INTERNATIONAL STANDARD

ISO 13347-2

First edition
2004-08-15

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

Part 2:
Reverberant room method

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

Partie 2: Méthode de la salle réverbérante

Reference number
ISO 13347-2:2004(E)

PDF disclaimer

This PDF file may contain embedded typefaces. In accordance with Adobe's licensing policy, this file may be printed or viewed but shall not be edited unless the typefaces which are embedded are licensed to and installed on the computer performing the editing. In downloading this file, parties accept therein the responsibility of not infringing Adobe's licensing policy. The ISO Central Secretariat accepts no liability in this area.

Adobe is a trademark of Adobe Systems Incorporated.

Details of the software products used to create this PDF file can be found in the General Info relative to the file; the PDF-creation parameters were optimized for printing. Every care has been taken to ensure that the file is suitable for use by ISO member bodies. In the unlikely event that a problem relating to it is found, please inform the Central Secretariat at the address given below.

Contents

Page

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 13347-2 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 reverberant room method should be read in conjunction with ISO 13447-1 and each parts of ISO 13347 which details other methods for determining the sound power radiated by 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 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 the velocity profile there fully developed.

This part of ISO 13347 describes methods for determining sound power levels of fans in one-third 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 and type;

c) determining whether a fan complies with a specified upper limit of sound emission;

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

e) prediction of sound pressure level in an installation of which the fan forms a part;

f) engineering work to assist in developing quiet machinery and equipment.

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

Part 2:
Reverberant room method

1 Scope

This part of ISO 13347 gives a detailed description of reverberant room methods for the determination of fan sound power levels. It is for use under standardized laboratory conditions and recognises that tests in situ are subject to increased uncertainty. These test procedures are not necessarily appropriate to site test conditions. Acoustic system effects are presently the subject of considerable research effort.

ISO 5136, which covers the in-duct method, and ISO 10302 for small fans, should be used in conjunction with this part of ISO 13347.

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

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

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

ISO 7235:2003, *Acoustics — Laboratory measurement procedures for ducted silencers — Insertion loss, flow noise and total pressure loss*

ISO 10302:1996, *Acoustics — Method for the measurement of airborne noise omitted by small air-moving devices*

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

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

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

3 Limitations on use

This part of ISO 13347 is intended to apply to industrial fans as defined in ISO 5801 and ISO 13349. It is limited to the determination of airborne sound emission for the specified set-ups. Vibration is not measured, nor is the sensitivity of airborne sound emission to vibration effects determined.

The size of the fan which can be tested in accordance with this part of ISO 13347 is limited only by the practical aspects of the test set-up. Test fan dimensions and air performance will control the room size. (Small fans may be tested according to this standard or to ISO 10302, according to usage).

The test arrangements in this part of ISO 13347 establish the laboratory conditions necessary for a successful test. Rarely will it be possible to meet these requirements in situ, and this part of ISO 13347 is not intended for field measurements. Intending users are reminded that, in these situations, the acoustic environment is unlikely to meet the specified conditions and there may well be additional acoustic system effects where inlet and outlet conditions at the fan are less than ideal.

4 Field of application

This part of ISO 13347 deals with the determination of the acoustic performance of industrial fans and, in addition, 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.

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 the appropriate IEC standard for household and similar fans, IEC 60704-2-7.

For reverberant field tests, the size of equipment under test is limited to less than 2 % of the room volume.

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:

a) type A: free inlet, free outlet;

b) type B: free inlet, ducted outlet;

c) type C: ducted inlet, free outlet;

d) type D: ducted inlet, ducted outlet.

4.1.1 Noise source

The noise source is a fan. The noise measured may contain contributions from the fan drive and transmission.

4.1.2 Character of noise

Steady broad band with discrete frequency tones.

4.1.3 Uncertainty

Engineering grade as defined in ISO 3740.

4.1.4 Quantities to be measured

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

Fan aerodynamic performance indicators including rotational speed, fan pressure and flowrate.

5 Instrumentation

Full details of the instrumentation and its requirements are given in ISO 13347-1. This 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. To be used for these purposes, the reference sound source (RSS) shall be of an appropriate type, be calibrated accurately and be properly maintained.

6 Test 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 fan to be tested be set in position in a test room, which is qualified according to the requirements of Annex A.

Once the test room has been qualified, sound pressure levels are recorded with the RSS operating. The fan is then operated without the RSS in operation at various performance points of interest for the given test speed, and the fan 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 fan for each operating point.

7 Acoustic environment

7.1 Test environment

The test environment shall be a reverberant environment. Measurements shall be taken in appropriate conditions (see Annex D of ISO 13347-1:2004).

7.2 Reverberant room

An enclosure meeting the requirements of Annex A is mandatory for the purposes of this part of ISO 13347. An enclosure meeting the requirements of Annex B is recommended for broad-band sound testing and is mandatory for the purpose of investigating pure tones and narrow bands.

8 Test set-up and ducting

8.1 Set-up categories

A number of specific fan test set-ups are allowed. They are determined by the airflow direction and the particular mounting arrangement of the test device. The fan sound pressure levels are measured in a reverberant room, which may be connected to a chamber or any other system to provide control and measurement of the fan air volume flowrate.

This part of ISO 13347 allows for the duct on the non-measured side to be plain or fitted with a simplified anechoic termination (see ISO 13347-1). Whether an anechoic term has been fitted or not, should be clearly stated in any test report.

Figure 1 shows the mounting for the determination of fan-inlet sound pressure levels and Figure 2 for the determination of fan-outlet sound levels. Figure 3 shows the mounting for the determination of fan casing sound levels for type D installations. With this arrangement, the following different sound power levels can be measured, using the notations defined in Table 1 of ISO 13347-1:2004:

L_W (A,in) : free inlet, type A installation

L_W (A,out) : free outlet, type A installation

L_W (B,in + cas) : free inlet + casing, type B installation

L_W (B,out) : ducted outlet, type B installation

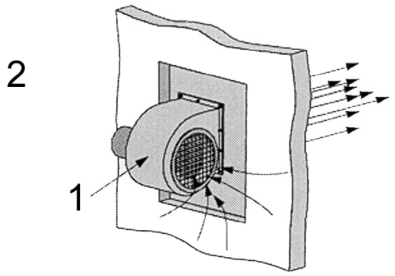
L_W (C,in) : ducted inlet, type C installation

L_W (C,out + cas) : free outlet + casing, type C installation

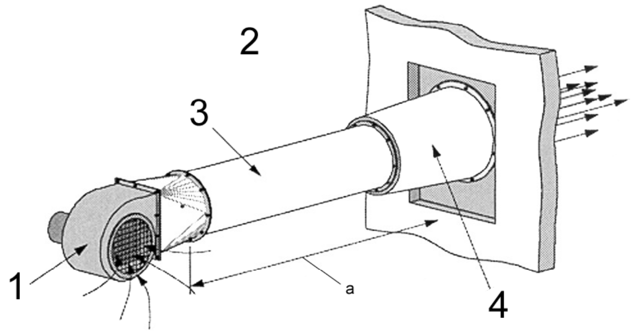
L_W (D,in + cas) : ducted inlet + casing, type D installation

L_W (D,out) : ducted outlet, type D installation

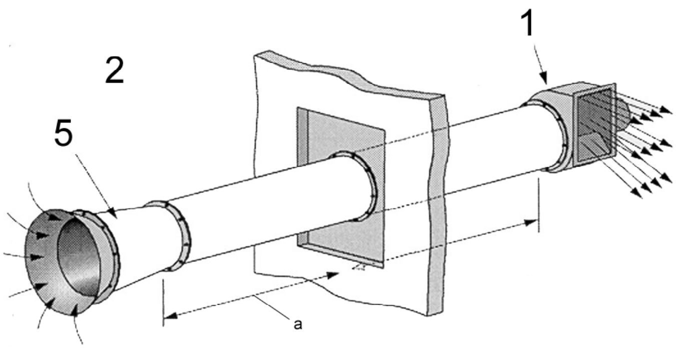
L_W (D,cas) : casing, type D installation



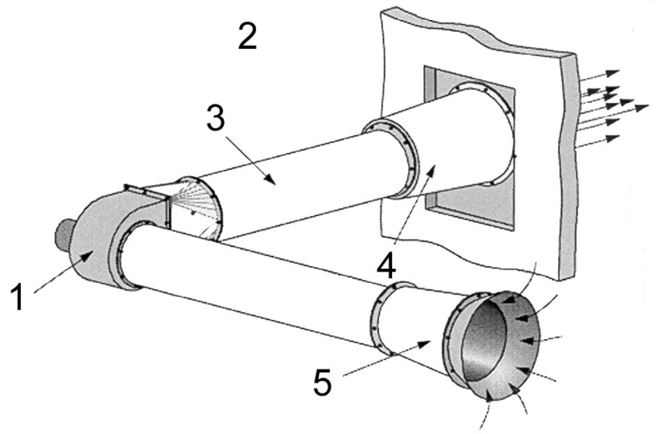
a) A: free inlet, free outlet



b) B: free inlet, ducted outlet



c) C: ducted inlet, free outlet



d) D: ducted inlet, ducted outlet

Key

1 fan

2 reverberant room

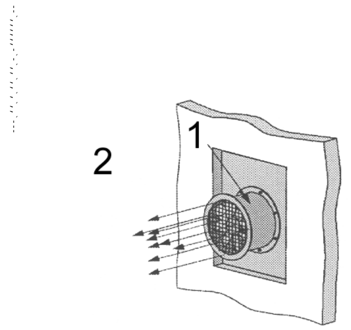
3 common part

4 simplified anechoic termination (see Annex D of ISO 13347-1:2004)

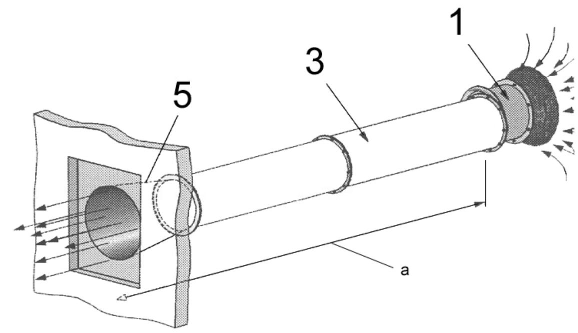
5 transmission element according to ISO 7235

[a] Reverberant room wall, alternative positions

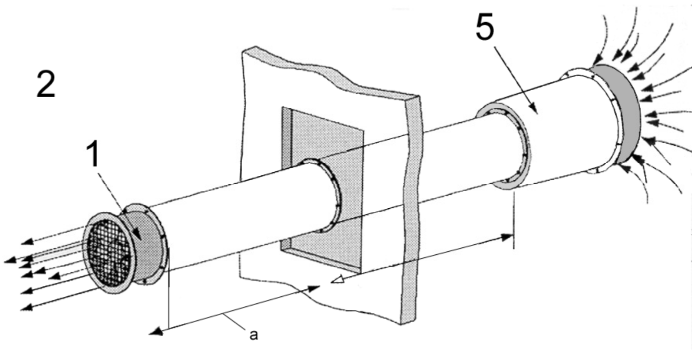
Figure 1 — Test set-up for fan-inlet sound measurement (centrifugal fan shown)



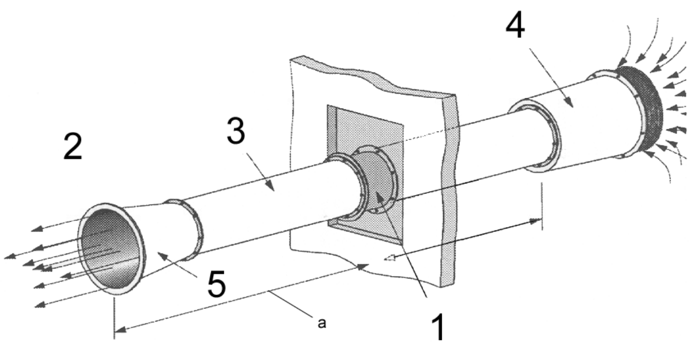
a) A: free inlet, free outlet



b) B: free inlet, ducted outlet



c) C: ducted inlet, free outlet



d) D: ducted inlet, ducted outlet

Key

1 fan

2 reverberant room

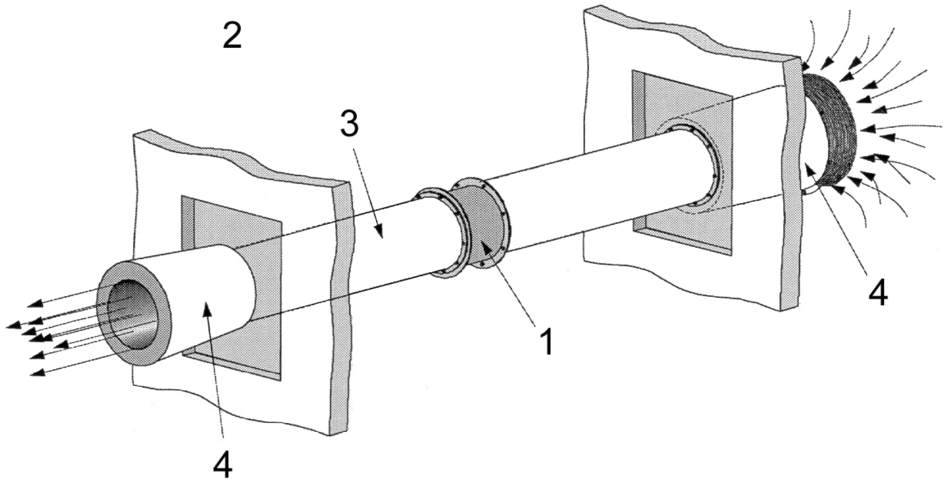
3 common part

4 simplified anechoic termination (see Annex D of ISO 13347-1:2004)

5 transmission element according to ISO 7235

a Reverberant room wall, alternative positions

Figure 2 — Test set-up for fan-outlet sound measurement (axial fan shown)



Key

1 fan

2 reverberant room

3 common part

4 simplified anechoic termination (see Annex D of ISO 13347-1:2004)

Figure 3 — Test set-up for fan-casing sound measurement (axial fan shown)

8.2 Sound pressure levels

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

This includes sound pressure levels measured in the test room with the fan off. The background noise includes all noise sources not directly associated with fan 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.

8.2.2 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.

8.2.3 Sound pressure levels, fan (L_p)

For a set of tests at various fan 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 A or B.

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

8.3 Aerodynamic performance

The control and measurement of the fan operating point on the fan characteristic shall be performed using one of the methods specified in ISO 5801.

8.4 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 15 s for frequency bands of 200 Hz and above.

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.

8.5 Mounting methods

The method of mounting fans, of connecting them to non-integral drivers and of connecting them to airflow test facilities is not specified. Any conventional method may be used including vibration isolation devices and short flexible connectors. Other than these, sound and vibration absorptive material may not be incorporated in the test fan unless it is a standard part of the unit. Ducts shall be of metal or other rigid, dense non-absorptive material, and have no exposed sound absorption material on the interior or exterior surfaces.

Driving motor and drive, when not an integral part of the fan, may 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 may not be treated in any manner, and normal belt tensions and bearings shall be used.

8.6 Duct length

The length of duct shall be consistent with ISO 5801. A simplified anechoic termination (see Annex D of ISO 13347-1:2004) shall be fitted to the duct end of the terminating duct in order to impose a specified acoustic loading (see Figures 1 to 3). If ducts on the unmeasured side are not acoustically terminated, the uncertainty in the 63 Hz octave band is 6,0 dB, and 3,0 dB in all higher octave bands.

In chamber or two-room set-ups, the length of duct shall be consistent with ISO 5801, which is necessary for the accurate establishment of the point of rating.

The length of duct shown in Figures 1 to 3 is consistent with the procedures of ISO 5801. Care shall be exercised to ensure that no duct resonance exists in close proximity to specific frequencies of interest, e.g., blade passage frequency.

Care should be taken to avoid duct lengths which are a multiple of $\frac{\lambda}{2}$ in any important frequencies.

It cannot be assumed that inlet and outlet sounds are always equal. Therefore, total sound power levels shall not be used to derive inlet sound power or outlet sound power.

To specify a standardized acoustical load impedance for ducted installations, all ducts connected to the test fan have to be terminated anechoically. A duct in which the sound pressure is to be measured for determination of the in-duct sound power according to ISO 5136 is called a “test duct”. Ducts which are used only to provide the standardized acoustic loading, i.e. in which no sound measurements are to be made, are called “terminating ducts”. The maximum permissible pressure reflection coefficients for test ducts and for terminating ducts as specified in ISO 5136 and are given in Table 4 of ISO 13347-1:2004.

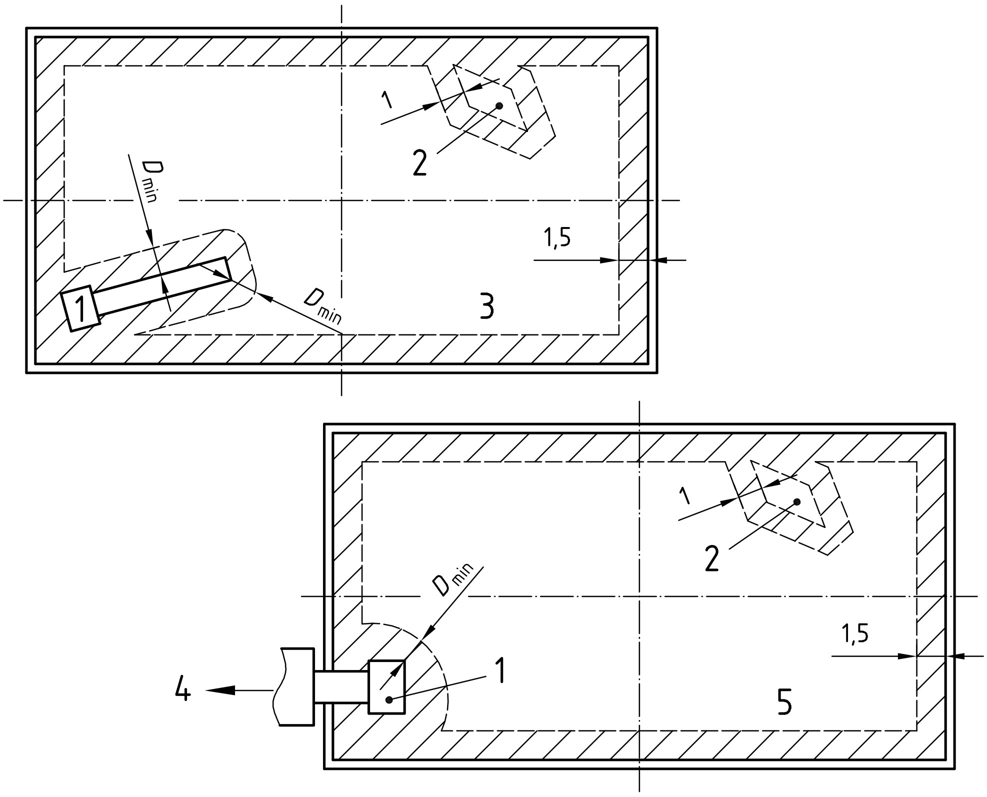
For details of transmission elements, refer to Annex D and ISO 7235.

If the cross-sectional area of the fan inlet or outlet is larger than 2 m^2 (this corresponds to a circular area of 1,6 m in diameter) alternative use of the in-duct method, reverberant field method, enveloping surface and sound intensity method is permitted to determine the in-duct sound power or free-space sound power level. This is based on the assumption that, for such large dimensions, the sound powers radiated into a duct and into free space are equal.

8.7 Microphone travel

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 may 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 graphic description of microphone placement limitations is shown in Figure 4. A microphone at different fixed positions, or an array of fixed microphones, may also be used in accordance with ISO 3741 and ISO 3743.

Dimensions in millimetres



Key

1 fan
2 optional vane sometimes used to modify the room acoustic properties
3 total sound testing
4 inlet or outlet testing
5 air test chamber or second room

NOTE $D_{min} = 0{,}610 \times 10^{[(L_{Wr} - L_{pq})/20]}$ m

where

$(L_{Wr} - L_{pq})$ is the maximum value for octave bands 125 to 400 Hz

Figure 4 — General limitations to test room arrangement

9 Observations

9.1 Point of operation

Although the acoustical observations necessary to determine sound power output are the same for all fan types, the non-acoustical observations necessary to determine the aerodynamic point of operation differ. This part of ISO 13347 provides different test set-ups for the testing of various fan types. Regardless of the test set-up, the point of operation shall be determined according to one of the methods specified in ISO 5801. The control of the fan operating condition shall be achieved by the means described in 9.5 of ISO 13447-1:2004.

9.2 Information to be recorded

The information to be recorded concerning the fan test is listed in Clause 10 of ISO 13347-1:2004.

10 Calculations

10.1 Background corrections

The observed RSS or test fan 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 13347, 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 formula:

Fan sound pressure level:

$$L_{p\mathrm{c}} = 10\lg\left(10^{\frac{L_{p\mathrm{m}}}{10}} - 10^{\frac{L_{p\mathrm{b}}}{10}}\right)$$

RSS sound pressure level:

$$L_{p\mathrm{q}} = 10\lg\left(10^{\frac{L_{p\mathrm{qm}}}{10}} - 10^{\frac{L_{p\mathrm{b}}}{10}}\right)$$

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

10.2 Sound power level, L_W

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

Fan inlet sound levels

Installation type	Equation L_W
A or B: free inlet	L_W (A,in) or L_W (B,in + cas) $= L_{p\text{c}} + (L_{W\text{r}} - L_{p\text{q}})$
C or D: ducted inlet [1)]	L_W (C,in) or L_W (D,in + cas) $= L_{p\text{c}} + (L_{W\text{r}} - L_{p\text{q}}) + E_\text{i}$

Fan outlet sound levels

Installation type	Equation L_W
A or C: free outlet	L_W (A,out) or L_W (C,out + cas) $= L_{p\text{c}} + (L_{W\text{r}} - L_{p\text{q}})$
B or D: ducted outlet [1)]	L_W (B,out) or L_W (D,out) $= L_{p\text{c}} + (L_{W\text{r}} - L_{p\text{q}}) + E_\text{o}$

Fan casing sound levels	Equation L_W
D: ducted inlet-ducted outlet	L_W (D,cas) $= L_{p\text{c}} + (L_{W\text{r}} - L_{p\text{q}})$

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

a) Acoustical energy in an outlet (or inlet) duct which terminates in a second room does not contribute to fan test sound pressure levels. This requires adequate transmission loss between adjoining rooms.

b) Directivity from the fan is averaged by the reverberant room and the microphone location is such that it records total average sound pressure levels.

c) Duct construction is such that the transmission lost through the duct wall is large enough to eliminate any addition to measured room sound pressure levels.

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

---

1) The sound power levels on the ducted inlet or ducted outlet should generally be determined by an induct method as detailed in ISO 5136. Measurements determined in a reverberant room with duct-end correction E_i or E_o (see Annex C of ISO 13347-1:2004) have a lower order of accuracy. Where Figures are obtained in this way then this should be clearly stated. The transmission coefficient of a transmission element may be determined according to the method described in Annex D.

Annex A
(normative)

Room qualification for sound sources with broad band sound

A.1 General

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

A.2 Instrumentation and equipment

The instrumentation and microphone traverse shall be the same as those used during the actual testing of a fan. The instrumentation shall conform to the requirements given in ISO 13347-1. The microphone traverse shall conform to the requirements of 8.7. The test procedure given in this annex requires the use of a reference sound source having the characteristics specified in ISO 13347-1.

A.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:

A.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 equation for D_{min} (see Figure 4). 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.

A.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 10.

A.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.

A.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:

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

where

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

$\overline{L_{pq}}$ is the arithmetic mean of L_{pq} values, in decibels, averaged over I source location;

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

A.5 Qualification

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

Table A.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 2 500	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 B
(informative)

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

B.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 3742. Qualification testing applies only to those one-third octave bands having mid-frequencies from 100 to 2 500 Hz, inclusive, as shown in Table B.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.

B.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 B.1. A digital frequency synthesiser 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.

B.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.

B.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 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.

B.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 $L_{p\text{s}}$ are measured for the discrete frequencies of the one-third octave band.

B.4 Computation

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

$$s = \left\{ \frac{1}{n_\text{s} - 1} \sum_{k=1}^{n_\text{s}} \left[\left(L_{p\text{s}} \right)_k - \overline{L_{p\text{s}}} \right]^2 \right\}^{1/2}$$

where

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

$\overline{L_{p\text{s}}}$ is the arithmetic mean of $(L_{p\text{s}})_k$ 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.

B.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 B.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 B.1 — Test frequencies for alternative qualification of a reverberant room facility for measuring sound power levels of noise sources containing significant discrete-frequency components
(from ISO 3742)

	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	A 53	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	325	400	530	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	126	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 B.2 — Maximum allowable standard deviations, s_r

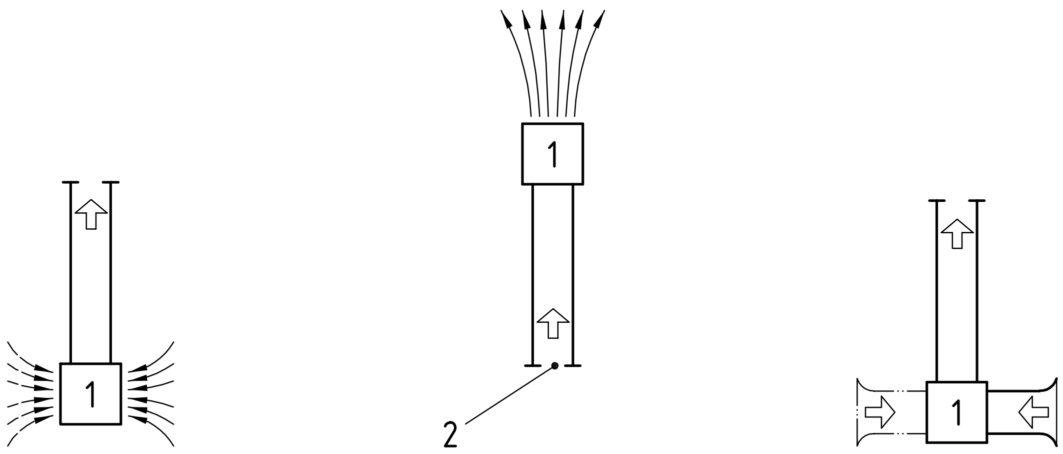
One-third octave band centre frequencies Hz	Maximum allowable standard deviation, s_r dB
100 to 160	3,0
200 to 315	2,0
400 to 630	1,5
800 to 2 500	1,0

Annex C
(informative)

Total fan sound testing with attached ducts

The sound power levels determined by this part of ISO 13347 reflect the sound produced at a known fan operating point. The length of test ducts used to determine sound power would, therefore, be identical to the duct length defined in ISO 5801. It has been determined that shorter or longer duct lengths may also be acceptable if they were used for the aerodynamic performance test. Care shall be taken to ensure that, for all lengths, no duct resonances exist in close proximity to specific frequencies of interest, e.g. blade passage frequencies. It is preferable for the non-measurement side of the fan to have an anechoically terminated duct.

Although it is recognised that the inlet and outlet sound power levels of a fan are generally not equal, it is necessary to make some assumption about the relationship between these levels to apply duct-end reflection correction. The equations given below are based upon the assumption that the inlet and outlet sound power levels of a fan are equal.



a) B: free inlet, ducted outlet **b) C: ducted inlet, free outlet** **c) D: ducted inlet, ducted outlet**

Key

1 fan

2 optional orifice

Figure C.1 — Fan total sound testing with ancillaries attached

Installation type Equations L_W

B: Free inlet, ducted outlet

$$L_W(\mathrm{B,in+cas}) = L_p + \left(L_{W\mathrm{r}} - L_{p\mathrm{q}}\right) + \left\{3 - \left[10\lg\left(1 + 10^{\left(E_\mathrm{o}/10\right)}\right)\right] + E_\mathrm{o}\right\}$$

C: Ducted inlet, free outlet

$$L_W(\mathrm{C,out+cas}) = L_p + \left(L_{W\mathrm{r}} - L_{p\mathrm{q}}\right) + \left\{3 - \left[10\lg\left(1 + 10^{\left(E_\mathrm{i}/10\right)}\right)\right] + E_\mathrm{i}\right\}$$

D: Ducted inlet, ducted outlet

$$L_W(\mathrm{D,cas}) = L_p + \left(L_{W\mathrm{r}} - L_{p\mathrm{q}}\right) + E_\mathrm{i} + E_\mathrm{o} + \left\{3 - \left[10\lg\left(10^{\left(E_\mathrm{o}/10\right)} + 10^{\left(E_\mathrm{i}/10\right)}\right)\right]\right\}$$

This test procedure and the above calculations are based on the following.

a) Directivity from the fan is averaged by the reverberant room and the microphone location is such that it senses total averaged sound pressure levels.

b) Duct construction is such that the transmission loss through the duct wall is large enough to eliminate any addition to measured sound pressure levels.

c) No resonances are present on either the fan structure, supporting devices, or driving devices that provide any significant pure tones that may add to the measured sound pressure

d) The factor of 3 in the above equations is based on the assumption that fan sound power is equally distributed between inlet and outlet.

Annex D
(normative)

Transmission element

D.1 Design for a transmission element

D.1.1 For measurement without flow, any horn shape or absorption in the transmission element is permissible, which limits the reflection coefficient in a way that it does not exceed the maximum permissible values given in Table 4 of ISO 13347-1:2004.

D.1.2 for the measurement of the flow noise (or regenerated sound), it is essential that the transmission element transmits most of the sound power into the connected reverberant room. It shall therefore have a small reflection coefficient and nearly zero dissipative losses (see 5.2.4.2 of ISO 7235:2003).

D.1.3 The requirement laid down in ISO 7235 is that the transmission element shall not produce flow noise (or regenerated sound) which influences the measurements in the reverberant room.

D.1.4 The wall of the transmission element shall have a high transmission loss to prevent sound energy losses through this wall.

D.1.5 A transmission element suitable for the measurement of flow noise (or regenerated sound) is a horn in which the enclosed angle of the walls does not exceed 15° and the walls are acoustically hard and rigid (see Figure D.1).

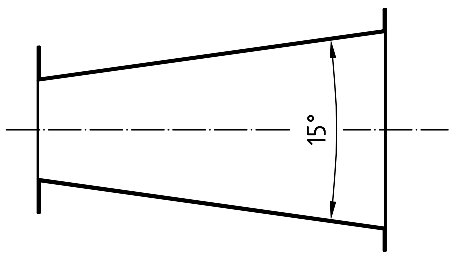


Figure D.1 — Diagram of a suitable transmission element

D.2 Determination of the transmission coefficient of a transmission element

D.2.1 The pressure reflection coefficient of the transmission element is given by the following formula:

$$r_\mathrm{a} = \frac{10^{\Delta L/20} - 1}{10^{\Delta L/20} + 1}$$

The transmission coefficient, τ, is calculated from the measurement of the difference, ΔL, between the maximum and minimum sound pressure levels of the standing wave in the duct using the formula:

$$\tau = 1 - r_a^2 = \frac{4 \times 10^{\Delta L/20}}{\left(10^{\Delta L/20} + 1\right)^2}$$

D.2.2 It is recommended that the transmission coefficient be measured using pure tones in one-third octave bands from 50 Hz up to the cut-off frequency, f_0, of the first cross-mode in the duct which is given by the formulas:

$f_0 = 0{,}586\ c/d$, for circular ducts

$f_0 = 0{,}5\ c/l$, for rectangular ducts

where

c is the speed of sound, in metres per second;

d is the diameter of the throat of the transmission element, with circular cross-section, in metres;

l is the length of the longer side of the rectangular cross-section of the throat of the transmission element, in metres.

Bibliography

[1] HARRIS, C.M., Ed., *Handbook of Noise Control*, 2nd Ed., MCGRAW-HILL, New York, 1979, Ch. 1, p. 2

[2] PARKER, S. P., Ed., *Dictionary of Scientific and Engineering Terms*, 4th Ed., MCGRAW-HILL, New York, 1989

[3] WOLHER, H. *Zweitormersungen an einen radialventilator modell*. Frankfurt: Forschunsvereinigung für Luft and Trocknungstechnik. 1970, 7(19)

[4] CREMER, L. *The treatment of fans as black boxes*. Second Annual Fairy lecture. J. Sound & Vibration., 1071, 16(1), pp. 1-15

[5] BOLTON, A. N. & Margetts, MIOA, E. J. *The influence of impedance on fan sound power*. National Engineering Laboratory, Dept of Trade & Industry UK publication, C124/84

[6] BAADE, P. *Effects of acoustic loading on axial flow fan noise generation*. Noise Control Engineering, January-February 1977, 8(1), pp. 5-15

[7] SEPMEYER, L. W., *Computed Frequency and Angular Distribution of the Normal Modes of Vibration in Rectangular Rooms*, Acoustical Society of America, Vol. 37-No 3, March 1965

[8] AMCA #1901-85-AI, *List of References on Room Calibration, Air Movement and Control Association, Inc.*, Arlington Heights, IL, 1985

[9] CROCKER, M. J., w/PANDE, L. and SANDBAKKEN, M., *Investigation of End, Reflection Coefficient Accuracy Problems* with AMCA Standard 300-67, *HL 81-16*, Purdue University, IN, 1981

[10] Noise Control Engineering, Vol. 7, No. 2, *Noise Measurement Facilities*, and ANSI S 1.21-1972, *Methods for the Determination of Sound*

[11] LEVINE, H. SCHWINGER J. *On the radiation of sound from an unflanged circular pipe*, Physical Review 7, pp. 383-406

[12] FARZAMI, R. and GUEDEL, A., *Influence of Straighteners on Induct Fan Sound Power Measurements* International Fan Noise Symposium, Senlis 1-3 September 1992

[13] NEISE, W. and MICHEL U. Aerodynamic Noise of Turbomachines, Chapter 14, *Installation Effects in fan Systems*, DLR, Berlin

[14] GUEDEL A., *Design of terminating ducts for fan noise testing*, Proceeding of Internoise 2000, August 2000

[15] ISO 266:1997, *Acoustics — Preferred frequencies*

[16] ISO 3741:1999, *Acoustics — Determination of sound power levels of noise sources using sound pressure — Precision methods for reverberation rooms*

[17] ISO 3742:1988, *Acoustics — Determination of sound power levels of noise sources — Precision methods for discrete-frequency and narrow-band sources in reverberation rooms*

[18] IEC 60704-2-7:1997, *Household and similar electrical appliances —Test code for the determination of airborne acoustical noise — Part 2: Particular requirements for fans*

ICS 17.140.20; 23.120

Price based on 22 pages