Mach factor

3.3.5
absolute stagnation pressure at a point
p_{sg}
absolute pressure which would be measured at a point in a flowing gas, if it were brought to rest via an isentropic process

3.3.6
conventional dynamic pressure at a point
p_d
pressure calculated from the velocity and the density of the air at the point

3.3.7
fan dynamic pressure at the fan outlet
p_{d2}
conventional dynamic pressure at the fan outlet calculated from the mass flow rate, the average gas density at the outlet and the outlet area

3.3.8
mass flow rate
q_m
mean value, over time, of the mass of air which passes through the specified airway cross-section per unit of time

3.3.9
inlet volume flow rate
q_{v1}
mass flow rate at the inlet divided by the corresponding mean value, over time, of the average density at the inlet

3.3.10
fan work per unit mass
W_m
increase in mechanical energy per unit mass of fluid passing through the fan

3.3.11
compressibility coefficient
k_p
ratio of the mechanical work done by the fan on the air to the work that would be done on an incompressible fluid with the same mass flow, inlet density and pressure ratio

3.3.12
fan air power
P_u
conventional output power which is the product of the mass flow rate and the fan work per unit mass, or the product of the inlet volume flow rate, the compressibility coefficient and the fan pressure

3.3.13
fan static air power
P_{us}
conventional output power which is the product of the mass flow rate and the fan static work per unit mass, or the product of the inlet volume flow rate, the compressibility coefficient and the fan static pressure

3.3.14
impeller power
P_r
mechanical power supplied to the fan impeller

NOTE This is applicable to direct driven impellers which are open (as in, for example, a plenum fan) or enclosed in a housing.

3.3.15
nominal motor power
P_N
rated output power of an electric motor

3.3.16
fan shaft power
P_a
mechanical power supplied to the fan shaft

3.3.17
motor output power
P_o
shaft power output of the motor or other prime mover

3.3.18
motor input power
P_e
electrical power supplied to the fan's motor

3.3.19
drive/control electrical input power
P_{ed}
electrical power supplied to the motor's drive or control

3.4 Definitions relating to fan efficiency

3.4.1
fan impeller efficiency
η_r
fan air power divided by the impeller power, P_r

3.4.2
fan shaft efficiency
η_a
fan air power divided by the fan shaft power, P_a

3.4.3
overall efficiency
η_e
fan air power divided by the input power for the fan and motor

3.4.4
overall static efficiency
η_{es}
fan static air power divided by the input power for the fan and motor

3.4.5
overall efficiency drive
η_{ed}
⟨transmission and motor/control system⟩ fan air power divided by the input power for the fan and motor combination which include transmission or variable speed controls to take account of all losses within the fan assembly

3.4.6
overall static efficiency drive
η_{esd}
⟨transmission and motor/control system⟩ fan static air power divided by the input power for the fan and motor combination which include transmission or variable speed controls to take account of all losses within the fan assembly

NOTE 1 The efficiency can be referred to the installation category (see Figure 3 and ISO 13349).

NOTE 2 Efficiency can be expressed as a proportion of unity. To obtain a per cent value, multiply the efficiency result by 100.

3.4.7
optimum efficiency
η_{opt}
maximum efficiency achieved on the fan air characteristic with all operational parameters, except the air system resistance, being fixed

3.4.8
compensation factor
C_c
factor, used in the determination of efficiencies for fans incorporating or fitted with variable speed drives

See Figure 5.

3.5 Fan efficiency grades

3.5.1
fan efficiency grade
FEG
efficiency grade for a bare shaft fan

NOTE The definitions given in 3.4.1 and 3.4.2 can apply.

3.5.2
fan motor efficiency grade
FMEG
efficiency grade for a driven fan

NOTE The definitions given in 3.4.3, 3.4.4, 3.4.5 and 3.4.6 can apply.

3.5.3
grade number
N_G
integer of the FMEG

4 Symbols and units

For the purposes of this document, the symbols and primary units in Table 1 for the parameters listed apply.

Table 1 — Symbols and units

Symbol	Description	Unit
C_c	Compensation factor to account for energy savings at part load	—
C_m	Compensation factor to account for suboptimal matching of components	—
D	Maximum impeller tip diameter (fan size)	mm
k_p	Compressibility coefficient	—
N_G	Grade number (integer) of the FMEG	—
P_a	Fan shaft power	W
P_b	Power loss in bearings	W
P_e	Motor input power	W
P_{ed}	Drive/control electrical input power	W
P_N	Nominal motor power	W
P_o	Motor output power	W

Table 1 (*continued*)

Symbol	Description	Unit
P_r	Impeller power	W
P_{sf}	Specific fan power	kW/(m^3/s) or W/(l/s)
P_u	Fan air power	W
P_{us}	Fan static air power	W
p_a	Atmospheric pressure	Pa
p_d	Conventional dynamic pressure at a point	Pa
p_{d2}	Fan dynamic pressure at the fan outlet	Pa
p_f	Fan pressure	Pa
p_{sf}	Fan static pressure	Pa
p_{sg}	Absolute stagnation pressure at a point	Pa
q_m	Mass flow rate	kg/s
q_{v1}	Inlet volume flow rate	m^3/s
W_m	Fan work per unit mass	J/kg
η_a	Fan shaft efficiency	Expressed as a decimal
η_b	Fan bearing efficiency	Expressed as a decimal
η_c	Variable speed drive efficiency	Expressed as a decimal
η_e	Overall efficiency for fans without drives	Expressed as a decimal
η_{ed}	Overall efficiency for fans with drives	Expressed as a decimal
η_{es}	Overall static efficiency for fans without drives	Expressed as a decimal
η_{esd}	Overall static efficiency for fans with drives	Expressed as a decimal
η_m	Motor efficiency	Expressed as a decimal
η_{opt}	Optimum efficiency	Expressed as a decimal
η_r	Fan impeller efficiency	Expressed as a decimal
η_T	Drive mechanism (transmission efficiency)	Expressed as a decimal
ρ_1	Average density at fan inlet	kg/m^3

NOTE Efficiency in per cent (%) divided by 100 equals the efficiency, expressed as a decimal.

5 Fan installation, efficiency and tolerance

5.1 General

Fans range from the purpose-built single fan to the series-produced certified ranges, which are manufactured in large quantities. A fan can be an impeller on a shaft with no drive mechanism attached (i.e. bare shaft fan) (see Figure 1), or a motor attached to a drive system attached to an impeller within an impeller housing. In that case, it can be supplemented by a volume control, such as a variable speed control or guide vanes (i.e. driven fan) (see Figure 2).

The variation in design has led to efficiency being defined in a number of ways to suit the demands of the fan type and the market.

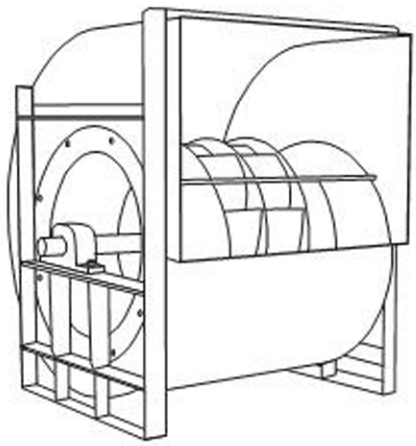
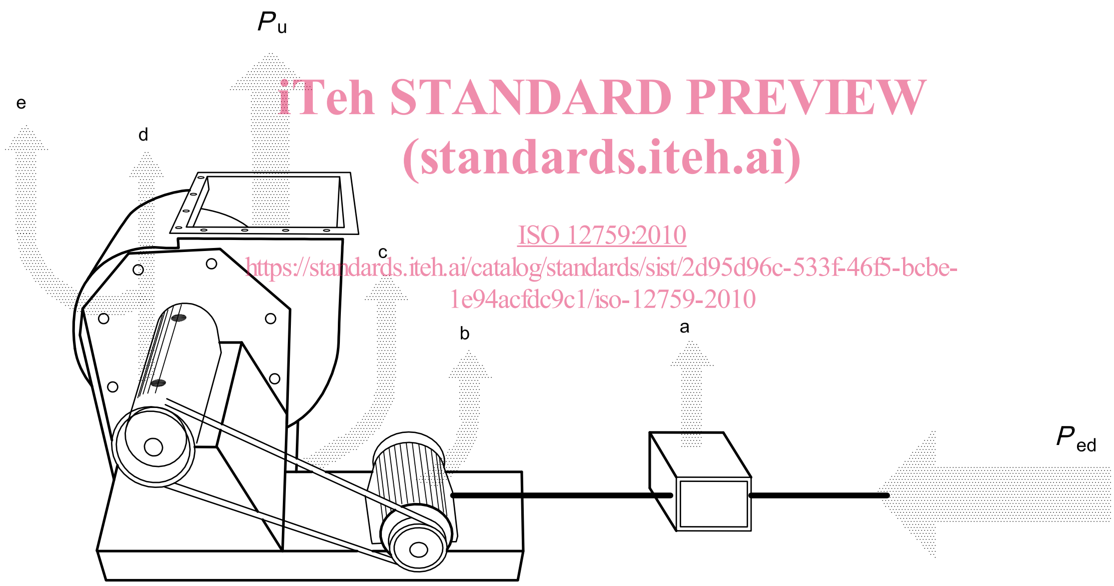


Figure 1 — Example of a bare shaft centrifugal fan



Key

P_u fan air power

P_{ed} drive/control electrical input power

a Variable speed device loss (heat). [The variable speed device can be fitted or not (see Clause 6).]

b Motor losses (heat).

c Belt losses (heat).

d Bearing losses (heat).

e Impeller and casing aerodynamic losses (heat).

Figure 2 — Example of a driven fan showing power losses

5.2 Use of installation categories

Fan efficiency ratings are frequently specific for each standardized test installation category.

If a fan is designed for a single installation category, its rated efficiency grade shall refer to that particular test installation category, and this shall be clearly identified.

If a fan is suitable for use with different installation categories, the fan efficiency grade shall be based on the efficiency ratings referring to the most suitable category, and this shall be clearly identified.

To determine the operating point of the fan, four installation categories shall be considered (see Figure 3). For details of test methods, see the following clauses of ISO 5801:2007:

a) category A installations — Clause 30;

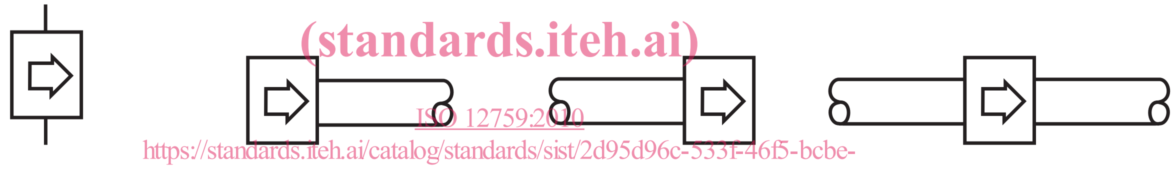
b) category B installations — Clause 31;

c) category C installations — Clause 32;

d) category D installations — Clause 33.

The standardized installation category used for rating the fan shall be clearly stated (see Annex C).

The motor input power and motor output power may be measured or determined using the methods given in ISO 5801. Installation category E is not included in this International Standard.



a) Category A   b) Category B   c) Category C   d) Category D

Figure 3 — Installation categories

5.3 Calculation of efficiency

5.3.1 The fan air power and efficiency are calculated from fan work per unit mass in accordance with ISO 5801:2007, 14.8.1.

5.3.2 For a bare shaft fan where bearing losses are excluded, the efficiency is given by Equation (1):

$$\eta_r = P_u / P_r \quad (1)$$

5.3.3 For a bare shaft fan where bearing losses are included, the efficiency is given by Equation (2):

$$\eta_a = P_u / P_a \quad (2)$$

5.3.4 For a driven fan that does not include a variable speed drive, where the input power can be determined, the overall efficiency is given by Equation (3) or (4):

$$\eta_e = P_u / P_e \quad (3)$$

$$\eta_{es} = P_{us} / P_e \quad (4)$$

