BS ISO 27327-2:2014

BSI Standards Publication

Fans — Air curtain units

Part 2: Laboratory methods of testing for sound power

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National foreword

This British Standard is the UK implementation of ISO 27327-2:2014.

The UK participation in its preparation was entrusted to Technical Committee MCE/17, Fans.

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

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Part 2:
Laboratory methods of testing for sound power

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Partie 2: Méthodes d'essai en laboratoire des niveaux de puissance acoustique

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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 documents 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).

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. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

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For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: Foreword - Supplementary information

The committee responsible for this document is ISO/TC 117, *Fans*.

ISO 27327 consists of the following parts, under the general title *Fans — Air curtain units:*

— *Part 1: Laboratory methods of testing for aerodynamic performance rating*

— *Part 2: Laboratory methods of testing for sound power*

The following parts are under preparation:

— *Part 3: Test method to determine energy effectiveness* [Technical Report]

This corrected version of ISO 27327-2:2014 incorporates the following correction:

— the sentence "This first edition of ISO 27327-2:2014 cancels and replaces ISO 13347-1:2004 and ISO 13347-2:2004" has been removed from the Foreword.

Introduction

The need for this part of ISO 27327 has been evident for some time. While a number of national standards exist for the measurement of fan noise, none addressed the particular considerations required for the noise testing of air curtain units.

Forming part of the ISO/TC 117 series of fan standards, this part of ISO 27327 deals with the determination of the air curtain unit sound power level appropriate to a particular application. In describing the test and rating procedures, numerous references are made to ISO 5801 and ISO 13347, as well as to other ISO standards.

The test procedures described in this part of ISO 27327 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 air curtain unit is not free from swirl nor fully developed.

This part of ISO 27327 describes methods for determining sound power levels of air curtain units in one-third-octave bandwidths and one-octave bandwidths.

Data obtained in accordance with this part of ISO 27327 can be used for the following purposes, amongst others:

a) comparison of air curtain units which are similar in size and type;

b) comparison of air curtain units which are different in size, type, design, speed, etc.;

c) determining whether an air curtain unit is suitable for a specified upper limit of sound emission;

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

e) prediction of sound pressure level in application of the air curtain unit;

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

Fans — Air curtain units —

Part 2:
Laboratory methods of testing for sound power

1 Scope

This part of ISO 27327 deals with the determination of the acoustic performance of air curtain units. In addition, it can be used to determine the acoustic performance of air curtain units combined with an ancillary device.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 266:1997, *Acoustics — Preferred frequencies*

ISO 3740:2000, *Acoustics — Determination of sound power levels of noise sources — Guidelines for the use of basic standards*

ISO 3741:2010, *Acoustics — Determination of sound power levels and sound energy levels of noise sources using sound pressure — Precision methods for reverberation test rooms*

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

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 3747, *Acoustics — Determination of sound power levels and sound energy levels of noise sources using sound pressure — Engineering/survey methods for use in situ in a reverberant environment*

ISO 5801:2007, *Industrial fans — Performance testing using standardized airways*

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

ISO 13347-1:2004, *Industrial fans — Determination of fan sound power levels under standardized laboratory conditions — Part 1: General overview*

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

ISO 13349:2010, *Fans — Vocabulary and definitions of categories*

ISO 27327-1:2009, *Fans — Air curtain units — Part 1: Laboratory methods of testing for aerodynamic performance rating*

3 Terms, definitions, symbols and units

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 3740, ISO 3747, ISO 5801, ISO 13347-1, ISO 13347-2, ISO 13349, ISO 27327-1 and the following apply.

3.1.1
inlet sound power level
sound power level of an air curtain unit determined at the air curtain unit inlet in test installation type A

3.1.2
outlet sound power level
sound power level of an air curtain unit determined at the air curtain outlet in test installation type A

3.1.3
total sound power level
sound power level of an air curtain unit in test installation type E

3.1.4
casing sound power level
sound power level radiated from an air curtain unit casing

Note 1 to entry: If the air curtain unit drive is external to the air curtain unit casing, the casing sound power shall include the sound power generated by and radiated from the air curtain unit drive.

3.1.5
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 10 000 Hz

Note 1 to entry: For special purposes, the frequency range can be extended at either end, provided that the test environment and instrument accuracy are satisfactory for use over the extended frequency range. For air curtain units which radiate sound at predominantly high (or low) frequency, the frequency range of interest can be limited in order to optimize the test facility and procedures.

3.1.6
blade passage frequency (BPF)
frequency of air curtain unit impeller blades passing a single fixed object

Note 1 to entry: The blade passage frequency is calculated by the following formula:

$$\mathrm{BPF} = \frac{xn}{60}\ \mathrm{Hz}$$

where

x is the number of blades;

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

3.1.7
chamber
enclosure used to regulate flow and absorb sound; it can also conform to air test chamber conditions outlined in ISO 5801

3.1.8
air curtain unit inlet area
A_1
summation of open areas (slots, holes, louvres, openings, etc.) through which air will flow into the air curtain unit; normally a grille and/or air inlet opening

3.1.9
air curtain unit outlet area
A_2
summation of open areas through which air will discharge out of the air curtain; normally a grille and/or air outlet opening

3.1.10
reverberant room
enclosure meeting the requirements of Annex A and/or Annex B of ISO 13347-2:2004

3.1.11
standard air
air with a density of 1,2 kg/m^3

Note 1 to entry: Standard air has a ratio of specific heats of 1,4 and a viscosity of 1,815 × 10^{-3} kg/m·s.

Note 2 to entry: 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 to entry: Air at 20 °C dry bulb temperature, 50 % relative humidity, and 101,325 kPa barometric pressure has these properties, but this is not part of the definition.

3.2 Air curtain unit sound power levels

Considering all possible combinations for installation conditions specified in Clause 4, five different sound power level (L_W) descriptions are defined in Table 1, e.g. 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	(E,tot)	total sound power level; type E installation (includes the contributions from the inlet, outlet, casing, and drive)
4	(A,in+cas)	free-inlet sound power level plus casing-radiated noise; type A installation
5	(A,out+cas)	free-outlet sound power level plus casing-radiated noise; type A installation

NOTE 1 All of these symbols can 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 can contribute to the noise radiated from a casing, then this should be clearly stated by the addition of "+dr", e.g. L_W (A,in+cas+dr).

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

NOTE 3 Where some portion of inlet noise is included in the measurement of outlet noise, this shall be clearly stated by the addition of "+in" or other similar notation, e.g. L_W (A,out+in).

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	air curtain unit inlet area	m^2
A_2	air curtain unit outlet area	m^2
c	speed of sound	m/s
D_{min}	minimum distance between equipment under test and reverberant room measurement surface	m
f	frequency	Hz
L_p	sound pressure level, re 20 µPa (2×10^{-5} Pa)	dB
L_{pc}	corrected sound pressure level of the air curtain unit	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_{pm}	recorded sound pressure level of air curtain unit 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
L_{ps}	recorded sound pressure level of pure tone noise source	dB
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)	-
s	standard deviation	dB
θ	air temperature	K
W	sound power	W
W_{ref}	reference sound power, re 1 pW (1×10^{-12} W)	dB

4 Limitations on use

4.1 General

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

The test procedures specified in this part of ISO 27327 are intended principally for tests conducted using standardized test configurations and under specified environments and conditions and cannot be appropriate to site test conditions.

The air curtain unit installation conditions conform to the following two categories of installation types:

— type A: free inlet, free outlet;

Used when measuring inlet noise only or outlet noise only, i.e. (i) ducted ACUs or (ii) recessed ACUs where the air inlet and air discharge of the ACU communicate with separate spaces (air inlet – ceiling void; air discharge – space to be served)

— type E: free inlet, free outlet.

Used when measuring total noise; i.e. (i) surface-mounted ACUs or (ii) recessed ACUs where the air inlet and air discharge of the ACU communicate with the same space

4.2 Noise source

The noise source is an air curtain unit. The noise measured can contain contributions from the fan drive and transmission.

4.3 Character of noise

Steady broadband with discrete frequency tones.

4.4 Uncertainty

Engineering grade, as defined in ISO 3740.

4.5 Quantities to be measured

Sound pressure levels in one-third octave frequency bands at discrete microphone positions or on a prescribed path.

Air curtain unit aerodynamic performance indicators, where applicable, e.g. rotational speed, static pressure, and flow rate.

5 Measurement uncertainty

Measurements made in conformance with this part of ISO 27327 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, instrument calibration, and sampling. They do not reflect variations in the sound power radiated by the air curtain unit itself due to, for example, changes in installation type or manufacturing tolerances. For further information, refer to Annex B.

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

One-third octave band frequencies Hz	Standard deviation dB
50 63 80	6,0*
100 125 160	3,0
200 250 315	3,0
400 500 630	3,0
800 1000 1250	3,0
1600 2000 2500	3,0
3150 4000 5000	3,0
6300 8000 10000	3,0

The uncertainties in Table 3 do not allow for the variations in sound power levels due to manufacturing tolerances. These are consequent differences between one air curtain unit and another of the same nominal design, rotational speed, etc. In any specifications which are part of a contract, it is necessary to apply tolerances to sound values. These can be calculated for a normal distribution of data by multiplying the quoted standard deviations by 2 to obtain 95 % confidence limits. A further deviation should also be added to account for manufacturing tolerances, as described in ISO 13348.

NOTE 1 When octave-band data are calculated, the uncertainty of each octave band level will not be greater than the largest uncertainty of the three constituent one-third octave bands.

NOTE 2 Only octave bands are shown for the reverberant room method in accordance with ISO 3743 (both parts).

NOTE 3 Figures marked with * in Table 3 have only been added to ISO 3740:2000. For general purposes, therefore, many existing rigs are designed to operate at a cut-off frequency of 100 Hz, thus giving the octave bands of interest as those between 125 Hz and 8 000 Hz.

Some air curtain units have significant quantities of noise in the 63 Hz octave band, and, for special purposes, it is permissible to extend the measurements to this band, provided the test environment and instrument accuracy are satisfactory over this extended range.

The uncertainty given for these low frequencies can only be achieved by exercising extreme care, and wherever possible, results should be restricted to octave bands of 125 Hz and above.

NOTE 4 Where the reverberant room is in full conformity with ISO 3743-1 (hard-walled test room), then the uncertainty can be reduced.

NOTE 5 Sound power levels obtained by using the methods described herein are for a fully developed flow into the air curtain unit without pre-swirl and straight-line flow out of the air curtain unit without swirl. Any disturbance in the airflow will increase the levels in a real installation.

NOTE 6 The figures given in column 2 are taken from ISO 13347-2.

The standard deviations in Table 3 are equivalent to those obtained from the engineering methods described in ISO 3743 (both parts) and ISO 3744, as appropriate. They are those which would result from a set of measurements which were undertaken on a single air curtain unit in a large number of different laboratories and include the cumulative effects of all causes of measurement uncertainty.

The repeatability of measurements in any one laboratory can be considerably better than the values in Table 3 would indicate.

6 Instrumentation

6.1 General

Depending on the test method, the instrumentation shall be as specified in this part of ISO 27327, together with ISO 3741, ISO 3743 (both parts), ISO 3744, ISO 13347-1, and ISO 13347-2. ISO 13347-1 also details the requirements for the reference sound source which shall be used to qualify the test room and shall be the basis of the substitution method.

Instrumentation shall be so designed as to determine the mean-square value of the sound pressure in octave and/or one-third octave bands averaged over time and space.

6.1.1 Microphone

A microphone of a standardized sound level meter shall be used.

6.1.2 Microphone cable

The microphone/cable system shall be such that the sensitivity does not change with temperature in the range encountered in the test. Cable flexing due to either microphone traversing or airflow across the cable should not introduce cable noise which interferes with the measurements.

6.1.3 Sound level meter or other microphone amplifier

The sound level meter or other amplifier used to amplify the microphone signal shall comply with the electrical requirements for sound level meters. The flat response shall be used.

6.2 Frequency analyser

The frequency analyser shall have the capacity of frequency analysing into one-third octave bandwidths in accordance with ISO 266.

6.3 Turbulence screens and windshields

6.3.1 Windshields

A microphone exposed to excessive air velocity will give a falsely high reading. This can be rectified by fitting the microphone with a nose cone or a foam ball.

If the air velocity over the microphone is greater than 1 m/s, a nose cone or foam ball shall be used. If a foam ball is used, the air velocity over the foam ball shall not exceed 15 m/s.

6.3.2 Wind-generated false noise

The flow of an airstream over a microphone fitted with a nose cone or foam ball will still generate an apparent change in sound pressure level at the microphone, even though it is reduced when compared to an unshielded microphone. This change is not attributable to the air curtain unit but is a function of microphone design.

6.4 Reference sound source (RSS)

A calibrated RSS shall conform to the requirements of Annex C.

7 Test procedure

7.1 Comparison method

The test method is based on a reference sound source (RSS) substitution for the determination of sound power. The reference documents for this method are ISO 3743-1 and ISO 3743-2.

Application of the test method requires that the air curtain unit to be tested be set in position in a test room, which is qualified according to the requirements of Annex E.

Once the test room has been qualified, sound pressure levels are recorded with the RSS operating. The air curtain unit is then operated without the RSS in operation at the given test speed and the air curtain unit sound pressure levels are recorded. Since the sound power levels of the RSS are known, the substitution method is used to determine the sound power levels of the air curtain unit for each operating point.

7.2 Direct method

The test method is based on measuring the reverberation times of the reverberation test room and using this and the measured test room volume to calculate sound power levels from the sound pressure levels produced by the air curtain unit under test.

The resulting sound pressure levels are sampled, filtered into one-third octave band widths, integrated, and averaged by means of a real time analyser using a spaced array of microphones. The value obtained at any particular frequency is then corrected into sound power levels using a mathematical expression. Octave band sound power levels are obtained by the logarithmic summation of the three equivalent one-third octave bands.

The reference document for this method is ISO 3741.

8 Acoustic environment

8.1 Test environment

The test environment shall be a reverberant environment.

8.2 Reverberant room

An enclosure meeting the requirements of Annex E is mandatory for the purposes of this part of ISO 27327. An enclosure meeting the requirements of Annex F is recommended for broadband sound testing and is mandatory for the purpose of investigating pure tones and narrow bands.

9 Air curtain unit installation conditions

The measurement procedures specified in this part of ISO 27327 cover the following air curtain unit installations (see Clause 4):

— free inlet/free outlet (type A);

— free inlet/free outlet (type E).

10 Air curtain unit operating conditions

10.1 General

The noise generated by an air curtain unit is related to its operating conditions, i.e. its rotational speed, air curtain unit static pressure, and airflow rate. It is important that the aerodynamic duty is known when acoustic measurements are being made. Care is required to ensure that methods of determining or controlling the aerodynamic performance do not affect the noise generated by the fan or interfere with the acoustical measurements.

10.2 Measurement of ambient conditions

The ambient air conditions of temperature, pressure, and humidity shall be within the limits specified in the appropriate standards ISO 3743 (both parts), ISO 3744, and ISO 3745.

10.3 Air curtain unit rotational speed

The air curtain unit rotational speed shall be measured and held steady (within 1 % change) during the sound test. The fan rotational speed during the test shall be within 5 % of the specified rotational speed to minimize the change in fan sound power when applying the conversion rules.

When it is not possible to test an air curtain unit within these limits, an indirect test at a different speed is permitted, provided that the test is reported at the test speed and then scaled to the specified or nominal speed (see Annex A).

10.4 Determination of air curtain unit aerodynamic operating point

The identification of the operating point shall preferably be by measurement of air curtain unit static pressure using one of the methods specified in ISO 27327-1. The flow rate at the operating point can be inferred, indirectly, by a determination of air curtain unit static pressure.

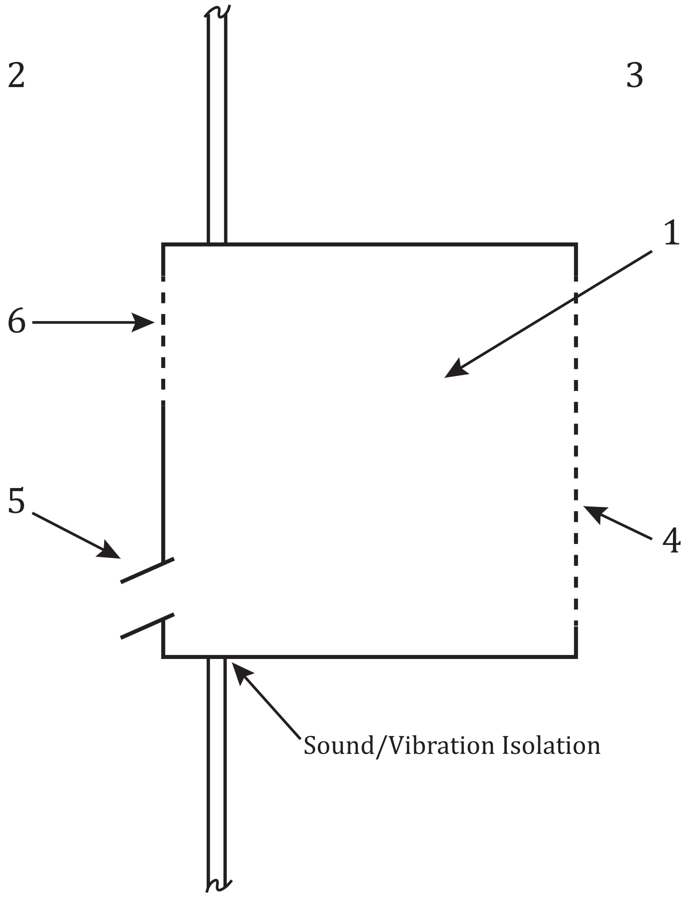
10.5 Control of air curtain unit operating condition

A throttling device shall be used to control the operating point. The sound level in the test environment generated by the throttling device shall be at least 10 dB below the measured sound level from the air curtain unit under test. The throttle arrangement shall be arranged integrally with the test chamber.

11 Test setup

11.1 Setup categories

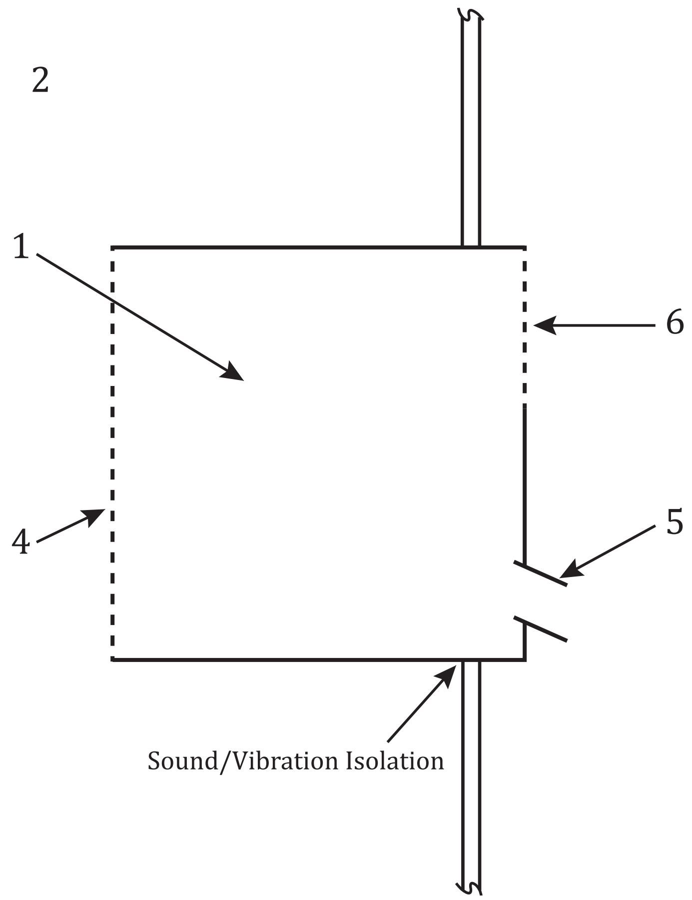
A number of specific air curtain unit test setups are allowed and are shown in Figures 1, 2, 3, 4, and 5. They are determined by the airflow direction and the particular mounting arrangement of the test device. The air curtain unit sound pressure levels are measured in a reverberant room, which can be connected to a chamber or any other system to provide control and measurement of the air curtain unit air volume flow rate.



Key

1 air curtain unit
2 reverberant room
3 testing chamber
4 air curtain unit inlet
5 air curtain unit outlet
6 optional secondary air curtain unit inlet

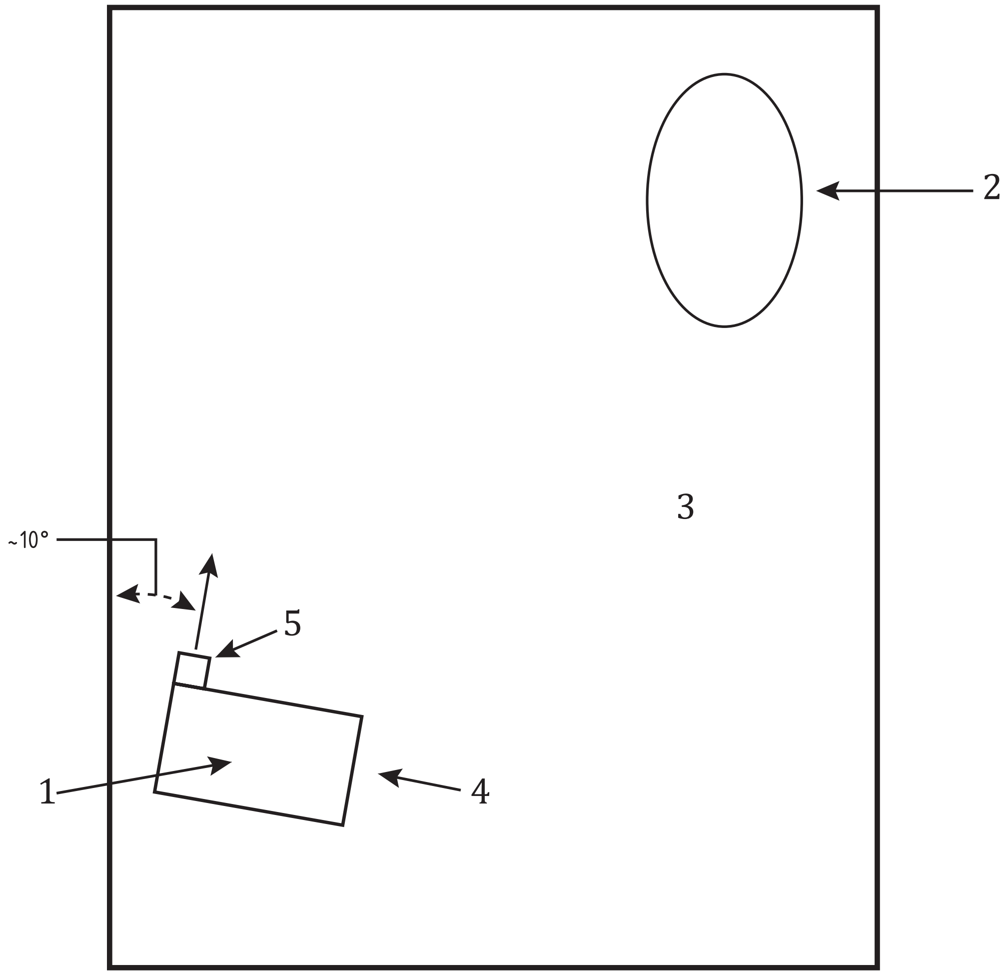
Figure 1 — Installation Type A Outlet test setup for air curtain unit outlet sound measurement



Key

1 air curtain unit
2 reverberant room
3 testing chamber
4 air curtain unit inlet
5 air curtain unit outlet
6 optional secondary air curtain unit inlet

Figure 2 — Installation Type A Inlet test setup for air curtain unit inlet sound measurement

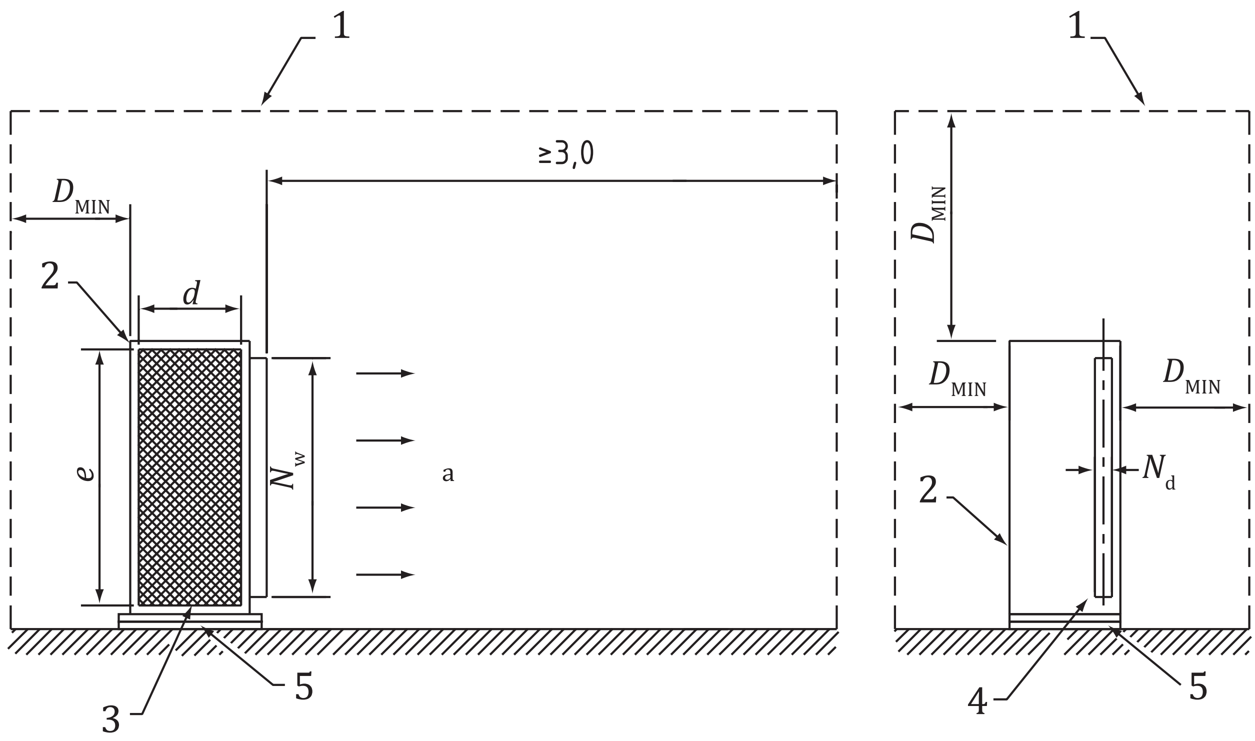


Key

1 air curtain unit
2 microphone path
3 reverberant room
4 air curtain unit inlet
5 air curtain unit outlet (generally pointed toward the centre of the room)

Figure 3 — Installation Type E test setup for air curtain unit total sound measurement

Dimensions in metres



a) Side elevation **b) Front elevation**

Key

1 reverberant room walls
2 ACU
3 ACU inlet
4 ACU discharge nozzle
5 sound/vibration isolating pads
[a] Airflow.

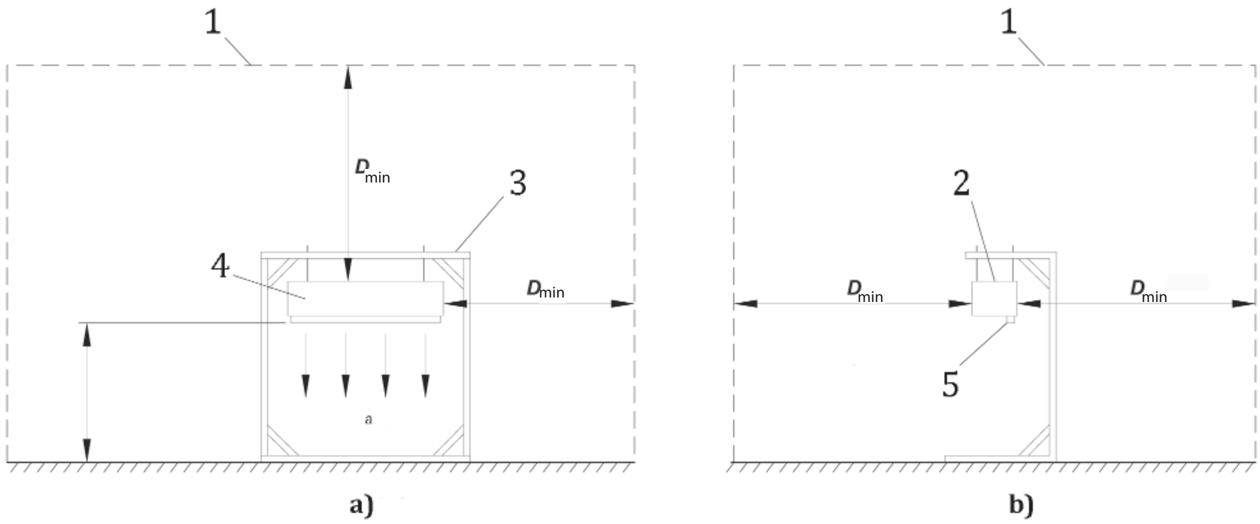
Figure 4 — Installation Type E test setup for vertical air curtain unit total sound measurement

$$D_{\min} = 4\sqrt{\frac{ed}{\pi}} \quad (1)$$

For air curtain units without a rectangular inlet, substitute the actual value of the inlet area for *ed* in Formula (1).

For air curtain units with multiple inlets, substitute the sum of all inlet areas for *ed* in Formula (1).

The reverberant room and placement of the air curtain unit shall meet all requirements of ISO 13347-2.



a) Side elevation **b) Front elevation**

Key

1 reverberant room walls
2 ACU inlet (inlet area = $e \times d$)
3 support frame
4 ACU
5 ACU air discharge nozzle
a Airflow.

Figure 5 — Installation Type E test setup for horizontal air curtain unit total sound measurement

11.2 Sound pressure levels

11.2.1 Sound pressure levels, background (L_{pb})

This includes sound pressure levels measured in the test room with the air curtain unit off. The background noise includes all noise sources not directly associated with air curtain unit sound. Examples of background sources are noise due to the motion of the microphone and any noise due to external sources. Efforts should be made to keep the background noise level at a minimum.

11.2.2 Sound pressure levels, RSS (L_{pqm})

These are the sound pressure levels in the test room with only the RSS operating. The levels include the background noise.

11.2.3 Sound pressure levels, air curtain unit (L_{pm})

For a set of tests at various air curtain unit points of operation, L_{pb} and L_{pqm} above need to be observed once, while L_{pm} shall be determined for each operating point.

NOTE 1 The observations above are valid only when taken in a room that has passed the room qualification procedures outlined in Annex E or Annex F.

NOTE 2 For further information on symbols, refer to ISO 13347-1.

11.3 Aerodynamic performance

The control and measurement of the air curtain unit operating point on the fan characteristic shall be performed using one of the methods specified in ISO 27327-1.

11.4 Test conditions

The test conditions shall be as nearly as possible the same for all sound pressure level readings. Operation of the microphone traverse and any rotating boom shall be the same for all readings. Observers and operators should not be in the test room during measurements, but if absolutely necessary, they shall be away from the sound source and remain in the same position for all tests. Readings shall be a time-weighted average over an integral number of microphone swings. The time span used shall be sufficient to provide a constant value and shall be a minimum of 30 s for frequency bands of 160 Hz and below and a minimum of 15 s for frequency bands of 200 Hz and above.

11.5 Mounting methods

The method of mounting air curtain units of connecting them to non-integral drivers and of connecting them to airflow test facilities is not specified. Any conventional method can be used, including vibration isolation devices and short flexible connectors. Other than these, sound and vibration absorptive material cannot be incorporated in the test air curtain unit unless it is a standard part of the unit.

Driving motor and drive, when not an integral part of the air curtain unit, can be damped or enclosed in any manner that does not expose sound absorption material to the test room. When the driving motor and drive are an integral part of the test unit, they cannot be treated in any manner, and normal belt tensions and bearings shall be used.

If the air curtain unit is intended to be mounted horizontally in use, the test unit shall be tested in this orientation. It shall be installed using the fixing points and method of suspension/anchorage as recommended by the manufacturer so it is installed as close to how it would be when fitted on site. This can involve fixing/hanging the test sample at a height to/from a suitable framework structure within the reverberant test room.

If the air curtain is intended to be mounted vertically in use “on one end,” the test unit shall be mounted “on end” such that the discharge nozzle width is perpendicular to the floor and the discharge airflow is parallel to the reverberant room wall within approximately 10° and pointed roughly in the direction of the microphone.

The air curtain unit and microphone shall be placed in opposite corners of the reverberant room to allow space for the jet flow from the nozzle to slow and circulate back to the air curtain unit inlet prior to impinging on the microphone.

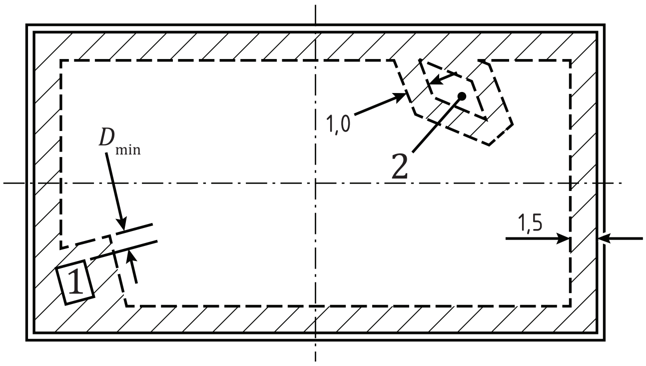
The air curtain unit shall be placed on vibration isolation.

11.6 Microphone travel or positions

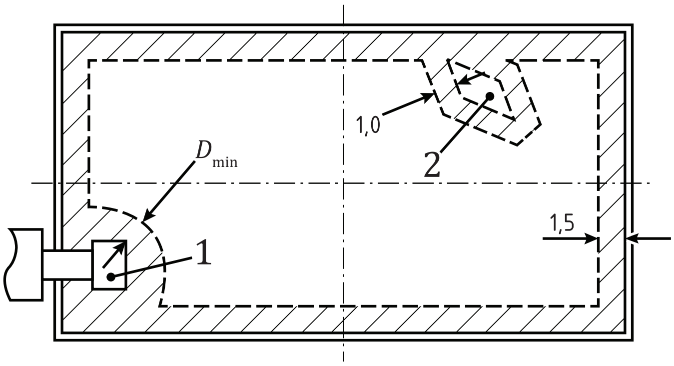
The microphone shall swing or move on the path of an arc or straight line with a minimum distance of 3 m between the extreme points of travel. As an alternative, it can be placed at a number of fixed points along this arc. The microphone traverse plane shall not be parallel, within 10°, to any room surface and the path shall tend to travel into and out of a corner formed by two walls of the room. A microphone at different fixed positions, or an array of fixed microphones, can also be used in accordance with ISO 3741 and ISO 3743 (both parts).

When a microphone at several different positions or an array of fixed microphones is used, the period of observation of the microphone output shall conform to the specifications of ISO 3743 (both parts). A graphic description of microphone placement limitations is shown in Figure 6.

Dimensions in metres



a) — Total sound testing (Type E)



b) — Inlet or outlet sound testing (Type A)

Key

1 air curtain unit

2 optional vane; sometimes used to modify the room acoustic properties

Figure 6 — General limitations to test room arrangement

$$D_{min} = 0{,}610 \times 10^{\left(\frac{L_{Wr} - L_{pq}}{20}\right)} \tag{2}$$

where

$\left(L_{Wr} - L_{pq}\right)$ is the maximum value for octave bands 125 Hz to 4 000 Hz.

12 Information to be recorded

12.1 General

Information given in 12.2 through 12.4 shall be compiled and recorded for all measurements made in accordance with this part of ISO 27327, when applicable.

12.2 Air curtain unit under test

12.2.1 Description of the air curtain unit under test

a) manufacturer;

b) model;

c) air curtain unit size or outside dimensions, height, length, width;

d) impeller diameter;

e) number of blades;

f) inlet area and dimensions, *e* and *d*;

g) outlet area and dimensions, N_w and N_d;

h) fan manufacturer and model number, if known.

12.2.2 Operating conditions

a) air curtain unit speed;

b) air curtain unit airflow rate;

c) air curtain unit static pressure at actual test conditions (Installation Type A only);

d) air density.

12.2.3 Mounting conditions

a) test Figure 1, 2, 3, 4 or 5;

b) test installation category, e.g. A or E;

c) sketch showing laboratory setup, including location of any equipment and acoustical measurements.

12.3 Acoustic environment

12.3.1 Description of the test environment and method

a) description of the physical treatment of the walls, ceiling, and floor;

b) sketch showing the location of the source and room contents;

c) indication of direct or comparison method.

12.3.2 Acoustical qualification of the test environment

12.3.3 Test data

a) barometric pressure;

b) ambient dry-bulb temperature;

c) ambient wet-bulb temperature;

d) dry-bulb temperature at the air curtain unit inlet;

e) static pressure at the air curtain unit inlet.

12.3.4 Laboratory and instrumentation

a) laboratory name;

b) laboratory location;

c) technician's name;

d) list of equipment used for the measurements including name, type, serial numbers, manufacturer, and dates of calibration;

e) bandwidth of frequency analyser;

f) scope of room qualification (data shall indicate if the test room is qualified for full or one-third octaves, and in the case of pure tone testing, the one-third octaves bands for which the qualification applies);

g) frequency response of the instrumentation system;

h) method used for calibration of the microphones and other system components, including the date and place of calibration;

i) characteristics of windshield (if used);

j) reference sound source type and serial number.

12.3.5 Location of the air curtain unit in the test environment

12.3.6 Additional noise sources

If a test air curtain unit has additional noise sources, a description of the source(s) in operation during the measurements (e.g. type of drive, size of motor, etc.).

12.4 Acoustical data appropriate to the method of test

12.4.1 The corrections (in dB), if any, applied in each one-third octave band for the frequency response of the microphone, frequency response of the filter in the pass band, background noise, etc.

12.4.2 Microphone positions.

12.4.3 The mean sound pressure level, L_p (in dB; reference 20 μPa), in each one-third octave frequency band of interest.

12.4.4 The sound power level, L_W (in dB; reference 1 pW), for all frequency bands used.

12.4.5 The sound power level, L_W (in dB; reference 1 pW), for all frequency bands used, corrected from test speed to specified speed in accordance with Annex A.

12.4.6 Remarks on the subjective impression of the noise (audible discrete tones, impulsive character, spectral content, temporal characteristics, etc.).

12.4.7 Remarks on the contributions of drive and transmission noise to the total noise.

12.4.8 The date and time when the measurements were performed.

12.4.9 The names of the test personnel.

12.4.10 Measurements taken relative to the environment:

a) background sound pressure level;

b) sound pressure level of the reference sound source;

c) background corrections for the reference sound source;

d) air curtain unit sound pressure level;

e) background corrections for the air curtain unit;

f) unweighted air curtain unit sound power level;

g) test data.

13 Calculations and evaluations

13.1 Calculation of one-third octave band levels

The one-third octave band sound power levels shall be combined to determine the octave band sound power levels as follows:

$$L_{W63} = 10\lg\left[10^{\left(\frac{L_{W50}}{10}\right)} + 10^{\left(\frac{L_{W63}}{10}\right)} + 10^{\left(\frac{L_{W80}}{10}\right)}\right] \quad (3)$$

$$L_{W125} = 10\lg\left[10^{\left(\frac{L_{W100}}{10}\right)} + 10^{\left(\frac{L_{W125}}{10}\right)} + 10^{\left(\frac{L_{W160}}{10}\right)}\right] \quad (4)$$

to

$$L_{W8000} = 10\lg\left[10^{\left(\frac{L_{W6300}}{10}\right)} + 10^{\left(\frac{L_{W8000}}{10}\right)} + 10^{\left(\frac{L_{W10000}}{10}\right)}\right] \quad (5)$$

13.2 Calculation of overall sound power levels

The overall sound power levels shall be calculated from the one-third octave band levels according to the following formula:

$$L_W = 10\lg\left[10^{\left(\frac{L_{W50}}{10}\right)} + 10^{\left(\frac{L_{W63}}{10}\right)} + \ldots + 10^{\left(\frac{L_{W8000}}{10}\right)} + 10^{\left(\frac{L_{W10000}}{10}\right)}\right] \quad (6)$$

13.3 Calculation of A-weighted sound power level

The overall A-weighted sound power level, dBA, shall be calculated from the one-third octave band levels. For each one-third octave band, the A-weighted sound power level is calculated from the following formula:

$$L_W\text{A band} = L_W\text{ band} + C \quad (7)$$

where

C is the correction taken from ISO 3744, Table 2, to be added to the one-third octave band sound pressure level to derive the A-weighted sound pressure level in that frequency band.

The overall A-weighted sound power level is then calculated from the following formula:

$$L_W\text{A} = 10\lg\left[10^{\left(\frac{L_W\text{A}_{50}}{10}\right)} + 10^{\left(\frac{L_W\text{A}_{63}}{10}\right)} + \ldots + 10^{\left(\frac{L_W\text{A}_{8000}}{10}\right)} + 10^{\left(\frac{L_W\text{A}_{10000}}{10}\right)}\right] \quad (8)$$

13.4 Background corrections

The observed RSS or air curtain unit sound pressure level readings include both the sound source and the background noise sources. The effect of the background noise level shall be subtracted from the observed sound pressure level. The corrections for background level depend on the difference between the observed sound pressure level and the background noise level. When the difference between the observed level and the background level in one or more frequency bands is less than 6 dB, the corresponding sound source level cannot be accurately determined by this part of ISO 27327, and a reduction of the background noise pressure level or an increase in the sound source level is necessary. In the event that this is not achievable, the background correction shall not be made and the combined background-plus-sound-source levels shall be reported individually.

Sound pressure levels shall be corrected for background noise level by logarithmic subtraction using the following formulas:

Air curtain unit sound pressure level:

$$L_{pc} = 10\lg\left(10^{\frac{L_{pm}}{10}} - 10^{\frac{L_{pb}}{10}}\right) \tag{9}$$

RSS sound pressure level:

$$L_{pq} = 10\lg\left(10^{\frac{L_{pqm}}{10}} - 10^{\frac{L_{pb}}{10}}\right) \tag{10}$$

When the difference between the observed sound pressure levels (RSS – background) in a frequency band is less than 6 dB, the corresponding sound pressure level from the source cannot be determined accurately by this part of ISO 27327. For any band for which the difference between the background and the (background + source) sound pressure level is less than 6 dB, L_{pc} shall be reported as 1,3 dB less than L_{pm}. The data for each such band shall be clearly marked as upper boundary levels.

NOTE When the background noise level is at least 15 dB below the sound pressure level reading, the correction above is unnecessary.

13.5 Sound power level, L_W

The sound power level in each frequency band is calculated from sound pressure levels of the air curtain unit and RSS, using the following expressions (see also 6.1 and the list of symbols in Table 2 of ISO 13347-1:2004):

Air curtain unit inlet sound levels

Installation type	Formula L_W
A: free inlet	$L_W\,(\text{A,in}) = L_{pc} + (L_{W\text{r}} - L_{pq})$

Air curtain unit outlet sound levels

Installation type	Formula L_W
A: free outlet	$L_W\,(\text{A,out}) = L_{pc} + (L_{W\text{r}} - L_{pq})$

Air curtain unit total sound levels

Installation type	Formula L_W
E: inlet, outlet, casing, drive	$L_W\,(\text{E,tot}) = L_{pc} + (L_{W\text{r}} - L_{p\text{q}})$

The test procedure and the above calculations are based on the following assumptions:

a) Directivity from the air curtain unit is averaged by the reverberant room and the microphone location is such that it records total average sound pressure levels.

b) No resonances are present on either the air curtain unit structure, supporting devices, or driving devices that provide any significant pure tones that can add to the recorded fan sound pressure levels.

13.6 Evaluation

Depending on the basic method used, the tests shall be evaluated:

— determination of (A-weighted) sound power level and, if required, in octave bands or in one-third octave bands, or;

— determination of sound power level in octave bands or in one-third octave bands, and on this basis, calculation of the A-weighted sound power level.

14 Test report

The test report shall include the information given in 14.1 through 14.4.

14.1 General

The sound power levels shall be reported, together with a statement that they have been obtained in full conformance with the procedures of this part of ISO 27327.

The report shall state that these sound power levels are given in decibels, reference 1 pW. The reported decibel shall be rounded off to the nearest whole number.

In addition, the report shall contain the following information:

a) manufacturer's air curtain unit designation;

b) manufacturer's size reference and specified rotational speed;

c) type of test installation (type A or E), whether the measurements are total or at the inlet or the outlet of the air curtain unit and whether the noise includes contributions from the drive and transmission, e.g. installation type A, free-inlet sound power level plus casing-radiated noise, L_W (A,in+cas);

d) inlet airflow rate and sound power level at the test condition;

e) inlet airflow rate and sound power level at the specified speed;

f) indication of direct or comparison method.

The test report shall give the designation of the test method and the details listed in 13.1 through 13.6.

14.2 Description of test site, arrangement of fan, location of measuring points

The sound power level determined shall be designated as described in Table 1.

14.3 Instrumentation used

The test report shall detail the instrumentation used.

14.4 Subjective assessment of the noise character

In particular, any discrete tones which are distinctly audible shall be indicated. The test report should detail the formula used.

14.5 Measured values of the noise character

According to the method used, some or all of the following shall be reported, as appropriate:

a) sound pressure level (A-weighted and/or in frequency bands) at each measuring point;

b) background-noise sound pressure level (A-weighted and/or in frequency bands) at each measuring point;

c) A-weighted sound power level, L_WA, and if required, sound power level for each octave band or one-third octave band in the frequency range of interest (uncertainty of measurement for L_WA if necessary).

Annex A
(normative)

Effect of rotational speed changes

The rules for conversion applicable in this Annex are related to changes of speed only with the purpose of correcting the sound power level determined from measurements at the test speed to fixed or specified speeds, not differing by more than 5 % from the test speed.

The rule for change of rotational speed, *n*, is for each one-third octave band test point:

$$L_{W\mathrm{o}} = L_{Wt} = 50\,\lg\left[\frac{n_\mathrm{o}}{n_t}\right] \tag{A.1}$$

o relates to the specified speed,

t relates to the test speed.

This formula should not be used for any purpose other than scaling for this speed change.

This formula should not be used to scale A-weighted overall noise levels.

Annex B
(normative)

Uncertainty analysis

B.1 General

The analysis of uncertainty associated with measurements performed with this part of ISO 27327 provides identification of certain critical points of the proposed method, so as to recognize the limitations of the results. Furthermore, it provides an approximation, in real values, of the imprecision in the recorded results.

B.2 Definitions

Precision error is an error which causes readings to take random values on either side of some mean value.

Systematic error is an error that persists and cannot be considered as due entirely to chance.

Uncertainty is an estimated value for the error, i.e. what we think an error would be if we could and did measure it by calibration. Although uncertainty can be the result of both precision and systematic errors, only precision errors can be treated by statistical methods.

The uncertainty in the researched value is described by specifying the measured value followed by the uncertainty interval at the desired confidence level:

$$W = m \pm w, \text{ at } P \text{ confidence level} \tag{B.1}$$

where

- m is the measured value;
- w is the uncertainty;
- P confidence level, expressed in %.

B.3 Uncertainties

The uncertainties associated with measurements of power levels performed in accordance with the standard are room response (B.4), air curtain unit operating points (B.5), instrument error (B.6), and RSS (B.7). Other areas of interest involve the use of full or one-third octave bands (B.8) and the problems associated with testing and rating in the 63 Hz band.

B.4 Room response

A reverberant room is an appropriate place for measuring the acoustical power of a source emitting a steady sound power, such as an air curtain unit. However, the room shall be diffuse enough to produce a reverberant field.

When a sound source is operated inside a reverberant room, the sound waves are reflected by the walls and are propagated in all directions. If the paths of all the waves could be seen, we would notice a number of repetitions (for example, the path followed by a wave reflected between two parallel walls). These particular paths are called *normal modes*. The greater the number of normal modes, the better the sound dispersion inside the room. The modes shall be sufficiently numerous in any measurement band so that the microphone traverse will serve to average the sound pressure. The number of normal modes in a given space increases with frequency. Hence, it is usually more precise to measure higher frequencies. When the number of modes are few, it helps to measure the sound in many locations and average the results. The two important sources of error that can affect the measurements taken in a reverberant room are

a) the error introduced by measuring the sound field at a limited number of points and

b) variations of sound power with the source location.

Many sources radiate sound which is not entirely broadband but contains significant discrete-frequency components called, in common usage, *pure tones*. Some fans generate a pure tone at the blade frequency and sometimes at harmonic frequencies.

In a reverberant room, these pure tones tend to excite certain modes, which will dominate all others. This will noticeably increase the variability of the pressure field due to an insufficient dispersion of the sound field. Consequently, the precision of the results is reduced due to the inaccuracy of the sound pressure averaging.

B.4.1 Broadband measurement in a reverberant room

Broadband sound is uniformly distributed in frequency, with relatively steady levels and with no prominent discrete-frequency or narrow-band components. Measurements of broadband sound can be taken in a room qualified according to Annex E of this part of ISO 27327.

B.4.2 Pure tone measurement in a reverberant room

When a discrete-frequency component is present in the spectrum of a source, the spatial variations in the sound pressure level usually exhibit maxima separated by minima having an average spacing of approximately 0,8λ, where λ is the wavelength corresponding to the discrete frequency of interest.

The presence of a significant discrete-frequency component in the noise produced by a source can often be detected by a simple listening test. If such a component is audible, or detectable by narrow-band analysis, the qualification procedure described in Annex F of this part of ISO 27327 is recommended.

If the room is not qualified for pure tone measurement, the measurement uncertainty will most probably be higher in the bands containing the blade passage frequency and its harmonics than if measured in a qualified room. Typical uncertainties can have a magnitude of ± 8 dB.

Discrete-frequency components can be present in the spectrum, even when these components are not audible. A conclusion that no discrete-frequency components are present can only be reached by performing the test described in B.4.3.

B.4.3 Test for discrete-frequency components

The following procedure can be used to estimate the (spatial) standard deviation of the sound pressure levels produced by the air curtain unit under test in the room.

Select an array of six fixed microphones (or a single microphone at six positions) spaced at least $\lambda/2$ apart, where λ is the wavelength of the sound corresponding to the lowest band mid-frequency of interest, and meeting all of the requirements for microphone positions in Annex E of this part of ISO 27327. Locate the source at a single position in the test room in accordance with Annex E of this part of ISO 27327.

Obtain the time-averaged sound pressure level, L_{pj}, at each microphone position according to the techniques described in Annex E.

For each one-third octave band within the frequency range of interest, calculate the standard deviation, *s*, from the following formula:

$$s = \sqrt{\frac{1}{n_\mathrm{m}-1}\sum_{j=1}^{n_\mathrm{m}}\left(L_{p\mathrm{cj}}-\overline{L_{p\mathrm{j}}}\right)^2} \quad \text{(B.2)}$$

where

$L_{p\mathrm{cj}}$ is the sound pressure level, corrected for the background noise level in accordance with the procedures for the microphone position, expressed in decibels;

$\overline{L_{p\mathrm{j}}}$ is the arithmetic mean of ($L_{p\mathrm{cj}}$) values, averaged over all microphone positions, expressed in decibels;

n_m is the number of microphone positions (=6).

The magnitude of *s* depends upon the properties of the sound field in the test room. These properties are influenced by the characteristics of the room, as well as the characteristics of the noise source (i.e. directivity and spectrum of the emitted sound). In theory, a standard deviation of 5,57 dB corresponds to a spectral component of zero bandwidth, i.e. a discrete tone.

Table B.1 — Characterization of the presence of discrete-frequency or narrow-band components, based upon the spatial variation of the sound field

Standard deviation, *s* dB	**Characterization**
$s < 1,5$	Assume broadband source. Use procedures of Annex D of ISO 27327-2.
$1,5 < s < 3$	Assume that a narrow-band of noise is present. Recommend use of the qualification procedure in Annex F of ISO 27327-2.
$s > 3$	Assume that a discrete tone is present. Test room shall qualify in accordance with Annex F of ISO 27327-2.

B.5 Air curtain unit operating points

Whenever the sound power level of an air curtain unit is measured, each measurement shall relate to one point of operation of the air curtain unit. Uncertainty in identifying this point thus affects the global uncertainty of the results. It is therefore recommended that the procedures of ISO 27327-1 be used as a guideline in identifying the operating points. The sound level sensitivity to change in the point of operation is a function of the product characteristics, and this will dictate how accurately the point of operation measurement should be made. Air curtain units that have a large sound power level change as flow is changed, at a given speed, are of more concern than air curtain units that show a small sound power level change for the same flow change.

B.6 Instrument error

The frequency response of the instrumentation system shall be flat over the frequency range of interest, to within the tolerances given in Table B.2.

Table B.2 — Tolerances for the instrumentation system

Frequency Hz	**Tolerance** dB
50 to 80	±2,0
100 to 400	±1,0
5 000 to 8 000	±1,5
10 000	±2,0

B.7 Reference sound source (RSS)

The sound power produced by the reference sound source shall be determined in octave and one-third octave bands within the tolerances specified in Table B.3.

Table B.3 — Calibration for sound reference source

One-third octave band mid-frequency Hz	**Tolerance** dB
50 to 80	±2,0
100 to 160	±1,0
200 to 4 000	±0,5
5 000 to 10 000	±1,0

B.8 Octave band VS one-third octave band

According to this part of ISO 27327, the frequency analysis of sound can be performed either in full octave bands or in one-third octave bands. Qualification of a reverberant room for pure tones can only be effected in the one-third octave band. Full octave band analysis takes less time since fewer numerical values are treated; however, this analysis supplies little information on the shape of a sound spectrum. Furthermore, full octave band analysis does not allow isolation of pure tones in a spectrum; the poor resolution of an octave band gives little information about a steeply sloping spectrum.

Annex C
(normative)

Calibration of reference sound source

C.1 General

Calibration of a reference sound source (RSS) in conformance with the requirements of ISO 6926 requires a hemi-anechoic room qualified for measurements over the entire frequency range of interest. Laboratories that otherwise would be able to perform the required calibration, but that are not qualified for measurements in the first octave band, can use the alternative procedure of this Annex. This alternative procedure is based on sound intensity measurements according to ISO 9614-1.

C.2 Equipment and facilities

Equipment and facilities shall be as required for RSS calibration in conformance with ISO 6926, with the exception that the hemi-anechoic chamber need not be qualified below the 125 Hz octave band (100 Hz one-third octave band). Sound intensity measuring equipment shall comply with the requirements of ISO 9614-1.

Additional reference sound sources can be sound power level calibrated by comparing the sound level of the source to another reference sound source that was calibrated in accordance with C.1 to C.5. The measurement procedure shall be in accordance with ISO 3741.

C.3 Qualification

The RSS calibration procedure of ISO 6926 shall be carried out over the 50 to 10 000 Hz one-third octave band frequency range and 63 to 8 000 Hz octave band range. If the calibration is in conformance with ISO 6926 in all respects, except for the qualification of the test facility below the 100 Hz one-third octave band, the alternative calibration procedure below can be used. If the calibration is not in complete conformance with ISO 6926 for any other reason, the alternative calibration procedure is not applicable.

C.4 Procedure

The requirements of ISO 6926 are duplicated in the lowest three octave (nine one-third) octave bands, with the substitution of sound intensity level measurements made in compliance with ISO 9614-1 for the sound pressure level measurements required by ISO 6926. For all measurements, sound intensity shall be measured in the outward radial direction. The sound power levels determined from these measurements shall be compared with those determined from the corresponding sound pressure level measurements. If, in all frequency bands, the determined sound power levels differ by no more than the tolerance of Table C.1, the calibrated sound power levels for the RSS are reported as specified in E.5. The directivity index is not calculated from the intensity measurements.

Table C.1 — Tolerance for sound power level difference

Octave band Hz	**One-third octave band** Hz	**Tolerance** dB
63	50 to 80	±4
125 to 250	100 to 315	±1,0

C.5 RSS sound power levels

The reported RSS sound power level and directivity index shall be those determined by the ISO 6926 procedure for the 100 to 10 000 Hz one-third octave and 125 to 8 000 Hz octave bands. For the 50 to 80 Hz one-third octave bands and 63 Hz octave band, the reported RSS sound power level shall be that determined from the intensity measurements, and the directivity index is not reported. The calibration report shall be marked to indicate the levels determined from the intensity measurements and shall indicate whether the calibration was performed in full compliance with this Annex.

Annex D
(informative)

Filter weighted measurements

In certain sound measurement situations, the presence of high-amplitude sound at low frequency (below 45 Hz) can reduce the effective dynamic range of the analyser in the measurement frequency range of interest for this part of ISO 27327 (45 Hz to 11,2 kHz). While use of an analyser with a large dynamic measurement range can possibly solve the problem, it can sometimes be necessary to use another approach.

Sound pressure level readings can be made with the sound level meter or signal amplifier set for a well-defined filter weighing effect in order to improve the dynamic range and measurement quality, provided that any effect in the frequency range 45 Hz to 11 200 Hz is compensated and the equipment satisfies all the requirements of Clause 6. The filter weighting response shall be less than 3 dB at all frequencies between 45 Hz and 11,2 kHz. The weighting filter shall be the same for all measurements (background, RSS and air curtain unit). The filter weighting values shall be added to the sound pressure level measurement spectrums to maintain calibration.

Annex E
(normative)

Room qualification for sound sources with broadband sound

E.1 General

This Annex covers the procedures for a broadband qualification of a test room for full and one-third octave bands. If pure tone qualification is required, refer to Annex F.

E.2 Instrumentation and equipment

The instrumentation and microphone traverse shall be the same as those used during the actual testing of an air curtain unit. The instrumentation shall conform to the requirements given in ISO 13347-1. The microphone traverse shall conform to the requirements of 11.6. The test procedure given in this Annex requires the use of a reference sound source having the characteristics specified in ISO 13347-1.

E.3 Test procedures

Eight or more measurements shall be taken of the reverberant-field sound pressure levels in the room, each with the RSS placed at a different location within the room, under the following conditions:

E.3.1 Each location for the RSS shall be selected on the floor and shall not be closer than 1 m to a wall and not closer to any microphone than the distance permitted by the formula for D_{min} (see Figures 4 and 5). The distance between any two source locations shall be greater than 1 m. No source location shall lie within ±300 mm of a room centreline. The reference sound source locations shall be in the general vicinity of the locations intended for the sound source being evaluated, as viewed in a plan view of the room.

E.3.2 With the reference sound source at each of the above locations, determine the average sound pressure levels in accordance with the procedures of Clause 13.

E.3.3 The microphone traverse, sound diffuser (if any), instrumentation, and observation time shall be identical to those used during the actual testing of a source.

E.4 Computation procedures

For each frequency band for which the test room shall be qualified, the standard deviations, in decibels, shall be computed using the formula:

$$s=\left\{\frac{1}{n_{\text{s}}-1}\sum_{j=1}^{n_{\text{s}}}\left[\left(L_{p\text{q}}\right)_j-\overline{L_{p\text{q}}}\right]^2\right\}^{1/2} \quad \text{(E.1)}$$

where

$(L_{p\text{q}})_j$ is the sound pressure level, in decibels, averaged over all microphone positions when the RSS is in the location;

$\overline{L_{p\text{q}}}$ is the arithmetic mean of $L_{p\text{q}}$ values, in decibels, averaged over one source location;

n_s is the number of RSS positions (a minimum of eight).

E.5 Qualification

For each frequency band, the test room qualifies for the measurement of broadband sound if the computed standard deviation does not exceed the limits in Table E.1.

Table E.1 — Maximum allowable standard deviation, *s*

Octave band mid-frequencies Hz	**One-third octave band mid-frequencies** Hz	**Maximum allowable standard deviation** dB
63	50 to 80	3,0
125	100 to 160	1,5
250 and 500	200 to 630	1,0
1 000 and 2 000	800 to 2 500	0,5
4 000 and 8 000	3 150 to 10 000	1,0

Annex F
(informative)

Room qualification for sound sources with pure tones/narrow-band sound

F.1 General

This Annex covers the procedure for the qualification of a test room to investigate pure tones only. The reference document for this procedure is ISO 13347-2. Qualification testing applies only to those one-third octave bands having mid-frequencies from 100 Hz to 2 500 Hz, inclusive, as shown in Table F.1. Qualification excludes those bands having centre frequencies below 100 Hz and is not required for those bands having a centre frequency greater than 2 500 Hz. The qualification testing applies to a specific location in the test room and determines which of the one-third octave bands the test room location is qualified for. Sound tests which are based on such qualification shall state the mid-frequency of the one-third octave bands qualified for the test by this procedure.

F.2 Instrumentation and equipment

The instrumentation shall comply with the requirement specified in ISO 13347-1 with the following substitutions/additions.

a) The signal analyser will be a one-third octave band analyser conforming to ISO 266:1997.

b) The sound source will consist of the following:

   1) a loudspeaker/horn; one or more, each having a sufficiently smooth frequency response within the range of frequencies to be qualified;

   2) a frequency generator, tuneable to and meeting the tolerances given for the frequencies given in Table F.1 (a digital frequency synthesizer is recommended for ease of setting frequency);

   3) a frequency counter accurate within ±0,05 Hz over the pertinent frequency range;

   4) a power amplifier of suitable power and having an output impedance compatible with the loudspeaker(s);

   5) a voltmeter capable of monitoring within ±0,05 % of the voltage across the loudspeaker at all test frequencies.

F.3 Test procedure

Qualification testing consists of two sections; the first being concerned with the near-field characteristics of the loudspeaker and the second with the test room itself. In both sections, measurements are made for each of the discrete frequencies associated with the one-third octave band being qualified. The same test equipment shall be used for both sections of the qualification testing.

F.3.1 Loudspeaker test

The loudspeaker shall be located on the surface of a hemi-anechoic field with the open cone facing upward. A microphone with its diaphragm horizontal is located over the centre of the loudspeaker, 10 mm to 20 mm above the plane of the loudspeaker rim. The input voltage to the loudspeaker shall be sufficiently strong to overcome background noise, but shall in no case be permitted to cause physical distortion of the loudspeaker components. The sound pressure levels for the discrete frequencies of a one-third octave band are then measured. The loudspeaker is suitable only if the sound pressure levels at adjacent frequencies do not differ by more than 1 dB. This test determines the near-field characteristics of the loudspeaker and gives calibration sound pressure levels for the loudspeaker.

F.3.2 Room test

The loudspeaker shall be positioned in the room at the horizontal and vertical coordinates of the equipment to be tested and placed so that the open cone faces away from the nearest room surface. Using the same input voltage to the loudspeaker as for the loudspeaker test, space- and time-averaged sound pressure levels, L_{ps}, are measured for the discrete frequencies of the one-third octave band.

F.4 Computation

The room test sound pressure levels, L_{ps}, are then corrected into $(L_{ps})_k$ to remove the effect of the loudspeaker's ear-field characteristic by subtracting the loudspeaker test sound pressure levels. The arithmetic mean $\overline{L_{ps}}$ for the room levels $(L_{ps})_k$ is then calculated, and finally, the standard deviation, s, of the difference between $(L_{ps})_k$ and $\overline{L_{ps}}$ is determined by

$$s = \left\{ \frac{1}{n_s - 1} \sum_{k=1}^{n_s} \left[\left(L_{ps} \right)_k - \overline{L_{ps}} \right]^2 \right\}^{1/2} \tag{F.1}$$

where

$(L_{ps})_k$ is the corrected room test sound pressure level (for a given test frequency);

$\overline{L_{ps}}$ is the arithmetic mean of $(L_{ps})_k$ values averaged over all n_s test frequencies;

n_s is the number of discrete test frequencies associated with the specific one-third octave band.

F.5 Qualification

A test room location is accepted as qualified for pure tone testing within a given one-third octave band if the standard deviation, s, for that band does not exceed the values given in Table F.2. If a one-third octave band does not qualify, some modifications will be required to the microphone location, to the test position, or to the room absorption.

Table F.1 — Test frequencies for alternative qualification of a reverberant room facility for measuring sound power levels of noise sources containing significant discrete-frequency components

	Centre frequency of one-third octave bands Hz														
	100	125	160	200	250	315	400	500	630	800	1 000	1 250	1 600	2 000	2 500
	—	—	147	—	—	—	361	—	—	—	—	—	1 470	—	—
	—	113	148	—	226	—	364	—	—	—	—	1 130	1 480	—	2 260
	—	114	149	—	228	—	367	445	564	712	—	1 140	1 490	—	2 280
	90	115	150	180	230	285	370	450	570	720	900	1 150	1 500	1 800	2 300
	91	116	151	182	232	288	373	455	576	728	910	1 160	1 510	1 820	2 320
	92	117	152	184	234	291	376	460	582	736	920	1 170	1 520	1 840	2 340
	93	118	153	186	236	294	379	465	588	744	930	1 180	1 530	1 860	2 360
	94	119	154	188	238	297	382	470	594	752	940	1 190	1 540	1 880	2 380
	95	120	155	190	240	300	385	475	600	760	950	1 200	1 550	1 900	2 400
	96	121	156	192	242	303	388	480	606	768	960	1 210	1 560	1 920	2 420
	97	122	157	194	244	306	391	485	612	776	970	1 220	1 570	1 940	2 440
	98	123	158	196	246	309	394	490	615	784	980	1 230	1 580	1 960	2 460
	99	124	159	198	248	312	397	495	624	792	990	1 240	1 590	1 980	2 480
	100	125	160	200	250	315	400	500	630	800	1 000	1 250	1 600	2 000	2 500
	101	126	161	202	252	318	403	505	636	808	1 010	1 260	1 610	2 020	2 520
	102	127	162	204	254	321	406	510	642	816	1 020	1 270	1 620	2 040	2 540
	103	128	163	206	256	324	409	515	648	824	1 030	1 280	1 630	2 060	2 560
	104	129	164	208	258	327	412	520	654	832	1 040	1 290	1 640	2 080	2 580
	105	130	165	210	260	330	415	525	660	840	1 050	1 300	1 650	2 100	2 600
	106	131	166	212	262	333	418	530	666	848	1 060	1 310	1 660	2 120	2 620
	107	132	167	214	264	336	421	535	672	856	1 070	1 320	1 670	2 140	2 640
	108	133	168	216	266	339	424	540	678	864	1 080	1 330	1 680	2 160	2 660
	109	134	169	218	268	342	427	545	684	872	1 090	1 340	1 690	2 180	2 680
	110	135	170	220	270	345	430	550	690	880	1 100	1 350	1 700	2 200	2 700
	111	136	171	222	272	348	433	555	696	888	1 110	1 360	1 710	2 220	2 720
	—	137	172	—	274	—	436	—	702	—	—	1 370	1 720	—	2 740
	—	138	173	—	276	—	439	—	—	—	—	1 380	1 730	—	2 760
Increment, Hz	1	1	1	2	2	3	3	5	6	8	10	10	10	20	20
Tolerance of Increment, Hz	±5	±0,3	±0,3	±0,3	±0,5	±0,5	±1	±1	±1,5	±2	±3	±3	±5	±5	±5
Number of test frequencies, n_S	22	26	27	22	26	22	27	23	24	23	22	26	23	22	26

Table F.2 — Maximum allowable standard deviation, s_r

One-third octave band mid-frequencies Hz	**Maximum allowable standard deviation** dB
50 to 80	3,0
100 to 160	1,5
200 to 630	1,0
800 to 2 500	0,5
3 150 to 10 000	1,0

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