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Fans — Efficiency classification for fans —

Part 1: General requirements

Ventilateurs — Classification du rendement des ventilateurs —

Partie 1: Exigences générales

Reference number
ISO 12759-1:2023(E)

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO document should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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

A list of all parts in the ISO 12759 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

The last decade has seen an escalation in the price and an increasing recognition of the finite life of many of the fossil fuels currently used. This has led to many nations reviewing methods of energy generation and usage.

To maintain economic growth there is therefore a need to promote energy efficiency. This requires better selection of equipment by users and thus better design of this equipment by manufacturers.

Fans of all types are used for ventilation, air conditioning, process engineering – drying, pneumatic conveying – combustion air supply and agriculture. The energy use of fans is thought to be in the region of 10 % to 15 % of the global electricity usage.

The fan industry is global in nature, with a considerable degree of exporting and licensing. To ensure that the definitive fan performance characteristics are common throughout the world, a series of standards has been developed.

Fans — Efficiency classification for fans —

Part 1:
General requirements

1 Scope

This document deals with the classification of fan power consumption and efficiency for many fan types given in the ISO12759 series. In addition, it details specific application efficiency classification information. These procedures are described in ISO 12759-3, ISO 12759-4, ISO 12759-5 and ISO 12759-6.

This document does not describe a method to compare these classifications and minimum efficiency limits (MELs).

This document applies to the fans, not to the system in which they are installed.

Air curtains are excluded from this standard.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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, *Fans — Performance testing using standardized airways*

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

ISO 13349-1, *Fans — Vocabulary and definitions of categories — Part 1: Vocabulary*

ISO 13349-2, *Fans — Vocabulary and definitions of categories. Part 2: Categories*

ISO 13350, *Fans — Performance testing of jet fans*

ANSI/AMCA Standard 230-23, *Laboratory Methods of Testing Air Circulating Fans for Rating and Certification*

ANSI/AMCA Standard 260-20, *Laboratory Methods of Testing Induced Flow Fans for Rating*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 5801, ISO 13349-1 and ISO 13349-2 and the following apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1
fan
rotary bladed machine that 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 to entry: The term “fan” is taken to mean the fan as supplied, without any addition to the inlet or outlet, except where such addition is specified.

Note 2 to entry: Fans are defined according to their installation category, function, fluid path and operating conditions.

Note 3 to entry: If the work per unit mass exceeds a value of 25 kJ/kg, the machine is termed a turbo-compressor. This means that, for a mean stagnation density through the fan of 1,2 kg/m^3, the fan pressure does not exceed 1,2 × 25 kJ/kg, i.e. 30 kPa, and the pressure ratio does not exceed 1,30, since atmospheric pressure is approximately 100 kPa.

3.2
fan without drives
fan without a motor, a drive, an attachment or accessories

Note 1 to entry: Also known as a bare shaft fan.

[SOURCE: ISO 12759-3:2019, 3.4]

3.3
driven fan
fan driven by an electrical motor.

Note 1 to entry: One or more impellers fitted to or connected to a motor with a stationary element, with or without transmission or variable speed drive (VSD).

[SOURCE: ISO 13349-1:2022, 3.1.3]

3.4
impeller
rotating part of the fan that is imparting energy into the gas flow

3.5
stationary element
stationary part which interacts with the air stream passing through the impeller,

Note 1 to entry: It is an element, or a combination of elements, that interacts with the airstream directing and/or guiding the gas stream towards, through and/or from the impeller, an element may also assist in the conversion of energy

EXAMPLE Housing, orifice ring, orifice panel, inlet bell (also known as venturi), inlet cone, inlet radius, inlet ring, inlet guide vane, outlet guide vane, outlet diffuser, nozzle.

Note 2 to entry: In some standards a stationary element is called a stator.

3.6
housing
stationary part which interacts with the air stream passing through the impeller

Note 1 to entry: A housing can be an element around the impeller which guides the gas stream towards, through and from the impeller.

Note 2 to entry: A housing can have additional parts included within or attached to it that affect the performance of the fan, such as inlet bell (also known as venturi), inlet cone, inlet radius, inlet ring, inlet guide vane, outlet guide vane or outlet diffuser.

3.7
inlet guide vane
vane positioned before the impeller to guide the gas stream towards the impeller

Note 1 to entry: The inlet guide vane can be adjustable.

3.8
outlet guide vane
vane positioned after the impeller to reduce the swirl from the impeller

Note 1 to entry: The outlet guide vane can be adjustable.

3.9
orifice ring
ring with an opening in which the fan sits and which allows the fan to be fixed to other structures

Note 1 to entry: An orifice is a plain hole in the physical partition (e.g. orifice panel) between the upstream and downstream airflow of the fan. It is a divide between the negative pressure and positive pressure areas that occur across the fan when there is a pressure difference between the fan inlet and fan outlet.

3.10
orifice panel
panel with an opening in which the fan sits and which allows the fan to be fixed to other structures

3.11
diffuser
device that improves the fan performance through static recovery

3.12
inlet cone
device that steers the air into the impeller and reduces the vena contracta and turbulence that can occur at a sharp edge of the housing

Note 1 to entry: Also known as venturi inlet, inlet bell or inlet radius.

3.13
nozzle
aperture or ajutage of the fan through which air or gas is discharged

3.14
fan without housing
fan designed not to rely upon a housing for its correct operation

Note 1 to entry: Includes at least an impeller and a stationary element, such as an inlet cone.

3.15
fan with housing
fan designed to rely upon a housing for its correct operation

3.16
installation category
fan test configuration according to the arrangement of standardised test airways

3.17
installation category A
installation with free inlet and free outlet with a partition

3.18
installation category B
installation with free inlet and ducted outlet

3.19
installation category C
installation with ducted inlet and free outlet

3.20
installation category D
installation with ducted inlet and ducted outlet

3.21
installation category E
installation with free inlet and free outlet without a partition

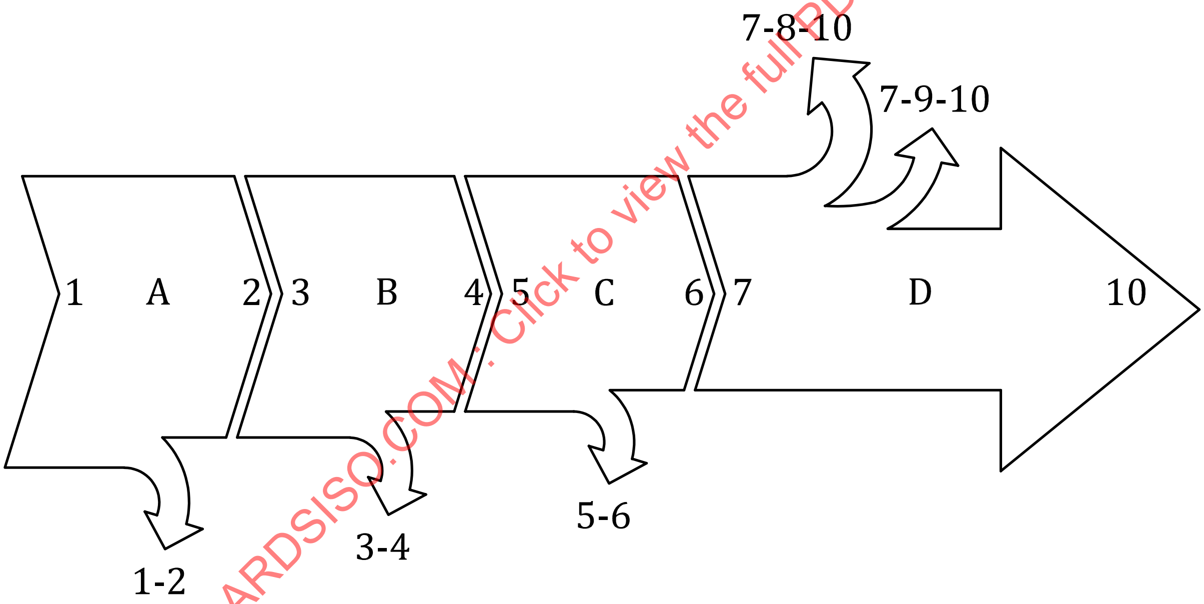
Note 1 to entry: Also known as test configuration category E.

Note 2 to entry: For jet fans, ISO 13350 is used for determining product efficiencies.

Note 3 to entry: In this installation category a fan cannot produce any static pressure rise.

3.22
power
amount of energy transferred or converted per unit of time

Note 1 to entry: The key in Figure 1 gives a fuller explanation to fan experts and non-fan experts on the losses within a fan system in terms that are understood by relevant industries.



Key	Term	Symbol	Source
A	complete drive module (CDM)		
B	electric motor		
C	mechanical transmission		
D	fan		
1	drive control electrical input power	P_{ed}	ISO 5801
	motor controller input power	P_{ci}	ISO 12759-2
	input power of the CDM	$P_{in,CDM}$	IEC 61800-9-2

2	motor controller output power	P_{co}	ISO 12769-2
	output power of CDM	$P_{out,CDM}$	IEC 61800-9-2
1 – 2	CDM losses		
3	motor input power	P_e	ISO 5801
	motor input power	P_{mi}	ISO 12759-2
	motor input power	P_1	IEC 60034-2-1
4	motor output power	P_{mo}	ISO 12759-2
	motor output power	P_2	IEC 60034-2-1
3 – 4	Motor losses		
5	transmission input power	P_{ti}	ISO 12759-2
6	transmission output power	P_{to}	ISO 12759-2
5 – 6	Mechanical transmission losses		
7	fan shaft power	P_a	ISO 5801
8	mechanical losses	—	—
7 – 8	bearing losses		
9	aerodynamic losses	—	ISO 5801
10	fan air power	P_u	ISO 5801
7 - 9 – 10	fan losses		
7 – 8 -10	fan losses including bearings		
3 – 10	driven fan losses		
1 – 10	driven fan losses including variable speed drive		

Figure 1 — Power diagram of fan drive system

3.22.1
efficiency
ratio between fan air power and a known input power

Table 1 — Relationship between powers and efficiencies

Input powers	Installation category	
	A & C Fan static air power (P_{us}) Static efficiencies	B & D Fan air power (P_u) Total efficiencies
Drive/control electrical input power (P_{ed})	$\eta_{esd} = P_{us} / P_{ed}$	$\eta_{ed} = P_u / P_{ed}$
Motor input power (P_e)	$\eta_{es} = P_{us} / P_e$	$\eta_e = P_u / P_e$
Motor output power (P_o)	$\eta_{os} = P_{us} / P_o$	$\eta_o = P_u / P_o$
Fan shaft power (P_a)	$\eta_{as} = P_{us} / P_a$	$\eta_a = P_u / P_a$
Fan impeller power (P_r)	$\eta_{rs} = P_{us} / P_r$	$\eta_r = P_u / P_r$

Note 1 to entry: See Figure 1 and Table 1.

3.22.2
efficiency category
method to distinguish efficiency for fan applications that consider strictly fan static pressure versus efficiency for fan applications that use fan total pressure

Note 1 to entry: The energy difference in gas at the output versus gas at the input is used to determine the efficiency: either the static efficiency, using fan static pressure, p_{fs}, or total efficiency, using fan pressure, p_f.

3.23
efficiency grade
numerical index which sets an efficiency target for fans of different type, size or power, or duty point

3.24
fan efficiency grade
FEG
efficiency grade for a fan without drives

3.25
fan motor efficiency grade
FMEG
efficiency grade for a driven fan

3.26
jet fan motor efficiency grade
JFMEG
efficiency grade for a jet fan

3.27
fan energy index
FEI
ratio of the reference electrical input power to the electrical input power of the actual fan for which the FEI is calculated, both calculated at the same duty point, which is characterized by a value of fan volume flow rate (q_V) and pressure (p_f or p_{fs}).

Note 1 to entry: FEI values can be calculated for each point on a fan curve

3.28
direct drive
means a driving arrangement for a fan where the impeller is connected 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;

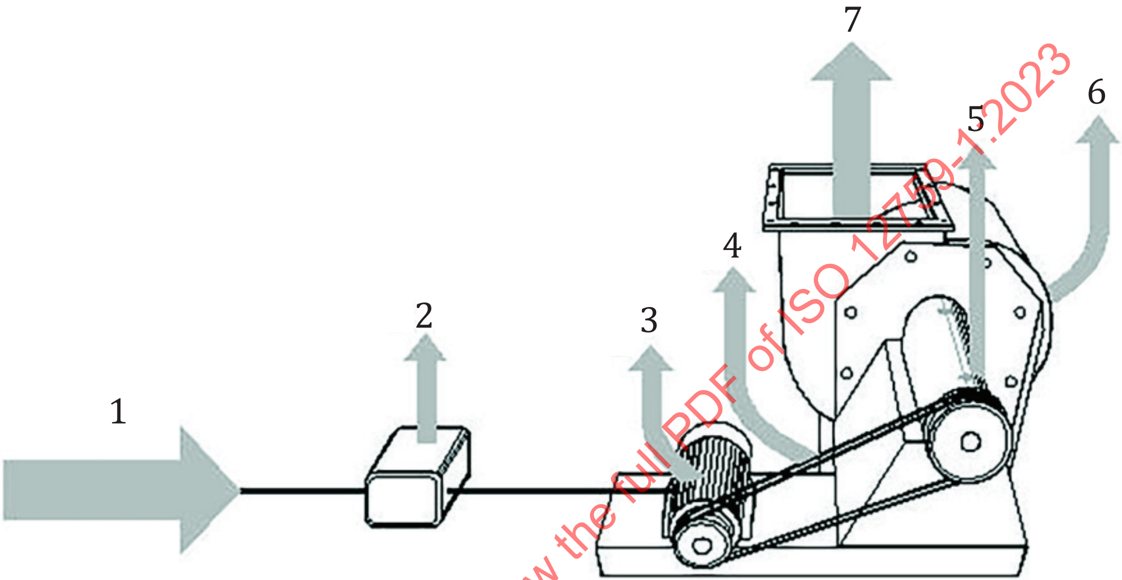
Note 1 to entry: Fan shaft power equals motor output power in the case of direct drive.

Note 2 to entry: Impeller power equals motor output power in the case of direct drive

3.29
mechanical transmission
mechanism by which mechanical power is transmitted from the output shaft of a motor to the impeller of the fan

EXAMPLE Belts and pulleys; (flat), (grooved) (v-belts), (synchronous belts); flexible and fluid couplings; gears, gearboxes.

Note 1 to entry: The fan impeller can be coupled directly to the output of the motor. This arrangement is a direct-drive without losses and the impeller rotational speed is synchronous with the motor rotational speed.



Key

1 electrical input power, P_{ed}
2 variable speed drive loss
3 motor losses
4 belt losses
5 bearing losses
6 impeller and casing aerodynamic losses
7 volume flow and pressure (air power P_u)

Figure 2 — Typical belt-driven fan

3.30
drive
device used to power a fan

EXAMPLE Motor, mechanical transmission (e.g. belt, couplings, gears), motor/control system (e.g. variable frequency controller, electronic commutator).

Note 1 to entry: Figure 2 gives an example of a fan driven by a motor and mechanical system (belt drive).

3.31
maximum declared operating speed
speed which the fan, combined with its drive system (made up of at least an electric motor plus any transmission and/or motor controller), can maintain under steady conditions and under stated air testing conditions, as defined by the manufacturer

Note 1 to entry: In some cases, a fan can have a mechanical design speed or safe operating speed which is above the maximum declared operating speed. However, in these cases it is the maximum declared speed at which the efficiency is calculated.

3.32
extended product
driven fan together with its connected motor, optional controller and mechanical transmission system

[SOURCE: IEC 61800-9-1:2017]

3.33
nominal speed
impeller rotational speed (rpm) defined by the manufacturer for which the test results have been converted

4 Symbols and units

The following symbols and units for the parameters listed shall be used.

Symbol	Term	Unit
k_p	compressibility coefficient	
P_a	fan shaft power	W
p_a	atmospheric pressure	Pa
p_d	dynamic pressure at a point	Pa
P_e	motor input power	W
P_{ed}	electrical input power	W
p_f	fan pressure	Pa
p_{fs}	fan static pressure	Pa
P_o	motor output power	W
P_r	impeller power	W
p_{sg}	absolute stagnation pressure at a point	Pa
P_u	fan air power	W
P_{us}	fan static air power	W
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
ρ_1	average gas density at fan inlet	kg/m^3
η_a	fan shaft efficiency	expressed as a decimal
η_e	overall efficiency	expressed as a decimal
η_r	fan impeller efficiency	expressed as a decimal
η_{opt}	optimum efficiency	expressed as a decimal

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

5 General requirements

5.1 General

The ISO 12759 series requires measurement procedures as prescribed in the measurement standards for establishing the parameters of fan performance, including efficiency. Levels of acceptable accuracy are contained within these measurement standards. The relationship between powers and efficiencies is the basis for determining the efficiency category of a fan. The efficiency category shall be determined by methods laid out in the standard series referenced above. A guide to fan types and installation categories is given in Table 2.

Direct comparison shall not be made between the classifications and MELs described in ISO 12759-3, ISO 12759-4, ISO 12759-5 and ISO 12759-6.

This information shall be used by manufacturers or their agents to provide efficiency classification data for their fans.

5.2 Identify the fan type

— axial fan (i)

— axial panel fan (ii)

— axial power roof ventilator (iii)

— centrifugal forward-curved fan (iv)

— centrifugal radial-bladed fan (v)

— centrifugal backward-curved fan without housing (vi)

— centrifugal backward-curved fan with housing (vii)

— centrifugal inline fan (viii)

— centrifugal power roof ventilator (ix)

— mixed-flow fan (x)

— cross-flow fan (xi)

— jet fan (xii)

— mixed-flow roof ventilator (xiii)

— induced-flow fan (xiv)

— circulating fan (xv)

NOTE Centrifugal airfoil and backward-inclined fans are subsets of centrifugal backward-curved fans; centrifugal radial-tipped fans are a subset of centrifugal radial fans.

5.3 Identify an appropriate installation category

See ISO 13349-1.

Table 2 — Possible combinations, type of fans and installation categories

Installation category	Fan type[a]														
	i	ii	iii	iv	v	vi	vii	viii	ix	x	xi	xii	xiii	xiv	xv
A	X	X	X	X	X	X	X	-	X	X	X	-	X	X	-
B	X	-	-	X	X	-	X	X	-	X	X	-	-	-	-
C	X	-	X	X	X	X	X	X	X	X	-	-	X	X	-
D	X	-	-	X	X	-	X	X	-	X	-	-	-	-	-
E	-	-	-	X	-	X	-	-	X	X	-	-	-	X	X

[a] See 5.2.

Key:

X = permissible combination

- = combination not possible

Table 2 *(continued)*

Installation category	Fan type[a]														
	i	ii	iii	iv	v	vi	vii	viii	ix	x	xi	xii	xiii	xiv	xv
ISO 13350	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-

[a] See 5.2.

Key:

X = permissible combination

- = combination not possible

The relationship between power and efficiency is the basis for determining the efficiency grade of a fan. The efficiency of a fan shall be determined by methods laid out in the standard series referenced in the scope. The efficiency grade whether it be:

a) fan Efficiency Grade, FEG, for fans without drives,

b) fan Motor Efficiency Grade, FMEG, for direct drive fans or fans with transmission systems,

c) jet Fan Motor Efficiency Grade, JFMEG, or

d) fan Energy Index, FEI,

is determined from the relevant parts of the ISO 12759 series.

A guide to fan types and installation categories is given in Table 2 and general information is given in Annex C.

Fans which are incorporated into other products may have secondary efficiency classifications, such as specific fan power (SFP) or energy effectiveness, a brief overview is given in Annex B.

6 Testing and calculation methods

6.1 General

All tests shall be undertaken in accordance with the relevant standard.

6.2 Test method

Choose a test method from one of the following standards appropriate to the fan type:

— ISO 5801 (standardised test configurations);

— ISO 13350 (jet fans);

— ANSI/AMCA 230-23 (air circulating fans);

— ANSI/AMCA 260-20 (induced flow fans).

Identify and describe the test setup used for testing the fan from the appropriate standard. For tests in accordance with ISO 5801 further guidance is given in Annex C on the influence of installation categories on fan performance.

6.3 Significant elements

Significant elements are all those parts which are required for continuous conversion of power (electrical or mechanical) into air volume flow rate and pressure.

Significant elements are essential parts that affect the final efficiency performance of the fan. It is not uncommon for fans to be supplied as component parts with some significant elements supplied by parties other than the original manufacturer who designed, tested and declared the original fan arrangement. The significant elements stated in the test report shall be used in the final installation. Failure to do so will mean the fan is not the same as that declared and the efficiency performance may be different.

The significant elements should meet the design criteria as used in the original test. They should be positioned in exactly the same relationship to each other as intended by the original manufacturer.

The fan shall be tested in accordance with the manufacturer's recommendations and with all significant elements stated in the test report fitted. The unit shall be tested to the appropriate method given in the applied testing standards, referenced in 6.2. Any calculations of fan efficiency metrics shall be done according to one of the parts in the ISO 12759 series.

Typical significant elements include:

— impeller (including all rotating parts which have an aerodynamic influence)

— housing (e.g.inlet bell, inlet guide vanes, outlet guide vanes, outlet diffuser)

— motor (e.g. cable conduits, cooling fins or heat sinks)

— transmission – mechanical (aerodynamic influence and influence on efficiency)

— transmission – electrical [motor controller (VSD]

— structural components that hold the production assembly in place and may interfere with the airflow (e.g. brackets supporting the motor or the bearings, protective guards, see Annex A)

Additional parts include devices not listed above that have an impact on the air power of the fan and which may interfere with the airflow.

6.4 Requirements of testing and calculation

6.4.1 General

When a fan is tested, measurements shall be taken in accordance with the relevant clauses appropriate to the fan. Where scaling is necessary it shall be carried out in accordance with the requirements of ISO 13348.

6.4.2 Choice of testing or calculation method

The determination of the fan efficiency shall be determined by the appropriate test and calculation procedures given in ISO 5801, ISO 13350 ANSI/AMCA 230-23, or ANSI/AMCA 260-20.

6.4.3 Full-size, maximum declared operating speed testing on a standardised airway

With the exception of the jet fans and induced flow fans, whenever the fan efficiency has to be determined by testing and a suitable standardised test airway is available, the fan shall be tested at its declared maximum operating speed and with standard ambient air, in accordance with the provisions of ISO 5801.

Small deviations in the measured fan performance are produced by small variations in the environmental conditions, affecting air density, and small deviations in the fan operating speed. Such density and speed variations shall be within the limits permitted by ISO 5801, and the test results shall be corrected as requested in ISO 5801, to produce the test results at standard air conditions and, when applicable, also to a nominal speed.

6.4.4 Testing using the scaling rules for fan performance

Some calculation procedures or "scaling rules" exist. They relate together the performance of a fan in kinematically similar duty points, achieved at different speeds and different densities of the handled medium, and, under conditions that compared fans are geometrically similar, even by fans of different sizes.

Such similarity rules apply to the performance of the fan, i.e. volume flow rate, pressure and mechanical power delivered to the impeller, and efficiency referred to the impeller power but not to the efficiency of the fan drive system, which, whenever necessary, shall be determined by other means.

Within the scope of this document, the scaling rules provided in ISO 13348 shall be used. Alternatively, other scaling rules may be applied provided that their reliability has been experimentally demonstrated.

The nominal performance of a fan is rated at its design density within the scope of this document. Rules to account for major changes in air density are seldom used, but changes in speed and/or size may be useful when the fan to be rated exceeds the capacity of the available test airways.

6.4.5 Full-size testing at modified-speed on a standardised airway

If the efficiency of the driven fan system can be determined separately, a test may be carried out in accordance with the provisions of ISO 5801 on the real-size fan but at a speed different from the declared operating speed.

This may provide a way to avoid exceeding the maximum achievable performance of the available test airway or the maximum power available at the test laboratory.

The fan being tested shall include effective aerodynamic reproduction of the parts of the real fan drive system which interfere with the airflow.

The mechanical power input to the fan impeller shall be measured in the course of the test with one of the methods provided in ISO 5801.

The mechanical performance of the fan running at declared operating speed shall then be calculated from the results of the test at modified speed, using the calculation procedures provided in ISO 13348.

The efficiency of the driven fan system at its maximum declared operating speed shall be multiplied by the fan efficiency to calculate the fan overall efficiency at the duty point.

6.4.6 Subscale testing on a standardised airway

If the size of the fan to be tested is equal to or larger than 1 m and a geometrically similar functional sub-scale model of the fan can be made available by the fan manufacturer, the test may be carried out on the smaller, geometrically similar model, provided that the efficiency of the fan drive system as used for the actual operation has been determined by other means.

The performance of the real fan shall then be calculated from the results of the test carried out on the smaller fan model and from the efficiency of the actual drive system as used to operate the fan.

The test on the smaller model shall be carried out in accordance with ISO 5801 and any additional conditions or requirements introduced by ISO 13348.

An assessment of the geometrical similarity between the sub-scale model and the full-size fan shall be part of the test procedure and the results shall be reported.

The performance of the full-scale fan shall then be calculated from the results of the test on the smaller model, including the measurement of the mechanical power input to the impeller, using the calculation procedures provided in ISO 13348. The fan mechanical efficiency shall then be multiplied by the efficiency of the actual fan drive system at the power and speed required at each duty point to determine the fan overall efficiency at the full-size, real-speed duty point.

6.5 Tolerances

At each stage of the fan design and manufacturing cycle, including conversion from prototype performance data or calculation, fabrication and testing of a purpose-designed fan, finite uncertainties will prevail and acceptance tolerances shall be applied.

Any test for fan performance is subject to error and the range within which these testing errors may be expected to lie is defined numerically as the uncertainty of measurement. In addition, the true performance of the fan (if it could be ascertained) would differ from that of other nominally identical fans, owing to inevitable variations in manufacture. The expected range of this manufacturing variation shall be added to the uncertainty of measurement to determine the minimum tolerance required for a performance specification.

For the purposes of this document the tolerances given in ISO 13348:2007, Clauses 5 and 6, should apply.

7 Ratings

Information on the efficiency classification for fans is given in ISO 12759-3, ISO 12759-4 and ISO 12759-5. Information on energy use classification for fans is given in ISO 12759-6.

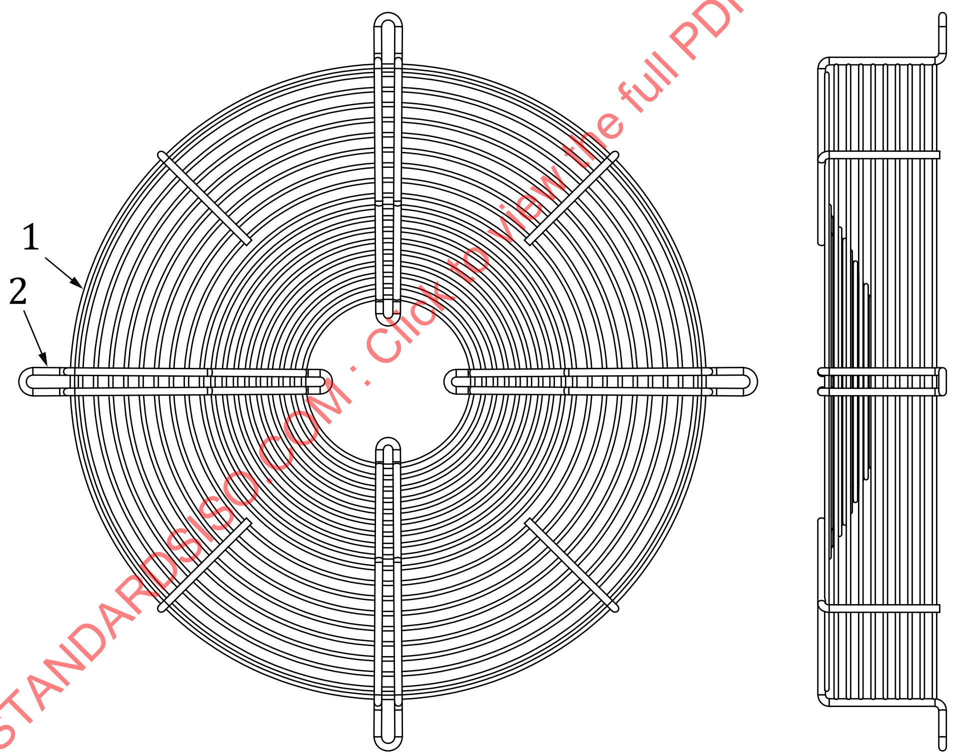
Annex A
(informative)

Protective guards

Protective guards may or may not be included in the measurement of the fan performance. If one is intended to be fitted in normal operation of the fan then it is preferable that the protective guard is fitted when determining the fan performance so as to include those losses.

Some regulations may require that the aerodynamic losses of the guard are not included in determining the energy efficiency of the fan or fan system. In such circumstances the guard shall be removed for the purpose of determining the performance of the fan.

To assist market surveillance, a pressure-loss rating for the guard shall be provided on request. This is to assist market surveillance authorities when they undertake performance check tests where a guard has subsequently been fitted. The pressure loss changes with volume flow and can be determined with direct measurement. Alternatively, the loss can be determined by applying the volume flow to a formula established by empirical analysis of similar guards.



Key

1 protective element

2 strut

Figure A.1 — Grid mounting, including protective element.