



BSI Standards Publication

Fans — Tolerances, methods of conversion and technical data presentation

National foreword

This British Standard is the UK implementation of ISO 13348:2025. It supersedes BS 848-9:2007, which is withdrawn.

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A list of organizations represented on this committee can be obtained on request to its committee manager.

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**International
Standard**

ISO 13348

**Fans — Tolerances, methods of
conversion and technical data
presentation**

*Ventilateurs — 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.

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*.

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/m³. 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 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

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

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

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 (m²).

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

$$f_M = \frac{p_{sg} - p}{p_d} \quad (10)$$

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 \(11\)](#):

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

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

$$Ma = \frac{v}{\sqrt{\kappa R_w \theta_{sg}}} = \frac{v}{c} \quad (12)$$

where

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

$$Ma_x = \frac{v_x}{\sqrt{\kappa R_x \theta_{sgx}}} \quad (13)$$

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

$$\eta = \frac{P_u}{P_r} = \frac{q_m p_F}{\rho_m P_r} = \frac{\psi}{\lambda} \quad (14)$$

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

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

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

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

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_f 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

$$\psi = \frac{2p_F}{\rho_m u^2} \quad (18)$$

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

$$u = \pi n D \quad (19)$$

where

n is the rotational speed/rotational frequency;

D is the impeller diameter.

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

3.22

hub-to-tip ratio

ξ

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

$$\xi = \frac{D_i}{D_r} \quad (20)$$

where

D_i is the hub-diameter;

D_r is the impeller diameter.

3.23

relative roughness

R_r

non-dimensional quantity equal to the maximum height per section roughness divided by 1,5 times a characteristic length

$$R_r = \frac{R_z}{1,5 \cdot l_{\text{char}}} \quad (21)$$

where

R_z is the maximum height per section roughness;

l_{char} is a characteristic length.

Note 1 to entry: Here, the maximum height per section divided by factor 1,5 depicts the equivalent sand roughness.

3.24

relative gap

S_r

non-dimensional quantity equal to the absolute gap width divided by the outer diameter or the tip-diameter of the fan.

$$S_r = \frac{S_a}{D_r} \quad (22)$$

where

S_a is the absolute gap width;

D_r is the impeller diameter.

3.25

specific speed

σ

non-dimensional quantity that characterizes the shape and operating range of a fan

$$\sigma = \frac{n}{(2\pi^2)^{-1/4} \cdot \left(\frac{p_F}{\rho_m}\right)^{-3/4} \cdot \left(\frac{q_m}{\rho_m}\right)^{-1/2}} \quad (23)$$

where

n is the rotational speed/rotational frequency;

p_F is the fan pressure;

ρ_m is the mean fluid density;

q_m is the mass flow rate.

Note 1 to entry: It is used to compare different fan designs and select the most appropriate fan for a given application.

3.26

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 1 to entry: It is expressed in decibels (dB).

3.27**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 1 to entry: It is expressed in decibels (dB).

3.28**A-weighted sound power level** L_{WA}

total sound power level using A-weighting

Note 1 to entry: See IEC 61672-1 for a definition of A-weighting.

Note 2 to entry: It is expressed in decibels (dB).

3.29**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 μ Pa

Note 1 to entry: It is expressed in decibels (dB).

3.30**A-weighted sound pressure level** L_{pA}

total sound pressure level using A-weighting

Note 1 to entry: For a definition of A-weighting, see IEC 61672-1.

Note 2 to entry: It is expressed in decibels (dB).

3.31**tolerance zone**

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

3.32**tolerance grade**

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

3.33**dimensionless frequency**

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

$$\chi = 10 \lg \frac{f_{\text{centre}}}{n} \quad (24)$$

where

f_{centre} is the octave centre frequency;
 n is the rotational speed/rotational frequency.

4 Symbols and abbreviated terms

For the purposes of this document, the following symbols and abbreviations apply.

Symbol	Term	Unit
A_2	Fan outlet area	m^2
A_x	Wetted surface of the section x	m^2
B	Depth of the casing	m
b_i	Inner depth of the impeller	m
b_r	Outer depth of the impeller	m
c	Velocity of sound	$\text{m} \cdot \text{s}^{-1}$
$C(Ma)$	Correction factor for Carnot losses	---
D_i	Inner diameter of the impeller	m
D_r	Diameter of impeller	m
e	Uncertainty of measurement	—
F_{Mx}	Mach factor for correction of dynamic pressure at section x	—
F_c	Shape factor of the Carnot loss coefficient	---
F_r	Shape factor of the impeller or rotor	---
F_s	Shape factor of the casing or stator	---
f_c	Carnot coefficient	---
f_{centre}	Octave centre frequency	Hz
f_r	Friction coefficient of the impeller or rotor	---
f_s	Friction coefficient of the casing or stator	---
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
l_r	Length of the blade	m
M	Index of measured value	—
Ma	Mach number at a point	—
Ma_x	Mach number at section x	—
n	Rotational speed/rotational frequency	$\text{r} \cdot \text{s}^{-1}$
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_F	fraction of free delivery fan airflow rate at the catalogued duty point	—
q_m	Inlet mass flow rate	$\text{kg} \cdot \text{s}^{-1}$
q_V	Inlet volume flow rate	$\text{m}^3 \cdot \text{s}^{-1}$

Symbol	Term	Unit
q_{vg}	gap volume flow	—
Re_u	Peripheral Reynolds number	—
Re_x^*	Local Reynolds number at the position x	---
R_w	Gas constant of fluid handled	J·kg ⁻¹ ·K ⁻¹
$R_{z,x}$	Absolute roughness at the position x	m
$R_{r,x}$	Relative roughness at the position x	---
$S_{a,x}$	Absolute gap at the position x	m
$S_{r,x}$	Relative gap at the position x	m
T	airflow tolerance	%
t	Limit deviation specified	—
u	Tip speed	m·s ⁻¹
v	Fluid velocity	m·s ⁻¹
z	Number of blades	---
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	—
ζ_C	Carnot loss coefficient	---
ζ_f	Friction loss coefficient	---
ζ_g	Gap loss coefficient	—
η	Fan efficiency	—
η_{opt}	Fan optimum efficiency	—
θ	Fluid absolute temperature	K
λ	Power coefficient	—
μ	Dynamic viscosity	Pa·s
μ_g	Flow coefficient through the gap	---
ξ	hub-tip ratio	---
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
σ	specific speed	—
τ	Air flow test tolerance	%
φ	Fan flow coefficient	—
χ	Dimensionless frequency	—
ψ	Pressure coefficient	—

5 Performance tolerances for purpose-designed fans and series-produced non-certified 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 13349-1 and ISO 13349-2.

5.1.2 Tolerance grade

The tolerance grade shall be stated in accordance with the requirements specified in [5.3.1](#).

A supplier can only provide a fan once the customer has provided 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 fan supplier

5.2.1 Essential information

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

- a) Operational parameters at design conditions, especially volume or mass flow rate, 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 For many installations, the fan supplier does not provide the motor. As such, it might not be possible to state the type of drive, its speed, and other associated ratings.

The information shall be provided in Documentation (in accordance with [Annex A](#)). In addition, the fan shall wear a marking that displays essential information (in accordance with [Annex B](#)).

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 14694).
- e) The mass moment of inertia of the rotating parts, or if applicable, the starting torque curve.

5.3 Tolerances

5.3.1 Tolerance grades

Measuring uncertainties include systematic deviation of a measured value from the true value of the property, deviations if the same product is measured with the same instrumentation, method, and laboratory numerous times, and deviations if the same product is measured by different laboratories. Measuring uncertainties shall be considered differently from manufacturing 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.

Zero or exclusively positive tolerances cannot be supported and are not recommended.

Uncertainties are spurious, random, or systematic which affect design, fabrication and therefore fan performance. Uncertainties are not absolute and because of this are handled statistically, i.e. a level of confidence is attributed to the measured quantity lying within the uncertainty boundary of the true value.

Tolerances are the definition of acceptability for uncertainties. They are absolute and can vary according to the application. They effectively define an absolute limit for uncertainties which would otherwise have to be expressed statistically. The user is therefore provided with absolute criteria for fan selection and acceptance.

This document acknowledges that there are two different sources of uncertainty influencing performance tests.

Design and manufacturing processes have inherent dimensional uncertainties leading to deviations of important mechanical dimensions from the target value. This, again, will lead to inevitable deviations in performance data:

- $\pm t_{qV}$ limit deviation of volume flow;
- $\pm t_{pF}$ limit deviation of fan pressure;
- $\pm t_{Pa}$ limit deviation of fan shaft power;
- $-t_{\eta}$ limit deviation of fan efficiency;
- $+t_{LWA}$ limit deviation of A-weighted fan sound power level.

The design and manufacturing accuracy obtainable in practice is defined in a number of International Standards (e.g. ISO 2768-1). Design and manufacturing tolerances are treated in [Clause 6](#) of this document. Higher accuracy will, as a rule, require more expensive production methods. The fan user shall decide which uncertainties in performance data are permissible, bearing in mind the consequences on cost.

This can be illustrated for an axial fan with a cast impeller. The impeller could be a rough sand casting or a more accurate die casting. The surface could be improved by polishing or remain untreated. The tip diameter may be machined or remain as-cast. The aerodynamic effects of electric motors placed in the air stream may reduce the fan performance. For low uncertainty, it is not sufficient to achieve small tolerances for the tip gap, etc. Larger or smaller deviations from the intended mechanical dimensions, and uncertainties in the conversion of test data, will affect each performance value differently. For example, a variation of the width of a radial impeller will have a larger influence on the volume flow-rate than on the fan pressure. Measurements also have inherent uncertainties.

Limitations in the measuring accuracy of the instruments used, and deviations from the standardized test-duct arrangements according to ISO 5801, will influence the confidence that can be applied to the uncertainty of the resulting characteristic values, such as capacity, fan pressure, power consumption, speed and sound power level. These values, being measured independently by different instruments, will have errors that are unrelated and, as such, their influence on test results shall be considered independently. The following tolerances are identified, taking into account potential imperfections of the measuring arrangement:

- $\pm \Delta_{qV}$ tolerance of volume flow measurements;
- $\pm \Delta_{pF}$ tolerance of fan pressure measurements;
- $\pm \Delta_{Pa}$ tolerance of fan shaft power measurements;
- $\pm \Delta_{LW}$ tolerance of fan noise power measurements.

These tolerances are not limited to the errors of the instruments or the test arrangement employed. They also allow for human error associated with the reading of the instruments and the interpolation of intermediate values. This is particularly relevant for large fans, where the difficulty in achieving standardized test arrangements can be the largest source of error.

To provide for the variety of fan types and applications, a list of four tolerance grades, with typical applications, has been defined in [Table 1](#). As indicated above, these range from accurately machined impellers for special-

purpose fans to sheet-metal fabricated impellers with wide tolerances used for applications where other criteria are more important than optimum fan performance. It should be noted that the tolerance grades of classes are only examples for possible applications

Table 1 — Guide for fan “air and noise” tolerance grades 1 to 4

Tolerance grade (air and noise)	Typical application	Material of, and manufacturing processes used for, major aerodynamic components	Approx. min. shaft power ^a kW
AN1	Mining (e.g. main fan), process engineering, power stations (e.g. exhaust fan), wind tunnels, tunnels, etc.	Machined in some places, cast (high accuracy)	> 500
AN2	Mining, power stations, wind tunnels, tunnels, process engineering, air conditioning	Sheet or plastic material, partly machined, cast (medium accuracy)	> 50
AN3	Process engineering, air conditioning, industrial fans, tunnels, power station fans and industrial fans for harsh (abrasive or corrosive) conditions	Sheet material, cast (medium to low accuracy), special surface protection (e.g. hot-dip galvanizing, moulded plastics)	> 10
AN4	Process engineering, ships fans, agriculture, small fans, power station fans and industrial fans for harsh (abrasive or corrosive) conditions	Sheet material, special surface protection (e.g. rubber coating), moulded or extruded plastics	—

^a For each class, a recommendation has been given only for the lower power limit; an upper limit is not essential. For example, even if the power is greater than 500 kW, any one of the grades may be assigned.

The information given in [Table 1](#) may be used as a guide only. It shall be considered with which degree of accuracy the expected performance data has been established, often requiring agreement between purchaser and supplier when selecting a suitable grade. Uncommon installation conditions — for example, distorted inlet flow — or a system with components situated in the inflow, such as protective screens or structural supports, shall be allowed for. Special agreements shall be made for fans whose drive causes marked fluctuations in rotational speed.

Motors used for direct-driven axial flow fans may be in the airstream without an aerodynamic fairing. This could produce an additional aerodynamic blockage. In such cases, an allowance for motor effect should be agreed between the supplier and purchaser.

It should be remembered that specifications which require zero and/or exclusively positive tolerances, with respect to fan pressure and flow, are not recommended. They can neither be supported in theory nor in practice, and lead to substantial over-design and unnecessarily increased operating cost.

5.4 Purchasing arrangements

Before a contract is signed it shall be agreed whether a performance test shall be included. This is not normally required, especially if the fan is subject to a certified ratings programme (see [Clause 6](#)) or if the supplier has a laboratory meeting the requirements of ISO/IEC 17025.

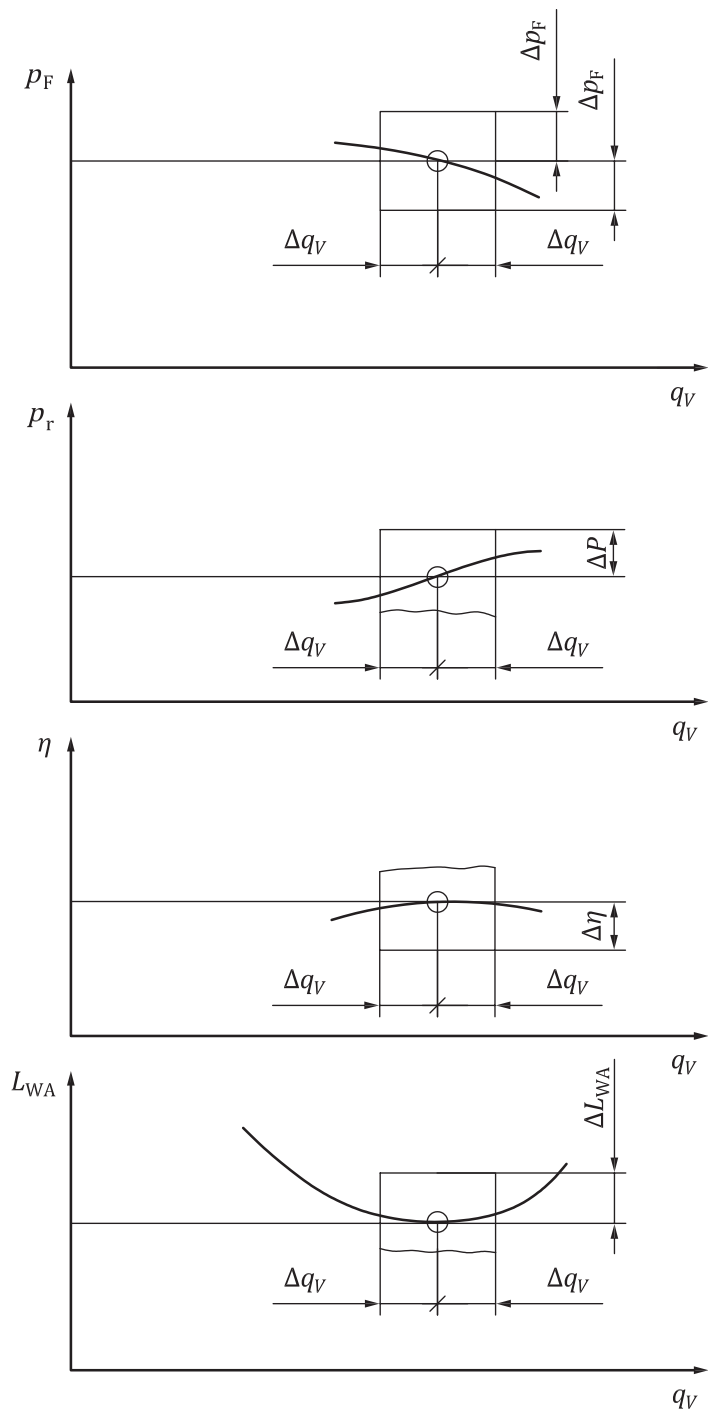
5.5 Contractual testing

5.5.1 Tolerance magnitude near optimum efficiency

Four tolerance grades are given in [Table 2](#) for the fan volume flow, pressure, shaft power and sound power level (see also [Figure 1](#)). In the normal case, these grades are applicable to all contractual agreements between the purchaser and the supplier, and if not, a separate agreement should be obtained. The operating point is assumed to lie where the efficiency, as stated by the supplier, is at least 0,9 times the stated best efficiency η_{opt} . Outside this range, tolerances are applied as detailed in [5.5.2](#)

Table 2 — Manufacturing tolerance grades

Parameter	Tolerance grade (air and noise)				Additional information
	AN1	AN2	AN3	AN4	
Volume flow rate, q_V	±1 %	±2,5 %	±5 %	±10 %	$\Delta_{q_V} = t_{q_V} \cdot q_V$
Fan pressure p_F	±1 %	±2,5 %	±5 %	±10 %	$\Delta_{p_F} = t_{p_F} \cdot p_F$
Power, P_r ^{a, b}	+2 %	+3 %	+8 %	+16 %	$\Delta_P = t_P \cdot P_r$ Negative deviations are permissible. For small fans, P , shall be the motor input power.
Efficiency, η	−1 %	−2 %	−5 %	−12 %	$\Delta_\eta = t_\eta$ i.e. the value of t_η is identical with the permissible tolerance of the efficiency. Positive deviations are permissible.
A-weighted sound power level, L_{WA} ^c	+2 dB	+3 dB	+4 dB	+6 dB	$\Delta_{L_{WA}} = t_{L_{WA}}$ The value of $t_{L_{WA}}$ is a permissible tolerance of the sound power level. Negative deviations are permissible.
Sound pressure levels are dependent on the environment. Tolerances will be higher due to wave length effects, local resonances, directional factors, room effects, etc. In particular, sound pressure levels measured close to fan casings are heavily influenced by “near-field” effects and, as such, great care should be taken when using sound pressure measurements. As a guide the tolerances, given above for sound power may have to be doubled. ^a The power should be clearly defined: i.e. whether it is impeller power, shaft power (including bearing losses), overall fan power (including transmission losses, e.g. coupling or vee-belt drive losses), or motor input power (applicable especially to small fans). See also ISO 5801, ISO 13349-1, ISO 13349-2 and IEC 60034-2. ^b The power measurement of electric motors shall be carried out with a sinusoidal supply on nominal frequency and voltage. The voltage from frequency converters could give higher power values due to additional losses within the motor. ^c The measuring uncertainty of octave or one-third octave band sound power levels increases significantly, while universal scaling rules are not accepted. (see 8.2.3.1). It is therefore recommended that tolerance band levels not be included in contractual terms.					



Key

- p_F fan pressure
- P_r fan power
- η fan efficiency
- L_{WA} A-weighted fan sound power level
- q_V inlet volume flow rate

NOTE While the uncertainty fields are elliptical, rectangles are used for practical reasons.

Figure 1 — Limit deviations (tolerance ranges) for agreed operational parameters in accordance with [Table 1](#)