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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

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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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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

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

This third edition cancels and replaces the second edition (ISO 13348:2007), which has been technically revised.

The main changes are as follows:

— terms have been revised;

— symbols and units in Clause 4 have been updated;

— Clauses 6 and 7 have been revised;

— additional information provided in Annex D.

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

This document aims to clarify technical aspects of contracts where fan performance is concerned, and the accuracy and consistency of performance details published in technical catalogues.

In this document, 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 can agree to adopt alternative methods.

For series-produced non-certified 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 5.

For series-produced fans in certified ratings programmes, 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 AMCA (Air Movement and Control Association) International, Inc. certified reference program rules[16],[17],[18]).

Fans — Tolerances, methods of conversion and technical data presentation

1 Scope

This document specifies performance tolerances and the technical data presentation for 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, 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 document applies the five 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;
- E free inlet and free outlet without a partition.

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 five 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.

The efficiency scaling procedures described in 8.1.5 apply to centrifugal fans and axial fans within the specific speed ranges shown in Table 4. To date, there is no experimental data to confirm how they apply to mixed flow fans, having specific speeds in between.

Category E fans are treated in Clause 7.

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 5801:2017, *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 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*

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 terms and definitions given in ISO 5801, ISO 5802, ISO 13349-1, ISO 13349-2 and ISO 13350 and the following apply.

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

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

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

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

Note 1 to entry: For the purpose of this document 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
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

$$p_{sgx} = p_x + p_{dx} f_{Mx} \quad (1)$$

Note 1 to entry: The average stagnation pressure can be calculated by Formula (2):

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

where

κ	is the isentropic exponent;
p_x	is the static pressure at the section x;
p_{dx}	is the dynamic pressure at the section x;
f_{Mx}	is the Mach factor coefficient at the section x;
Ma_x	is the Mach number at the section x.

Note 2 to entry: 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 cross-section, and the average gauge pressure, p_{ex}

$$p_{tx} = p_{ex} + p_{dx} f_{Mx} = p_{sgx} - p_a \quad (3)$$

where

p_{ex}	is the mean gauge pressure at the cross-section x;
p_{dx}	is the dynamic pressure at the cross-section x;
f_{Mx}	is the Mach factor coefficient at the cross-section x;
p_{sgx}	is the stagnation pressure at the cross-section x;
p_a	is the atmospheric pressure.

Note 1 to entry: When the Mach number, *Ma*, is less than 0,122, the Mach factor, F_{Mx}, can be neglected

Note 2 to entry: See ISO 5801

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 to entry: 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 to entry: 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

$$p_{d2} = \rho_2 \frac{v_{m2}^2}{2} = \frac{1}{2\rho_2}\left(\frac{q_m}{A_2}\right)^2 \quad (4)$$

where

ρ_2	is the fluid density at the fan outlet;
v_{m2}	is the fluid velocity at the fan outlet;
q_m	is the mass flow rate;
A_2	is the fan outlet area.

Note 1 to entry: 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

$$\varphi = \frac{4\, q_{V1}}{\pi D_r^2 u} \quad (5)$$

where

q_{V1} is the volume flow rate at the fan inlet;

D_r is the diameter of the impeller;

u is the tip speed of the impeller.

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

Note 1 to entry: 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

$$p_F = p_{sg2} - p_{sg1} \quad (6)$$

$$p_F = p_{tF} = p_{t2} - p_{t1} \text{ if } Ma < 0{,}122 \quad (7)$$

where

p_{sg2} is the stagnation pressure at the fan outlet;

p_{sg1} is the stagnation pressure at the fan inlet;

p_{t2} is the total pressure at the fan outlet;

p_{t1} is the total pressure at the fan inlet.

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

Note 2 to entry: 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}

$$p_{sF} = p_{sg2} - p_{d2} f_{M2} - p_{sg1} = p_2 - p_{sg1} \quad (8)$$

$$p_{sF} = p_{t2} - p_{t1} - p_{d2} \text{ if } Ma < 0{,}122 \text{ at the fan outlet area} \quad (9)$$

where

p_{sg2} is the stagnation pressure at the fan outlet;

p_{d2} is the dynamic pressure at the fan outlet;

f_{M2} is the Mach factor coefficient at the fan outlet;

p_{sg1} is the stagnation pressure at the fan inlet;

p_{t2} is the total pressure at the fan outlet;

p_{t1} is the total pressure at the fan inlet.

Note 1 to entry: It is expressed in pascals (Pa).

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

$$f_M = \frac{p_{sg} - p}{p_d} \tag{10}$$

where

p_{sg} is the stagnation pressure;

p is the absolute pressure;

p_d is the dynamic pressure.

Note 1 to entry: The Mach factor can be calculated by Formula (11):

$$f_M = 1 + \frac{Ma^2}{4} + \frac{(2-\kappa)Ma^4}{24} + \frac{(2-\kappa)(2-2\kappa)Ma^6}{192} + \ldots \text{valid for } \kappa = 1,4 \tag{11}$$

where

κ is the isentropic exponent;

Ma is the Mach number.

Note 2 to entry: It is dimensionless.

3.13
Mach number at a point
Ma
ratio of the air velocity to the velocity of sound at the fan inlet stagnation conditions

$$Ma = \frac{v}{\sqrt{\kappa R_w \theta_{sg}}} = \frac{v}{c} \tag{12}$$

where

c is the velocity of sound, $c = \sqrt{\kappa R_\mathrm{w} \theta_\mathrm{sg}}$;

v is the fluid velocity;

κ is the isentropic exponent;

R_w is the gas constant of humid gas;

θ_sg is the stagnation temperature.

Note 1 to entry: 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

$$Ma_\mathrm{x} = \frac{v_\mathrm{x}}{\sqrt{\kappa R_\mathrm{x} \theta_\mathrm{sgx}}} \tag{13}$$

where

v_x is the fluid velocity at the cross-section x;

κ is the isentropic exponent;

R_w is the gas constant of humid gas;

θ_sgx is the stagnation temperature at the cross-section x.

Note 1 to entry: It is dimensionless.

3.15
efficiency
η
ratio of fan air power to the fan impeller power

$$\eta = \frac{P_\mathrm{u}}{P_\mathrm{r}} = \frac{q_\mathrm{m} p_\mathrm{F}}{\rho_\mathrm{m} P_\mathrm{r}} = \frac{\psi}{\lambda} \tag{14}$$

where

P_u is the fan air power;

P_r is the fan impeller power;

q_m is the mass flow rate;

p_F is the fan pressure;

ρ_m is the mean fluid density;

φ is the fan flow coefficient;

ψ is the fan pressure coefficient;

λ is the fan power coefficient.

Note 1 to entry: It is expressed as a percentage.

3.16
optimum efficiency
η_{opt}
maximum efficiency achieved on the fan air characteristic with all operational parameters, except the air system resistance, being fixed

Note 1 to entry: The operating point where optimum efficiency is achieved is called the best efficiency point (BEP).

3.17
peripheral Reynolds number
Re_u
Reynolds number based on the tip speed, u

$$Re_u = \frac{u D_r \rho_1}{\mu_1} \quad (15)$$

where

u	is the tip speed;
D_r	is the impeller diameter;
ρ_1	is the fluid density at the fan inlet;
μ_1	is the fluid dynamic viscosity.

Note 1 to entry: It is dimensionless.

3.18
peripheral Mach number
Ma_u
Mach number based on the tip speed, u

$$Ma_u = \frac{u}{\sqrt{\kappa R_w \Theta_{sg1}}} = \frac{u}{c} \quad (16)$$

where

u	is the tip speed;
κ	is the isentropic exponent;
R_w	is the gas constant of humid gas;
θ_{sg1}	is the stagnation temperature at the fan inlet;
c	is the velocity of sound.

Note 1 to entry: It is dimensionless.

3.19
power coefficient
λ
non-dimensional quantity related to the impeller power using the mean fluid density and the tip speed

$$\lambda = \frac{2P_r}{q_m u^2} \quad (17)$$

where

P_r is the fan impeller power;

q_m is the mass flow rate;

u is the tip speed.

3.20
pressure coefficient
ψ
non-dimensional number related to the fan pressure using the mean density of the gas and the tip speed of the impeller

$$\psi = \frac{2p_F}{\rho_m u^2} \tag{18}$$

where

p_F is the fan pressure;

ρ_m is the mean fluid density;

u is the tip speed.

3.21
tip speed
u
peripheral speed of the impeller blades at their maximum diameter

$$u = \pi n D \tag{19}$$

where

n is the rotational speed/rotational frequency;

D is the impeller diameter.

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

3.22
hub-to-tip ratio
ξ
ratio of the hub-diameter to the tip-diameter of an axial fan

$$\xi = \frac{D_i}{D_r} \tag{20}$$

where

D_i is the hub-diameter;

D_r is the impeller diameter.

3.23
relative roughness
R_r