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Industrial fans — Determination of fan sound power levels under standardized laboratory conditions —

Part 1: General overview

Ventilateurs industriels — Détermination des niveaux de puissance acoustique des ventilateurs dans des conditions de laboratoire normalisées —

Partie 1: Présentation générale

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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 13347-1 was prepared by Technical Committee ISO/TC 117, *Industrial fans*.

ISO 13347 consists of the following parts, under the general title *Industrial fans — Determination of fan sound power levels under standardized laboratory conditions*:

— *Part 1: General overview*

— *Part 2: Reverberant room method*

— *Part 3: Enveloping surface methods*

— *Part 4: Sound intensity method*

Introduction

The need for this new International Standard, ISO 13347, has been evident for some time. Whilst a number of national standards exist for the measurement of fan noise, none has received universal acceptance nor may comparisons be readily made.

Forming part of the ISO/TC 117 series of fan standards, this part of ISO 13347 deals with the determination of the fan sound power level appropriate to a particular application. In describing the test and rating procedures, numerous references are made to ISO 5801 as well as to other relevant ISO standards. This general overview should be read in conjunction with the appropriate part of ISO 13347 that specifies, in detail, methods for determining the sound power propagated from a fan in specified installation conditions as a function of frequency.

This part of ISO 13347 primarily deals with the determination of sound power levels of industrial fans used in four types of installations (see Clause 4) for ducted applications.

The test procedures described in this part of ISO 13347 relate to laboratory conditions. The measurement of performance under site conditions is not included. Acoustic system effects can be considerable where the airflow into and out of the fan is not free from swirl, nor fully developed.

This part of ISO 13347 describes methods for determining sound power levels of fans in one-third octave bandwidths and one octave bandwidths.

Data obtained in accordance with this part of ISO 13347 may be used for the following purposes amongst others:

a) comparison of fans which are similar in size and type;

b) comparison of fans which are different in size, type, design, speed, etc;

c) determining whether a fan is suitable for a specified upper limit of sound emission;

d) scaling of fan noise from one size and speed to another size and speed of the same type of fan;

e) prediction of sound pressure level in application of the fan;

f) engineering work to assist in developing machinery and equipment with lower sound emissions.

Industrial fans — Determination of fan sound power levels under standardized laboratory conditions —

Part 1: General overview

1 Scope

This part of ISO 13347 deals with the determination of the acoustic performance of industrial fans. In addition, it may be used to determine the acoustic performance of fans combined with an ancillary device such as a roof cowl or damper or, where the fan is fitted with a silencer, the sound power resulting from the fan and silencer combination.

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 266, *Acoustics — Preferred frequencies*

ISO 1000, *SI units and recommendations for the use of their multiples and of certain other units*

ISO 3741, *Acoustics — Determination of sound power levels of noise sources using sound pressure — Precision methods for reverberation rooms*

ISO 3743-1, *Acoustics — Determination of sound power levels of noise sources — Engineering methods for small, movable sources in reverberant fields — Part 1: Comparison method for hard-walled test rooms*

ISO 3743-2, *Acoustics — Determination of sound power levels of noise sources using sound pressure — Engineering methods for small, movable sources in reverberant fields — Part 2: Methods for special reverberation test rooms*

ISO 3744:1994, *Acoustics — Determination of sound power levels of noise sources using sound pressure — Engineering method in an essentially free field over a reflecting plane*

ISO 3745, *Acoustics — Determination of sound power levels of noise sources using sound pressure — Precision methods for anechoic and semi-anechoic rooms*

ISO 5136:2003, *Acoustics — Determination of sound power radiated into a duct by fans and other air-moving devices — In-duct method*

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

ISO 6926:1999, *Acoustics — Requirements for the performance and calibration of reference sound sources for the determination of sound power levels*

ISO 9614-1, *Acoustics — Determination of sound power levels of noise sources using sound intensity — Part 1: Measurement at discrete points*

ISO 10302, *Acoustics — Method for the measurement of airborne noise emitted by small air-moving devices*

ISO 13347-2:2004, *Industrial fans — Determination of fan sound power levels under standardized laboratory conditions — Part 2: Reverberant room method*

ISO 13347-3:2004, *Industrial fans — Determination of fan sound power levels under standardized laboratory conditions — Part 3: Enveloping surface methods*

ISO 13347-4:2004, *Industrial fans — Determination of fan sound power levels under standardized laboratory conditions — Part 4: Sound intensity method*

ISO 13349, *Industrial fans — Vocabulary and definitions of categories*

ISO 13350:1999, *Industrial fans — Performance testing of jet fans*

3 Terms, definitions, symbols and units

3.1 Terms and definitions

For the purposes of this document, the non-acoustical terms and units defined in ISO 5801, ISO 13349 and ISO 1000, apply; the following acoustical definitions apply, they are taken from ISO 3470 to 3747 wherever possible and some have been expanded to fit the specific needs of this document.

3.1.1
inlet sound power level
sound power level of a fan determined at the fan inlet in a specified test installation type, A, B, C or D

3.1.2
outlet sound power level
sound power level of a fan determined at the fan outlet in a specified test installation, type A, B, C or D

3.1.3
casing sound power level
sound power level radiated from a fan casing

NOTE 1 If the fan drive is external to the fan casing, the casing sound power shall include the sound power generated by and radiated from the fan drive

NOTE 2 When cataloguing a range of fans, it is not always possible to include the motor noise, as this will vary according to the power and type of motor selected. Motor noise may then be omitted, provided this fact is clearly stated.

3.1.4
frequency range of interest
frequency range including octave bands with centre frequencies between 63 Hz and 8 000 Hz and one-third octave bands with centre frequencies between 50 Hz and I0 000 Hz

NOTE For special purposes, the frequency range may be extended at either end, provided that the test environment and instrument accuracy are satisfactory for use over the extended frequency range. For fans which radiate sound at predominantly high (or low) frequency, the frequency range of interest may be limited in order to optimise the test facility and procedures.

3.1.5
blade passage frequency
BPF
frequency of fan impeller blades passing a single fixed object

NOTE The blade passage frequency is calculated by the following formula

$$\mathrm{BPF} = \frac{x \times n}{60}\ \mathrm{Hz}$$

where

x is the number of blades;

n is the fan speed, expressed in revolutions per minute.

3.1.6
chamber
enclosure used to regulate flow and absorb sound; it may also conform to air test chamber conditions outlined in ISO 5801

3.1.7
ducted fan
fan having a duct connected to either its inlet or outlet, or both

3.1.8
fan inlet area
A_1
surface plane bounded by the upstream extremity of the air-moving device

NOTE The inlet area is, by convention, taken as the gross area in the inlet plane inside the casing.

3.1.9
fan outlet area
A_2
surface plane bounded by the downstream extremity of the air-moving device

NOTE The fan outlet area is, by convention, taken as the gross area in the outlet plane inside the casing.

3.1.10
end reflection

phenomenon which occurs whenever sound is transmitted across an abrupt change in area such as at the end of a duct in a room

NOTE When end reflection occurs, some of the sound is reflected back into the duct and does not escape into the room.

3.1.11
non-ducted fan
fan without a duct connected to either its inlet or outlet

3.1.12
reverberant room
enclosure meeting the requirements of Annex A and/or Annex B of ISO 13347-2:2004

3.1.13
reference point of fan equipment
position that is used to define and locate the measurement surface relative to the fan equipment under test, see Figures 1 to 4 of ISO 13347-3:2004

NOTE 1 Generally, the reference point is the centroid of the centres of all inlets and outlets that contribute to the sound power level being determined.

NOTE 2 For total sound power testing of fan equipment with a single inlet and a single outlet, the reference point is the midpoint of the line that joins the centres of the inlet and the outlet.

NOTE 3 For fan inlet (or outlet) sound power testing of equipment with a single inlet (or single outlet), the reference point is the centre of that inlet (or outlet)

3.1.14
standard air
air with a density of 1,2 kg/m^3

NOTE 1 Standard air has a ratio of specific heats of 1,4 and a viscosity of 1,815 E-03 Pa·s.

NOTE 2 Air at 16 °C dry bulb temperature, 50 % relative humidity and 100 kPa barometric pressure has these properties, but this is not part of the definition.

NOTE 3 Air at 20 °C dry bulb temperature, 50 % relative humidity and 101.325 kPa barometric pressure also has these properties but this is not a part of the definition.

3.2 Fan sound power levels

Considering all possible combinations for installation conditions specified in Clause 4, twelve different sound power level (L_W) descriptions are defined in Table 1, for example L_W (A,in).

Table 1 — Sound power levels

Number	Suffix	Description
1	(A,in)	free-inlet sound power level, type A installation.
2	(A,out)	free-outlet sound power level; type A installation.
3	(A,tot)	total sound power level of a fan type A installation (includes the contributions from the inlet, outlet, fan casing and drive).
4	(B,in)	free-inlet sound power level; type B installation.
5	(B,in+cas)	free-inlet sound power level plus casing-radiated noise; type B installation.
6	(B,out)	ducted outlet sound power level; type B installation.
7	(C,in)	ducted inlet sound power level; type C installation.
8	(C,out)	free-outlet sound power level; type C installation
9	(C,out+cas)	free-outlet sound power level plus casing-radiated noise; type C installation
10	(D,in)	ducted inlet sound power level; type D installation.
11	(D,out)	ducted outlet sound power level; type D installation.
12	(D,cas)	casing-radiated sound power level; type D installation.

NOTE 1 All of these symbols may be used to indicate levels in one-third octave or octave frequency bands as well as overall sound power levels and A-weighted sound power levels, provided that the sound power to which the symbols relate is clearly defined.

Where noise from the drive may contribute to the noise radiated from a casing then this should be clearly stated by the addition of +dr e.g., L_W (D,cas + dr).

NOTE 2 Not all of the above levels need to be measured for a particular fan.

3.3 Other symbols

For consistency and mutual understanding, it is recommended that the symbols and units shown in Table 2 be used in reporting and calculation. Unless otherwise noted, the subscript number refers to the mid-frequency of the octave band or one-third octave band number.

Table 2 — Symbols, units

Symbol	Term	SI unit
A_1	fan inlet area	m^2
A_2	fan outlet area	m^2
c	speed of sound	m/s
D_r	distance between reference box and rectangular measurement surface	m
D_o	characteristic acoustic source dimension	m
D_N	nominal diameter of bellmouth/opening in reflecting plane	m
D_{min}	minimum distance between equipment under test and reverberant room measurement surface	m
d	duct diameter	m
d_e	equivalent diameter (of rectangular duct)	m
E_o	duct outlet end correction	dB
E_i	duct inlet end correction	dB
E_W	adjustment to sound power level for duct end correction(s)	dB
f	frequency	Hz
h	height of centre of orifice above floor level, or above another reflection plane	m
I	sound intensity	W/m^2
$\overline{I}$	surface average sound intensity	W/m^2
I_n	sound intensity I at measurement location n	W/m^2
I_{ref}	reference intensity, 1 pW/m^2 (1×10^{-12} W/m^2)	—
l_c	measurement surface characteristic dimension (length)	m
K_1	background-noise correction	dB
K_2	environmental noise correction	dB
l	dimensions of the reference box	m
L_i	sound intensity level (re. 1 pW/m^2)	dB
$\overline{L_i}$	surface average sound intensity level	dB
L_{if}	fan sound intensity level	dB
$\overline{L_{if}}$	surface average fan sound intensity level	dB
L_{iq}	RSS sound intensity level	dB
$\overline{L_{iq}}$	surface average RSS sound intensity level	dB
L_p	sound pressure level, re 20 µPa (2×10^{-5} Pa)	dB
L_{pc}	corrected sound pressure level of the fan	dB
L_{pb}	recorded sound pressure level of room background as measured over the normal microphone path	dB
$\overline{L_{pb}}$	background sound pressure level	dB
L_{pbn}	L_{pb} at measurement location n	dB
L_{Wrq}	RSS calibration sound power level	dB
L_{pm}	recorded sound pressure level of fan and room background as measured over the normal microphone path	dB
L_{pq}	corrected sound pressure level of the RSS	dB
L_{pqm}	recorded sound pressure level of the RSS and room background as measured over the normal microphone path	dB

Table 2 (*continued*)

Symbol	Term	SI unit
L_W	sound power level, re 1 pW (1×10^{-12} W)	dB
L_{Wr}	sound power level of RSS	dB
λ	wavelength	m
M	Mach number	Dimensionless
p	sound pressure	Pa
p_{ref}	reference sound pressure, 20 µPa (2×10^{-5} Pa)	—
p_s	fan static pressure	Pa
p_t	fan (total) pressure	Pa
r	radius of spherical (hemispherical) measurement surface	m
r_d	duct area/Orifice area	Dimensionless
s	standard deviation	dB
θ	air temperature	K
S	measurement surface area	m^2
S_H	cross-sectional area of a section through the fan in the measurement surface plane	m^2
S_s	portion of measurement surface in contact with discharge flow for fans with outlet orifice	m^2
W	sound power	W
W_{ref}	reference sound power, 1 pW (1×10^{-12} W)	dB
z	measurement surface characteristic dimension (height above reflecting plane)	m
δ_{Wn}	convergence index (with n measurement locations)	dB

4 Limitations on use

For low-power fans (up to 3 kW) that could be run from a domestic power supply (single phase AC at a voltage not exceeding 250 V and a current not exceeding 16 A), reference should be made to IEC 60704-2-7 which covers household and similar fans.

For in-duct tests, the test duct diameter range as specified in ISO 5136 is from 0,15 m to 2 m (for more details see 6.5).

For reverberant room tests, the size of fan is limited to less than 2 % of the room volume.

There are no restrictions on the size of fan which may be tested by enveloping surface and sound intensity methods, provided the test environment meets the specified acoustic requirements. A test procedure is specified in Clause 9 of ISO 13350:1999 for testing jet fans.

The test procedures specified in this part of ISO 13347 are intended principally for tests conducted using standardized test configurations and under specified environments and conditions and may not be appropriate to site test conditions.

The fan installation conditions conform to the four categories of installation types specified in ISO 5801:

— type A: free inlet, free outlet;

— type B: free inlet, ducted outlet;

— type C: ducted inlet, free outlet;

— type D: ducted inlet, ducted outlet.

5 Measurement uncertainty

Measurements made in conformance with this part of ISO 13347 tend to result in standard deviations which are equal to or less than those given in Table 3. These standard deviations take into account the cumulative effects of all causes of measurement uncertainty, such as source location, duct end reflections, duct transitions, instrument calibration, derivation of sound power from sound pressure and sampling. They do not reflect variations in the sound power radiated by the fan itself due, for example, to changes in installation conditions or manufacturing tolerances. For further information refer to Annex C.

Reverberant field tests have, for many years, been carried out without the addition of anechoic terminations on the non-measured side of the fan. This part of ISO 13347 allows for tests to be performed both with and without such terminations, but it must be recognised that the results will be different. It shall be clearly stated. in all documentation, test reports, catalogues, etc., whether or not anechoic terminations were fitted.

Table 3 — Uncertainty in determination of the frequency-band sound power levels

One-third octave band frequencies	**Standard deviation,** dB				
	In-duct	**Reverberant field** (see also ISO 3743-2)		**Enveloping surface methods**	**Sound intensity field**
Hz	(see also ISO 5136)	**with anechoic terminations**	**without anechoic terminations**	(see also ISO 3744)	(see also ISO 9614-1)
50	3,5			5,0	3,0
63	3,0	*5,0	6,0	5,0	3,0
80	2,5			5,0	3,0
100	2,5			3,0	3,0
125	2,0	5,0	3,0	3,0	3,0
160	2,0			3,0	3,0
200	2,0			2,0	2,0
250	2,0	3,0	3,0	2,0	2,0
315	2,0			2,0	2,0
400	2,0			1,5	2,0
500	2,0	2,0	3,0	1,5	2,0
630	2,0			1,5	2,0
800	2,0			1,5	1,5
1000	2,0	2,0	3,0	1,5	1,5
1250	2,0			1,5	1,5
1600	2,0			1,5	1,5
2000	2,0	2,0	3,0	1,5	1,5
2500	2,0			1,5	1,5
3150	2,0			1,5	1,5
4000	2,0	2,0	3,0	1,5	1,5
5000	2,5			1,5	1,5
6300	3,0			2,5	2,5
8000	3,5	3,0	3,0	2,5	2,5
10000	4,0			2,5	*3,0