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

Ventilateurs industriels — Tolérances, méthodes de conversion et présentation des données techniques

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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 13348 was prepared by Technical Committee ISO/TC 117, *Industrial fans*.

Introduction

This International Standard endeavours to clarify those technical aspects of contracts where fan performance is concerned, and the accuracy and consistency of performance details published in technical catalogues.

In this International Standard a distinction is drawn between specially designed fans to suit a specific purpose, to meet a contract specification, and series-produced fans where the performance data is contained in a catalogue.

For purpose-designed fans the methods of calculating performance data under contract conditions, from performance data obtained under test conditions, are described in Clause 5 for both air and sound data. Four tolerance grades are given, each appropriate to a particular type of fan and/or its application. These procedures have been found satisfactory; however, the supplier and user could agree to adopt alternative methods.

For the series-produced fans, the associated technical data will be contained in a catalogue (electronic and/or printed form). In this case the recommended method of applying tolerances is as described in Clause 6, based on the rules of AMCA (Air Movement and Control Association) International, Inc. for the certified ratings programme [11], [12], [13]. An independent accredited body, under a certified ratings programme, can be called in to verify this data.

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

1 Scope

This International Standard specifies performance tolerances and the technical data presentation of industrial fans of all types. It does not apply for fans designed solely for low-volume air circulation, such as those used for household or similar purposes (ceiling and table fans, extractor fans, etc.). For jet fans refer to ISO 13350.

The upper limit of fan work per unit mass is normally 25 kJ kg^{-1}, corresponding to an increase of fan pressure of approximately 30 kPa for a mean density in the fan of 1,2 kg m^{-3}. For higher values, agreement is to be reached between the supplier and the user.

This International Standard embraces the four installation categories defined in ISO 5801:

A free inlet, free outlet;

B free inlet, ducted outlet;

C ducted inlet, free outlet;

D ducted inlet, ducted outlet.

The performance of a fan can vary considerably with the installation category it is operating within. Therefore, these categories form an important part of the definition of the fan's technical data presentation.

NOTE International acceptance of the four installation categories provides the opportunity to base a contract on the most appropriate fan category for the end user and the system designer. Correspondingly, the likelihood of the fan providing the agreed performance, without compromise or concession, is enhanced.

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 5801:1997, *Industrial fans — Performance testing using standardized airways*

ISO 5802, *Industrial fans — Performance testing* in situ

ISO 13347-1, *Industrial fans — Determination of fan sound power levels under standardized laboratory conditions — Part 1: General overview*

ISO 14694, *Industrial fans — Specifications for balance quality and vibration levels*

ISO 14695, *Industrial fans — Method of measurement of fan vibration*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

NOTE In some cases, more complete definitions are to be found in ISO 5801, ISO 5802 and ISO 13349.

3.1
industrial fan
fan other than that used for household or similar purposes such as air circulation, climatization

NOTE For the purpose of this International Standard and other industrial fan standards, a household fan is defined as having a single-phase motor operating at a maximum of 250 V and 16 A. With a sufficiently soft start, this equates to an input power of not more than 3 kW.

3.2
series-produced fan
catalogue fan
fan whose detailed performances is widely available in a catalogue (electronic and or printed), and which is frequently manufactured in significant quantities and available on short delivery

3.3
average stagnation pressure at a section x
p_{sgx}
sum of the conventional dynamic pressure, p_{dx}, corrected by the Mach factor coefficient, F_{Mx}, at the section, and the average absolute pressure, p_x

$$p_{sgx} = p_x + p_{dx} F_{Mx}$$

NOTE 1 The average stagnation pressure can be calculated by

$$p_{sgx} = p_x \left(1 + \frac{\kappa - 1}{2} Ma_x^2\right)^{\frac{\kappa}{\kappa - 1}}$$

NOTE 2 It is expressed in pascals (Pa).

3.4
average total pressure at a section x
p_{tx}
sum of the conventional dynamic pressure, p_{dx}, corrected by the Mach factor coefficient, F_{Mx}, at the section, and the average gauge pressure, p_{ex}

$$p_{tx} = p_{ex} + p_{dx} F_{Mx} = p_{sgx} - p_a$$

NOTE 1 When the Mach number, Ma, is less than 0,122, the Mach factor, F_{Mx}, can be neglected

NOTE 2 See ISO 5801, ISO 5802 and 13349 for definitions.

3.5
characteristic error
flow rate change produced along the actual system characteristic by the maximum fan performance deviation allowed by the tolerance grade selected

NOTE 1 Characteristic error is a function of the tolerance grade, the measurement uncertainty allowed, and the shape (local slope) of the fan and actual system characteristics

NOTE 2 For the actual system characteristics, see ISO 5801.

3.6
fan aerodynamic characteristic curves
fan pressure, power, efficiency, etc., against flow rate under specified ambient conditions and at a constant speed, or when fitted with a specified motor

3.7
fan dynamic pressure at 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 fan outlet area

$$p_{d2} = \rho_2 \frac{v_{m2}^2}{2} = \frac{1}{2\rho_2}\left(\frac{q_m}{A_2}\right)^2$$

NOTE It is expressed in pascals (Pa).

3.8
fan flow coefficient
φ
non-dimensional quantity equal to the mass flow rate divided by the product of the mean density, the peripheral speed of the impeller and the square of the diameter of the impeller

$$\varphi = \frac{q_m}{\rho_m u D_r^2} \quad \text{if } Ma \geqslant 0{,}122$$

$$\varphi = \frac{q_V}{u D_r^2} \quad \text{if } Ma < 0{,}122$$

3.9
fan outlet area
A_2
area inside the fan outlet casing flange

NOTE It is expressed in square metres (m^2).

3.10
fan pressure
p_F
difference between the stagnation pressure at the fan outlet and the stagnation pressure at the fan inlet

$$p_F = p_{sg2} - p_{sg1} \quad \text{if } Ma \geqslant 0{,}15$$

$$p_F = p_{tF} = p_{t2} - p_{t1} \quad \text{if } Ma < 0{,}15$$

NOTE 1 When expressing fan pressure, reference should be made to the installation category A, B, C or D.

NOTE 2 It is expressed in pascals (Pa).

3.11
fan static pressure
p_{sF}
conventional quantity defined as the difference between the fan pressure and the fan dynamic pressure corrected by Mach factor F_{M2}

$$p_{sF} = p_{sg2} - p_{d2}F_{M2} - p_{sg1} = p_2 - p_{sg1} \quad \text{if } Ma \geqslant 0{,}122 \text{ at the fan outlet area}$$

$$p_{sF} = p_{t2} - p_{t1} - p_{d2} \quad \text{if } Ma < 0{,}122 \text{ at the fan outlet area}$$

NOTE It is expressed in pascals (Pa).

3.12
Mach factor
F_M
correction factor applied to the dynamic pressure at a point

$$F_M = \frac{p_{sg} - p}{p_d}$$

NOTE 1 The Mach factor can be calculated by

$$F_M = 1 + \frac{Ma^2}{4} + \frac{(2-\kappa)Ma^4}{24} + \frac{(2-\kappa)(3-2\kappa)Ma^6}{192} + \dots \quad \text{valid for } \kappa = 1{,}4$$

NOTE 2 It is dimensionless.

3.13
Mach number at a point
Ma
ratio of the gas velocity at a point to the velocity of sound

$$Ma = \frac{v}{\sqrt{\kappa R_w \Theta}} = \frac{v}{c}$$

where

c is the velocity of sound, $c = \sqrt{\kappa R_w \Theta}$;

R_w is the gas constant of humid gas.

NOTE It is dimensionless.

3.14
Mach number at a section x
Ma_x
average gas velocity divided by the velocity of sound at the specified airway cross-section

$$Ma_x = \frac{v_{mx}}{\sqrt{\kappa R_w \Theta_x}}$$

NOTE It is dimensionless.

3.15
optimum efficiency
η_{opt}
maximum efficiency achieved on the fan air characteristic with all operational parameters, except the air system resistance, being fixed

NOTE It is expressed as a percentage.

3.16
peripheral Reynolds number
Re_u
Reynolds number based on the tip speed, u

NOTE It is dimensionless.

3.17
power coefficient
λ
non-dimensional quantity related to the impeller power using the mean fluid density at inlet

$$\lambda = \frac{P_r}{\rho_m u^3 D_r^2}$$

3.18
pressure coefficient
ψ
non-dimensional number related to the fan pressure using the mean density of the gas and the tip speed of the impellor

$$\psi = \frac{p_F}{\rho_m u^2}$$

3.19
tip speed
u
peripheral speed of the impeller blades at their maximum diameter

NOTE It is expressed in metres per second ($m \cdot s^{-1}$).

3.20
total sound power level
L_W
unweighted sound power level defined as 10 times the logarithm to the base 10 of the ratio of the sound power in watts to a reference value of 10^{-12} W (1 picowatt [pW])

NOTE It is expressed in decibels (dB).

3.21
octave band sound power level
L_{Wfc}
sound power level in an octave band with a defined centre frequency, defined as 10 times the logarithm to the base 10 of the ratio of the sound power in watts to a reference value of 10^{-12} W (1 picowatt [pW])

NOTE It is expressed in decibels (dB).

3.22
A-weighted sound power level
L_{WA}
total sound power level using A-weighting

NOTE 1 See IEC 61672-1 for a definition of A-weighting.

NOTE 2 It is expressed in decibels (dB).

3.23
total sound pressure level
L_p
unweighted total sound pressure level at a specified point and under specified conditions, normally in the octave bands with centre frequencies from 63 Hz to 8 kHz, defined as 10 times the logarithm to the base 10 of the ratio of the square of the sound pressure to the reference value of 20 μPa

NOTE It is expressed in decibels (dB).

3.24
A-weighted sound pressure level
L_{pA}
total sound pressure level using A-weighting

NOTE 1 For a definition of A-weighting, see IEC 61672-1.

NOTE 2 It is expressed in decibels (dB).

3.25
tolerance zone
range of values of the specified parameters allowed, according to the applicable tolerance grade

3.26
tolerance grade
designation defining the limit deviations from the agreed or published technical performance parameters

3.27
dimensionless frequency
χ
non-dimensional logarithmic function of the ratio between the centre frequency of an octave or third-octave band, and the rotational speed of the fan

$$\chi = 10 \lg \frac{f_c}{n}$$

4 Symbols and units

For the purposes of this docuemnt the following symbols apply:

Symbol	Term	Unit
A_2	Fan outlet area	m^2
c	Velocity of sound	$m \cdot s^{-1}$
D_r	Diameter of impeller	m
e	Uncertainty of measurement	—
F_{Mx}	Mach factor for correction of dynamic pressure at section x	—

Symbol	Term	Unit
f_c	Octave centre frequency	Hz
G	Index of agreed value	—
k	Parabolic constant $k = \psi_p/\varphi^2$	—
L_p	Sound pressure level	dB
L_{pA}	A-weighted sound pressure level	dB (A)
L_W	Sound power level	dB
L_{WA}	A-weighted sound power level	dB (A)
L_{Wfc}	Octave band sound power level	dB
M	Index of measured value	—
Ma	Mach number at a point	—
Ma_x	Mach number at section x	—
n	Rotational speed/rotational fequency	$r \cdot s^{-1}$
P_a	Mechanical power supplied to the fan shaft	W
P_m	Shaft power of electric motor	W
P_r	Mechanical power required by the fan impeller	W
p_a	Atmospheric pressure	Pa
p_{ex}	Mean gauge pressure in space and time at section x	Pa
p_F	Fan pressure	Pa
p_{dF}	Fan dynamic pressure	Pa
p_{d2}	Fan dynamic pressure at outlet	Pa
p_{sF}	Fan static pressure	Pa
p_{sg}	Absolute stagnation pressure	Pa
p_t	Average total pressure	Pa
p_x	Mean absolute pressure in space and time at a point	Pa
q_m	Inlet mass flow rate	$kg \cdot s^{-1}$
q_V	Inlet volume flow rate	$m^3 s^{-1}$
Re_u	Peripheral Reynolds number	—
R_w	Gas constant of fluid handled	$J \cdot kg^{-1} \cdot K^{-1}$
T	Air flow test tolerance	%
t	Limit deviation specified	—
u	Tip speed	$m \cdot s^{-1}$
v	Fluid velocity	$m \cdot s^{-1}$
κ	Ratio of specific heats of air, $\kappa = \frac{c_p}{c_v}$, where c_p is the massic heat capacity at constant pressure, and c_v is the massic heat capacity at constant volume	—
η	Fan efficiency	—
η_{opt}	Fan optimum efficiency	—
θ_x	Fluid absolute temperature at section x	K
λ	Power coefficient	—

Symbol	Term	Unit
μ	Dynamic viscosity	Pa·s
ρ	Density	kg·m^{-3}
ρ_m	Mean density of gas in fan	kg·m^{-3}
ρ_1	Density at fan inlet	kg·m^{-3}
ρ_2	Density at fan outlet	kg·m^{-3}
φ	Fan flow coefficient	—
χ	Dimensionless frequency	—
ψ	Pressure coefficient	—

5 Performance tolerances for purpose-designed fans

5.1 Information to be provided by the purchaser

5.1.1 Operational

The following information shall be provided.

a) Volume flow rate, q_V, rate at the fan inlet or mass flow rate q_m.

b) Total pressure increase, p_t, between fan inlet and outlet, or static pressure increase, p_s, at a specified discharge area.

c) Distribution of total pressure losses in the system between inlet and outlet side of fan.

d) Absolute pressure at fan inlet.

e) Density, ρ_1, of handled fluid at fan inlet.

f) Temperature of the gas handled at the fan inlet for normal operation relevant for the fan performance, and the maximum and minimum temperatures for which the fan is to be designed.

g) Dust, mist or vapour content of gas at fan inlet for normal operation, the properties of these, and their maximum content. Information as to whether the dust, mist or vapour is combustible, noxious, aggressive or sticky.

h) Maximum permissible A-weighted sound power level, in A-weighted decibels, as specified in ISO 13347-1.

i) Maximum permissible levels of mechanical vibration in service, as specified in ISO 14694.

j) System characteristic, if necessary.

k) Design speed cycles: i.e. the number of speed cycles per 24 h, the range of speed, if variable speed, plus the total number of start-stops the fan is to be designed for.

l) Other specifications (e.g. preferred rotational speed, type and range of control, orientation of the inlet and discharge, impeller rotation, as viewed from the driver). See ISO 13349.

5.1.2 Tolerance grade

The tolerance grade shall be stated in accordance with the requirements specified in 5.3.1.

A supplier will only be able to provide a fan for a particular application once the customer has provided him with all the information necessary to complete the order. This should take place before the tender is prepared or, at the latest, before a sales agreement has been reached. Such information is to include details on fan design, arrangement, construction, materials and scope of supply, and should be based on the customer's own calculations, measurements and experience in this field.

5.2 Information to be provided by the supplier

5.2.1 Essential information

If the supplier cannot refer to catalogue information, installation, maintenance or operation instructions, he shall generally provide the following information.

a) Operational parameters at design conditions, especially volume or mass flow, fan pressure, absorbed power and fan speed. The exact scope of supply, as well as any other accessories that the supplier considers necessary for installation and connection (e.g. motors, devices to prevent accidental contact, flexible connectors, control and shut-off devices, inlet boxes).

b) The major dimensions for connection, installation and transport.

c) The total mass of the assembly and the mass of the essential components supplied.

d) Important design features where essential for assembly, e.g. materials of construction. Other information should be supplied on request, or if necessary.

e) Motor output power.

f) Other information, e.g. the electric or pneumatic connected load, provision of sealing gas, cooling air and water.

g) Installation, operation, and maintenance instructions.

NOTE In many installations the electric drive motor is supplied directly by the supplier. As such, it may not be possible to state the type of drive, its rating and speed, etc.

5.2.2 Optional parameters

The following information may also be provided.

a) Fan power (see ISO 5801) as a function of the parameters listed in 5.1.

b) Rotational speed of the impeller as a function of the parameters listed in 5.1, and maximum permissible rotational speed.

c) A-weighted sound power level as specified in ISO 13347-1. Sound pressure levels are not recommended as they can be heavily influenced by the room acoustics and sound propagation from connecting ducts. In addition, they can be significantly influenced by directional characteristics, especially if the fan is of the open-inlet or outlet type. Sound pressure levels can only be stated under free-field conditions and may not be representative of actual room conditions.

d) Fan performance characteristic, if specifically requested by the purchaser. The following additional parameters may be supplied if specifically requested:

   1) fan efficiency (see ISO 5801) as a function of the parameters listed in 5.1;

   2) vibration values (see ISO 14695);

   3) balance quality (see ISO 14695).

e) The mass moment of inertia of the rotating parts, or if applicable, the starting torque curve.