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

Part 3: Enveloping surface methods

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

Partie 3: Méthodes de la surface enveloppante

Reference number
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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 13347-3 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

This part of ISO 13347 establishes a method for determining the sound power level of a fan. The method is reproducible in all laboratories which are qualified according to the requirements of this part of ISO 13347.

The method employs standard sound measurement instrumentation, applied to rooms which are restricted in certain acoustic properties. The test set-ups are generally designed to represent the physical orientation of a fan as installed, in accordance with ISO 5801.

Since sound power levels are considered independent of the acoustic environment around the fan, a good comparison may be made between two or more fans proposed for any specific air performance condition. Moreover, these values establish an accurate base for estimating the acoustical outcome of the fan installation in terms of sound pressure levels. A successful estimate of sound pressure levels requires extensive information on the fan and the environment in which it is to be located.

It is often advantageous for the equipment user to employ acoustical consultation to ensure that all factors which affect the final sound pressure levels are considered. More detailed information on the complexity of this situation may be found in acoustic text books.

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

Part 3: Enveloping surface methods

1 Scope

This part of ISO 13347 applies 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 sizes of fan which can be tested in accordance with this part of ISO 13347 are limited only by the practical aspects of the test set-up. Dimensional limitations, test fan dimensions, and air performance will control the room size, power and mounting requirements for the test fan. (Small fans may be tested according to this part of ISO 13347 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, there may well be additional acoustic system effects where inlet and outlet conditions at the fan are less than ideal.

The enveloping surface methods may be used for the determination of open inlet and/or open outlet sound power level of fans for the standardized installation types given in 3.1.

An estimation (with increased uncertainty) of ducted sound power for fans too small, or otherwise inconvenient, for testing by the in-duct method described in ISO 5136 may also be obtained by the addition of end reflection corrections (see Annex C of ISO 13347-1:2004).

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

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 standardised airways*

ISO 10302, *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*

3 Acoustic environment and ducting

3.1 General

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

— type A: free inlet, free outlet;

— type B: free inlet, ducted outlet;

— type C: ducted inlet, free outlet;

— type D: ducted inlet, ducted outlet, (casing breakout noise may also be determined for type D ducted inlet, ducted outlet).

The test environments that are suitable for measurements according to this procedure are specified in detail in ISO 3744. They can be outdoors or indoors.

For fans generating large flowrates, it is preferable that measurements are undertaken in a large space to minimise the recalculation of turbulent airflow through the fan and to ensure that microphones are not positioned in high velocity flowrates.

Care should be taken to conduct outdoor tests on still calm days where the effects of the wind on fan aerodynamic and/or noise performance may be discounted. A maximum wind speed of 3 m/s is recommended.

During the period of the tests, the variation in the ambient air temperature and in relative humidity should not exceed ± 5 %.

For tests according to this procedure, the environment correction K_2 should be less than or equal to 2 dB in any one-third octave band (see Annex A). In practice, this limit of 2 dB may be difficult to obtain in a real-world test area, but it has been shown that this limit is not actually required to achieve good repeatability in fan noise measurement [1].

3.2 Test installation

3.2.1 General

The test installation shall comply with the general requirements of this clause and with the requirements given in ISO 13347-1:2004, Clause 6, as appropriate.

The ducting and anechoic termination and flow measurement and control device, when necessary, fitted to the fan for tests for installation types B, C and D shall be as specified in ISO 5136 and ISO 5801. Simplified anechoic termination shall be fitted, see also ISO 13347-1.

The appropriate operating condition shall be determined from a measurement of the air volume flowrate and fan pressure in accordance with ISO 5801.

The sound pressure level in the test area due to the noise generated by the flow measurement or control device shall be at least 10 dB below the measured sound pressure level from the fan under test.

When an air vent is necessary for air to recirculate into or out of the test area, it shall be silenced and placed on the room surface. It may also be used to regulate the air flow.

If practicable, all auxiliary equipment necessary for the fan under test shall be located outside the test area which shall be cleared of all objects which may interfere with the measurements.

Care should be taken to ensure that any electrical conduits and fittings, piping, or air ducts connected to the equipment do not radiate significant amounts of sound energy into the test area.

3.2.2 Type A installation

The fan shall be placed over an aperture in the reflecting plane such that the fan inlet or outlet orifice (as appropriate) is axially located in relation to the reflecting plane in a manner representative of its recommended installation. The fan orifice shall be placed coaxially with the wall aperture, and, to ensure satisfactory air flow conditions, the aperture shall be larger all round than the fan orifice by an amount at least as great as the thickness of the reflecting plane structure, and the intervening gap shall be sealed by a panel. Provision shall be made for determining and adjusting the fan air flowrate.

Care should be taken to avoid vibration of the sealing panel.

NOTE The reverberant conditions of the non-measured side may affect the measurements made on the measured side of the fan. Highly reverberant conditions on the non-measured side may lead to higher levels of sound power level being determined than if free field conditions existed on the non-measurement side.

3.2.3 Type B installation

The inlet of the fan shall be placed in the vicinity of the centre of the test area. Ducting connected to the fan discharge shall either be of sufficiently massive construction or be treated externally so as to avoid transmission of undesired noise from within the duct.

The duct shall be terminated with a simplified anechoic device as described in ISO 13347-1. The outlet duct shall comprise an intermediate duct, a transition duct if necessary, a test duct or terminating duct and an anechoic termination (see Annex D of ISO 13447-1:2004).

Precautions should be taken to ensure that noise from the flow control or flow measurement device does not interfere with noise from the fan at any of the measurement locations.

NOTE Unless precautions are made to ensure otherwise, the sound pressure levels measured will include noise radiated from the fan casing and the fan drive motor (see ISO 13347-1).

3.2.4 Type C installation

The outlet of the fan shall be placed in the vicinity of the centre of the test area. Ducting connected to the fan inlet shall either be of sufficiently massive construction or be treated externally so as to avoid transmission of undesired noise from within the duct.

The duct shall be terminated with a simplified anechoic device as described in ISO 13347-1. The inlet duct shall comprise an intermediate duct, a transition duct if necessary, a test duct or terminating duct and an anechoic termination (see Annex D of ISO 13347-1:2004).

Precautions should be taken to ensure that noise from the flow control or flow measurement devices does not interfere with noise from the fan at any of the measurement locations.

NOTE Unless precautions are made to ensure otherwise, the sound pressure levels measured will include noise radiated from the fan casing and the fan drive motor (see ISO 13347-1).

3.2.5 Casing sound power, type D installation

The sound power radiated from the external surface of the fan casing and, if appropriate, from the drive, may be determined by this method provided that noise radiated from the associated ducting is minimal. The ducting connected to the fan inlet or outlet shall be terminated with a simplified anechoic device as described in ISO 13347-1 to ensure that the reflection coefficients are within the limits specified in Table 4 of ISO 13347-1:2004 and shall also comply with 3.2.1, 3.2.3 and 3.2.4 of this part of ISO 13347.

3.2.6 Ducted small fans

Fans with test ducts smaller in diameter than those specified in Clause 8 of ISO 13347-1:2004 cannot be tested by the in-duct method.

If an indication of the in-duct sound power level is required, it may be obtained for these fans by applying the end reflection correction to the sound pressure level determined in the room. This resultant sound power level is not a true in-duct sound power level, but may be taken as a characteristic in-duct sound power level for small fans for the purposes of noise control calculations. The end reflection correction E may be found from Figure C.1 of ISO 13347-1:2004.

$$L_W \text{ in-duct} = L_W + E$$

3.3 Fan-powered exhaust ventilators

Fan-powered exhaust ventilators may be tested by the free field method. When it is not possible to mount a unit with gravity controlled shutters in its correct mounting attitude, the shutters shall be locked in the correct mounting operating position. The units shall be mounted in as representative a manner as possible with only that degree of vibration isolation recommended for a normal site installation. The opening in the test room shall be dimensionally similar to the recommended opening for the installed unit. The powered ventilator shall not be separated from the external face of the test room by a connecting duct but additional fittings may be used to simulate accurately the mounting conditions specified by the manufacturer.

3.4 Drive and transmission noise

In cases where the fan drive and its inlet and outlet are in the same measurement space, the noise will be partly aerodynamic and partly due to the drive and transmission. If the drive is representative of that supplied with the fan, this noise shall be taken to be the noise from the fan assembly. In cases where drive and transmission are not supplied as standard, the contribution to the noise made by these shall be checked by removing the fan impeller and substituting an equal and smooth surfaced mass. The noise thus obtained shall be measured. If this is 10 dB or more below the level in any octave band due to the complete assembly, transmission noise may be ignored. For differences between 6 dB and 10 dB, background noise corrections in accordance with ISO 3744 shall be made. Otherwise, some action shall be taken to reduce noise from this source. If the drive and transmission are considered to make a significant contribution to the total noise, this fact shall be included in the test report.

4 Determination of measurement surface

4.1 General

This part of ISO 13347 recognises a number of different methods for defining the positions at which microphones shall be placed for measuring the fan noise. The general principle is to define a hypothetical surface enveloping some or all of the source, or if there is a reflecting plane, enveloping the source and terminating on the reflecting plane.

4.2 Measurement surfaces

The different measurement surfaces are as follows.

4.2.1 A rectangular parallelepiped enclosing the sound source as shown in Figure 1. This surface is easily and accurately measured. It may include part of the casing radiated noise, in which case this shall be clearly identified. Directivity of the noise is not easily deduced.

4.2.2 A sphere, or hemisphere over a reflecting plane, as shown in Figures 2, 3 and 4. This surface conveniently requires the use of a rotating boom if the positions are to be easily reproduced. Directivity of the sound may be deduced by plotting curves of equal dB value through the levels at the measuring points.

4.2.3 A small-radius hemisphere, the centre of which is located at the intersection of the axis of symmetry of the inlet(s) and of the plane normal to this axis at the inlet under consideration, as shown in Figure 5. This method is suitable for use in more restricted spaces, but is generally confined to the measurement of inlet noise on fans having a ducted outlet. For absolute comparisons, the use of a Reference Sound Source is necessary.

4.3 Arrangement of measuring points (rectangular parallelepiped)

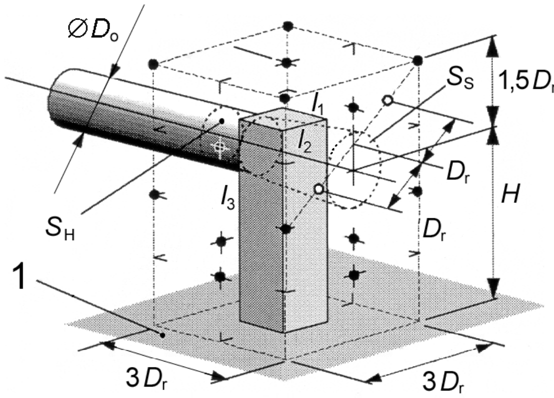
A hypothetical reference surface in the form of a rectangular parallelepiped (reference box) shall enclose the fan, any protruding elements which are not significant radiators of sound energy being disregarded.

For the determination of sound power level L_W(B,in + cas) or L_W(B,out) the reference box shall be selected in such a way that it encloses a portion of the space at the orifice, and in the case of outlet orifices, a portion of the discharge flow, and that it terminates, if required, on the reflecting plane(s). The dimensions of the reference box are functions of the diameter of the orifice, D, and of its height above the reflecting floor, h (see Figure 1).

The measuring points shall lie on the measurement surface enclosing the object under test or the reference box at the measurement distance, d, and terminating on sound reflecting boundary surfaces of the installation site (e.g. on a floor) or of the fan.

NOTE 1 If only one reflecting plane is present (e.g. outdoors) on which the fan is placed, to which it is attached or which incorporates the inlet or outlet orifice, a hemispherical measurement surface as specified in 3.3 may be used as an alternative (e.g. for table and ceiling fans). This is particularly the case if the directivity of the fan is to be determined and if the wind speed at the microphone does not exceed 5 m/s.

NOTE 2 See also Table 1 which includes further necessary information to determine microphone positions.



Key

1 floor or wall

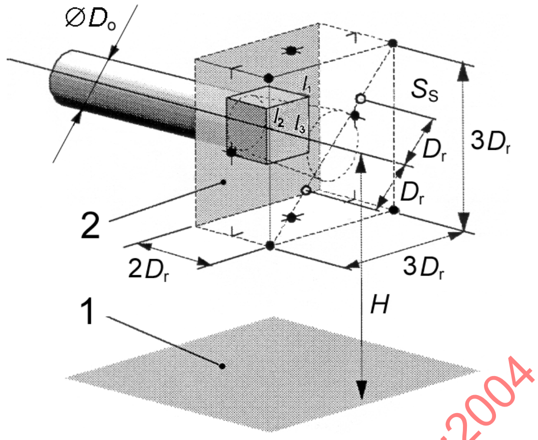
Measurement surface area $S = 54D_r^2 - S_H$

- 12 measuring points

X additional measuring point for fans with inlet orifice

O additional measuring points for fans with outlet orifice, on a diagonal as shown in the illustration at distance D_r from the flow axis

a) Sound radiated from a duct at a larger distance from floor or wall, with $h \geqslant 45D_r$



Key

1 floor or wall

2 reflecting plane

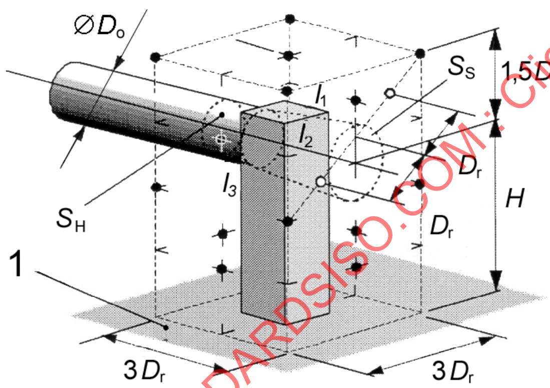
Measurement surface area $S = 33D_r^2$

- 8 measuring points

X additional measuring point for fans with inlet orifice

O additional measuring points for fans with outlet orifice, on a diagonal as shown in the illustration at distance D_r from the flow axis

b) Sound radiated from a wall orifice at a larger distance from floor or wall, with $h \geqslant 45D_r$



Key

1 reflecting floor or wall

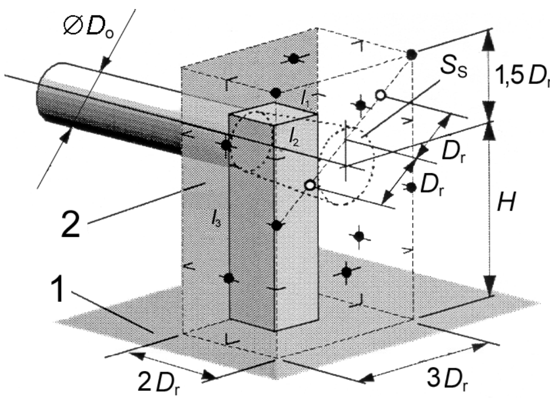
Measurement surface area $S = 9D_r^2 + 12D_r(h + 15D_r) - S_H$

- 15 measuring points

X additional measuring point for fans with inlet orifice

O additional measuring points for fans with outlet orifice, on a diagonal as shown in the illustration

c) Sound radiated from a duct, with $1{,}5D_r < h < 45D_r$



Key

1 reflecting floor or wall

2 reflecting plane

Measurement surface area $S = 6D_r^2 + 7D_r(h + 15D_r)$

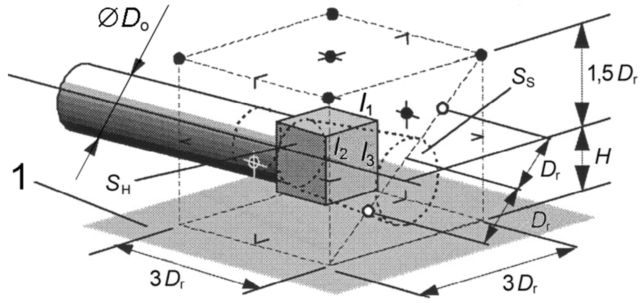
- 10 measuring points

X additional measuring point for fans with inlet orifice

O additional measuring points for fans with outlet orifice, on a diagonal as shown in the illustration

d) Sound radiated from a wall orifice, with $1{,}5D_r < h < 45D_r$

Figure 1 — Microphone positions for a rectangular parallelepiped



Key

1 reflecting floor or wall

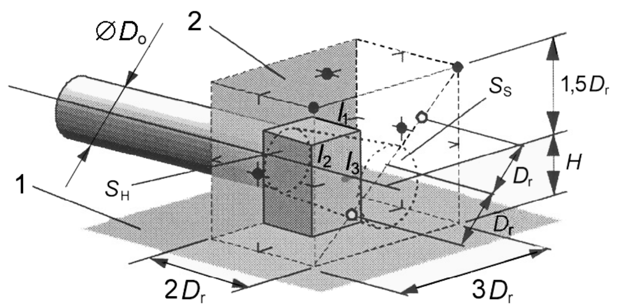
Measurement surface area $S = 9D_r^2 + 12D_r(h + 15D_r) - S_H$

- 7 measuring points

X additional measuring point for fans with inlet orifice

O additional measuring points for fans with outlet orifice, on a diagonal as shown in the illustration

e) Sound radiated from a duct, with $h \leqslant 1{,}5D_r$



Key

1 reflecting floor or wall

2 reflecting plane

Measurement surface area $S = 6D_r^2 + 7D_r(h + 15D_r)$

- 5 measuring points

X additional measuring point for fans with inlet orifice

O additional measuring points for fans with outlet orifice, on a diagonal as shown in the illustration

f) Sound radiated from a wall orifice, with $h \leqslant 1{,}5D_r$

Figure 1 (*continued*)

Table 1 — Explanatory comments regarding measurement points for rectangular parallelepiped surface

Symbol	Description
D_o	the largest dimension of the circular or rectangular orifice
D_r	the measurement distance
H	the height of centre of orifice above flow level or above another reflecting plane
l_1, l_2, l_3	dimensions of the reference box
S	the measurement surface area
S_H	the cross-sectional area of a section through the fan in the measurement surface plane), only to be determined approximately; illustrated here for axial fans in examples a), c) and e) above
S_s	the portion of measurement surface in contact with the discharge flow, for fans with outlet orifice

The following conditions should apply: $l_1 = l_2 = l_3 = \begin{cases} D_o, \text{ for } D_o \geqslant 0{,}5 \text{ m} \\ 0{,}5 \text{ m, for } D_o < 0{,}5 \text{ m} \end{cases}$

or $l_3 = h + D_r/2$

The arrangement of the measuring points shall be as follows.

a) For the determination of total sound power levels L_W(A,tot) casing and free inlet sound power L_W(B,in+cas) and casing and free outlet sound power L_W(C,out+cas). The measurement surface and the arrangement of the measuring points as shown in Figure 1 with a measurement distance of 1 m shall be used, unless the largest value of D_o for the inlet orifice or for the outlet orifice exceed 1 m. For this case, a measurement distance, D_r, equal to D_o, shall be used (see Note). In the vicinity of the outlet orifice, the measuring points shall be arranged in such a way that the air flow does not come into contact with the microphone (similar to Figure 1 for fans with outlet orifice). The use of a foam windscreen is recommended as an additional precaution.

b) For the determination of casing sound power level L_W(D,cas), the rectangular parallelepiped measurement distance preferably being 1 m.

c) For the determination of free inlet or free outlet sound power level L_W(B,in) or L_W(C,out), the rectangular parallelepiped measurement surface and the arrangement of the measuring points as shown in Figure 1 shall be used. In this respect, D_r and the arrangement of the measuring points are functions of D_o or h.

NOTE This arrangement ensures that the S_s portion of the measurement surface which is exposed to the discharge flow, in the case of fans with outlet orifice, has a surface area of less than 10 % of the total measurement surface area, S.

The use of a foam windscreen is recommended for microphone positions situated close to the discharge flow. A turbulence screen (sampling tube) should not be used.

4.4 Arrangement of measuring points (large sphere or hemisphere)

The general principle is that the microphone positions lie on a hypothetical surface completely enveloping the source or, if there is a reflecting plane, enveloping the source and terminating on the reflecting plane.

When the measurement surface is a sphere, it shall be centred on the geometric centre of the fan inlet or outlet plane as appropriate, or the duct end for small ducted fans.

When the measurement surface is a hemisphere, it shall be centred on the projection of the fan inlet or outlet onto the reflecting surface for installation types B and C respectively. For installation type A, the fan inlet or outlet shall be at the centre of the hemisphere. For ducted small fans, the hemisphere shall be centred on the projection of the duct end onto the reflecting surface.

The radius of the measurement surface shall be sufficiently great to ensure that the positions at which the sound pressure measurements are performed are not within the acoustic near field of the fan. The extent of the acoustic near field is approximated by defining a characteristic dimension, D_o, which shall be related to the fan size and its location.

NOTE The maximum radius of the measurement surface may be constrained by the magnitude of the environmental corrections, K_2, becoming greater than 2 dB at large distances, or by the background noise level becoming too high at large distances.

4.4.1 Hemispherical measurement surface (installation type A)

The measurement surface shall be a hemisphere of radius r centred at $x = 0$, $y = 0$, $z = 0$

where

$$3D_e \leqslant r$$

The radius of the hemisphere shall be at least three times the equivalent diameter D_e and not less than 1 m. For type A installations, $D_o = D_e$.

4.4.2 Characteristic dimension D_o (installation types B, C and D)

If the fan inlet or outlet diameter or equivalent diameter is D_e, the fan shall be mounted so that the distance, h, from the ground reflecting plane to the centreline of the fan inlet or discharge is not less than D_e.

NOTE For ducted small fans, D_e is the diameter of the duct.

When the fan is to be installed with its inlet or outlet centreline closer than the distance D_e to the reflecting plane, it should be tested as such, and this should be noted in the test report.

The characteristic dimension, D_o, is:

$$D_o = h + (D_e/2)$$

when the fan opening at inlet or outlet is circular, and

$$D_o = h + (b_1/2) \text{ or } D_o = h + (b_2/2) \text{ whichever is the greater.}$$

where

b_1 is the greater dimension of the rectangular fan inlet, in metres;

b_2 is the greater dimension of the rectangular fan outlet, in metres.

4.4.3 Hemispherical and spherical measurement surfaces (installation types B, C and D)

The measurement surface shall be a hemisphere or sphere of radius, r, centred at $x = 0$, $y = 0$, $z = 0$.

r is given by the greater value of:

either $2D_o \leqslant r$

or $4h \leqslant r$

r shall not be less than 1 m.

4.4.4 Location of microphone positions

In order to obtain the average value of the mean square pressure on the surface of the test sphere or hemisphere, an array of microphone positions shall be used. The positions shall be distributed over the surface of the test sphere or hemisphere.

4.4.4.1 Hemispherical measurement surface

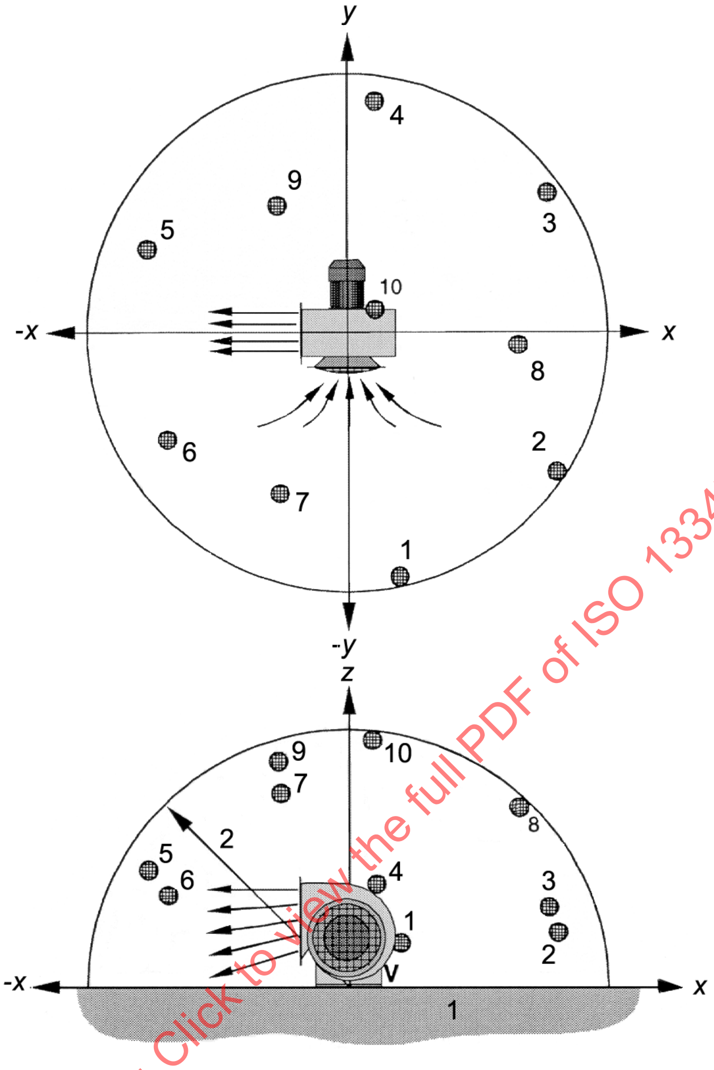
For installation type A, 10 microphone positions shall be distributed over the hemisphere. The Cartesian coordinate axis shall be defined so that the open inlet or outlet point along the positive x-axis and the z-axis is at right angles to the reflecting surface.

The points are indicated in Figure 2 and the coordinates are given in Table 2.

Table 2 — Coordinates of microphone locations for hemispherical measurement surface for type A installations and corresponding representative surface areas

Position i	x-coordinate x/r	y-coordinate y/r	z-coordinate z/r	Surface area S_i
1	0,16	– 0,96	0,22	0,2 πr^2
2	0,78	– 0,60	0,20	0,2 πr^2
3	0,78	0,55	0,31	0,2 πr^2
4	0,16	0,90	0,41	0,2 πr^2
5	– 0,83	0,32	0,45	0,2 πr^2
6	– 0,83	– 0,40	0,38	0,2 πr^2
7	– 0,26	– 0,65	0,71	0,2 πr^2
8	0,74	– 0,07	0,67	0,2 πr^2
9	– 0,26	0,50	0,83	0,2 πr^2
10	0,10	0,10	0,99	0,2 πr^2
				Total 2 πr^2

NOTE r is the radius of the hemispherical measurement surface.



Key

1 reference plane

2 radius of hemisphere r

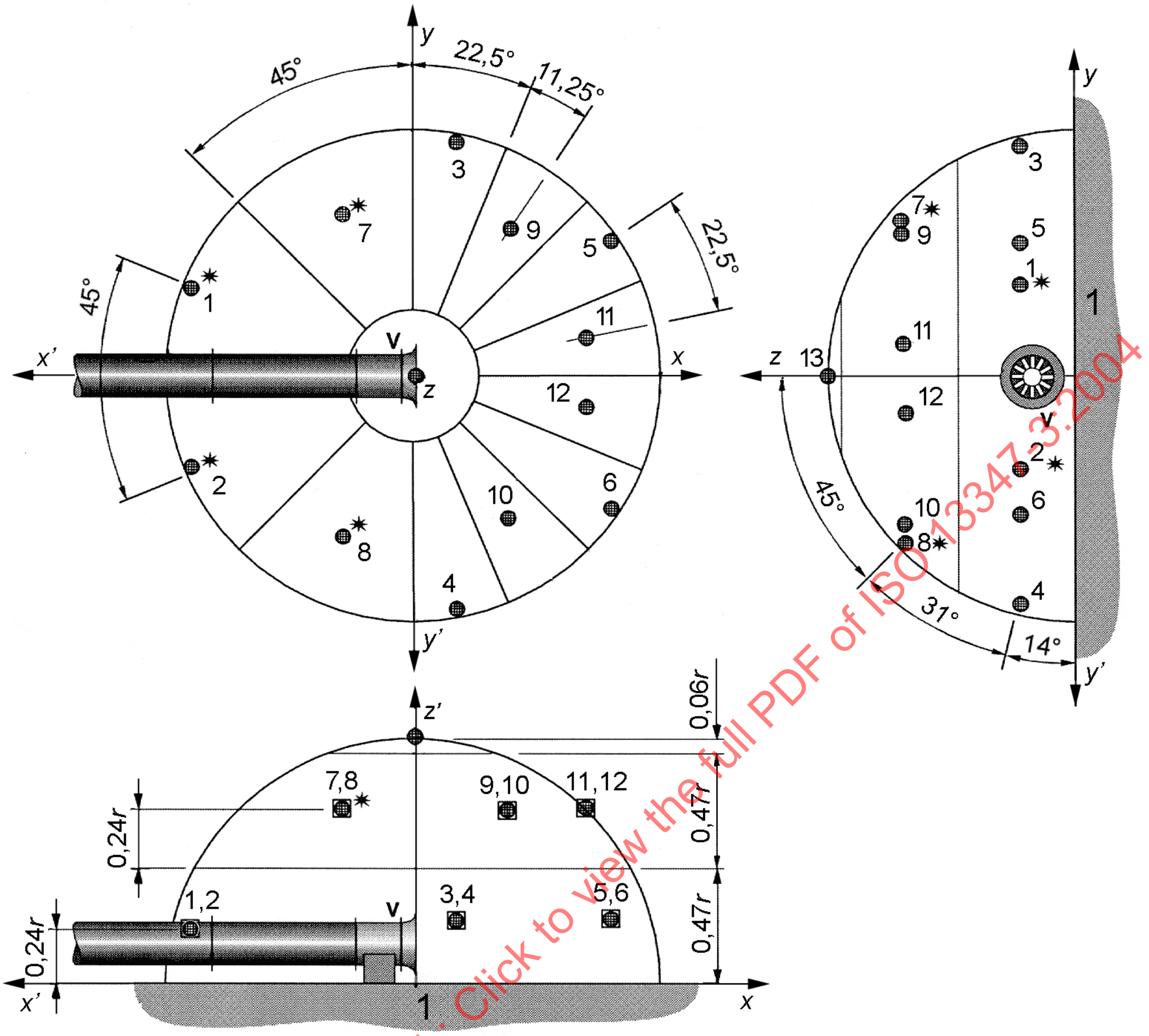
● indicates microphone position

V indicates position of fan

Figure 2 — Microphone positions for a hemispherical measurement surface for type A installation
(see Table 2)

For installation types B and C, 13 microphone positions shall be distributed over the hemisphere. The Cartesian coordinate axis shall be defined so that the open inlet or outlet point along the positive x-axis and the z-axis is at right angles to the reflecting surface.

The points are indicated in Figure 3 and the coordinates are given in Table 3.



Key

1 reference plane

V Fan position

Duct

Microphone position

Two such positions in line of sight

_____ Boundary of zone represented by microphone position

* Position representing zone of double normal area

Figure 3 — Microphone positions for a hemispherical measurement surface for type B and C installations (see Table 3)

Table 3 — Coordinate of microphone locations for hemispherical measurement surface for type B and C installations and corresponding representative surface areas

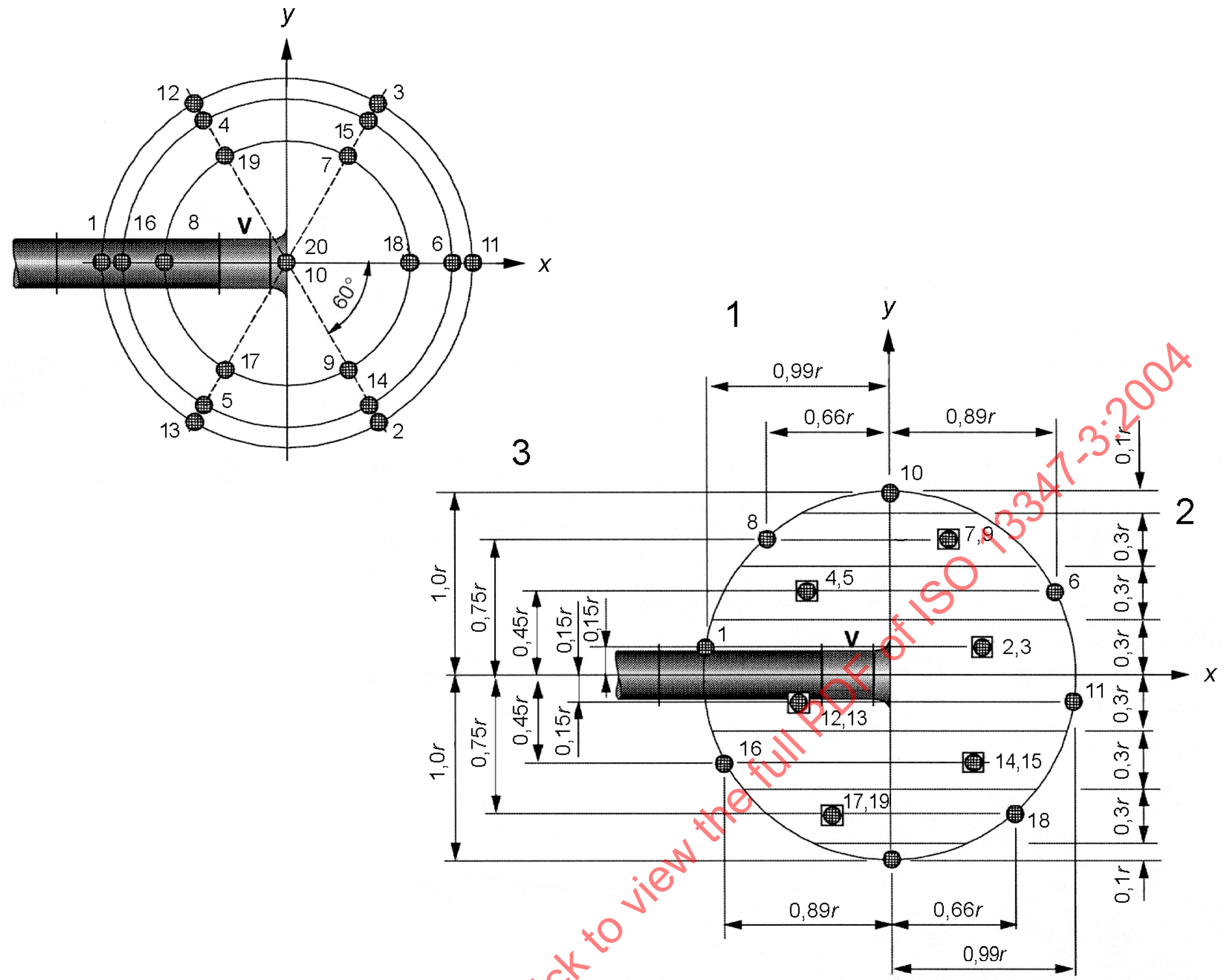
Position i	x-coordinate x/r	y-coordinate y/r	z-coordinate z/r	Surface area S_i
1	– 0,90	0,37	0,24	0,235 πr^2
2	– 0,90	– 0,37	0,24	0,235 πr^2
3	0,19	0,95	0,24	0,118 πr^2
4	0,19	– 0,95	0,24	0,118 πr^2
5	0,81	0,54	0,24	0,118 πr^2
6	0,81	– 0,54	0,24	0,118 πr^2
7	– 0,27	0,65	0,71	0,235 πr^2
8	– 0,27	– 0,65	0,71	0,235 πr^2
9	0,39	0,59	0,71	0,118 πr^2
10	0,39	– 0,59	0,71	0,118 πr^2
11	0,69	0,14	0,71	0,118 πr^2
12	0,69	– 0,14	0,71	0,118 πr^2
13	0,00	0,00	1,00	0,118 πr^2
				Total 2 πr^2

NOTE r is the radius of the hemispherical measurement surface.

4.4.4.2 Spherical measurement surface

Twenty microphone positions shall be distributed over the spherical surface. The Cartesian coordinate axis shall be defined so that the open inlet or outlet point along the positive x-axis and the z-axis points is vertically upwards.

The points are indicated in Figure 4 and the coordinates are given in Table 4.



Key

1 horizontal distance from centreline of array to microphone positions

2 height of corresponding areas of sphere

3 elevation of microphone positions

r radius of sphere

V Fan position

Duct

Microphone position

Two such positions in line of sight

_____ Boundary of zone represented by microphone position

* Position representing zone of double normal area

Figure 4 — Microphone positions for a spherical measurement surface (see Table 4)

Table 4 — Coordinates of microphone locations for spherical measurement surface and corresponding representative surface areas

Position i	x-coordinate x/r	y-coordinate y/r	z-coordinate z/r	Surface area S_i
1	– 0,99	0	0,15	0,2 πr^2
2	0,50	– 0,86	0,15	0,2 πr^2
3	0,50	0,86	0,15	0,2 πr^2
4	– 0,45	0,77	0,45	0,2 πr^2
5	– 0,45	– 0,77	0,45	0,2 πr^2
6	0,89	0	0,45	0,2 πr^2
7	0,33	0,57	0,75	0,2 πr^2
8	– 0,66	0	0,75	0,2 πr^2
9	0,33	– 0,57	0,75	0,2 πr^2
10	0	0	1,0	0,2 πr^2
11	0,99	0	– 0,15	0,2 πr^2
12	– 0,50	0,86	– 0,15	0,2 πr^2
13	– 0,50	– 0,86	– 0,15	0,2 πr^2
14	0,45	– 0,77	– 0,45	0,2 πr^2
15	0,45	0,77	– 0,45	0,2 πr^2
16	– 0,89	0	– 0,45	0,2 πr^2
17	– 0,33	– 0,57	– 0,75	0,2 πr^2
18	0,66	0	– 0,75	0,2 πr^2
19	– 0,33	0,57	– 0,75	0,2 πr^2
20	0	0	– 1,0	0,2 πr^2
				Total 4 πr^2
NOTE r is the radius of the spherical measurement surface.				

4.5 Arrangement of measuring points (small hemisphere)

For each inlet incorporated in the fan under test, a measuring surface will be defined. If there are several inlets, the measuring surfaces shall not overlap; moreover, they shall be such that the measurement at any point of the surface corresponding to an inlet is not affected by the sound power emitted by the other inlet or inlets.

The measurement surface is a hemisphere, the centre of which is located at the intersection of the axis of symmetry of each inlet and of the plane normal to this axis at the inlet under consideration. This hemisphere is located on the upstream side with respect to the inlet (see Figures 5 and 6).

The radius of this hemisphere (see Figure 5 and 6 for the definition of D_N) will be taken as:

$$r = 1 + 0{,}5D_N$$

The measurement surface has an area S equal to $2\pi r^2$.

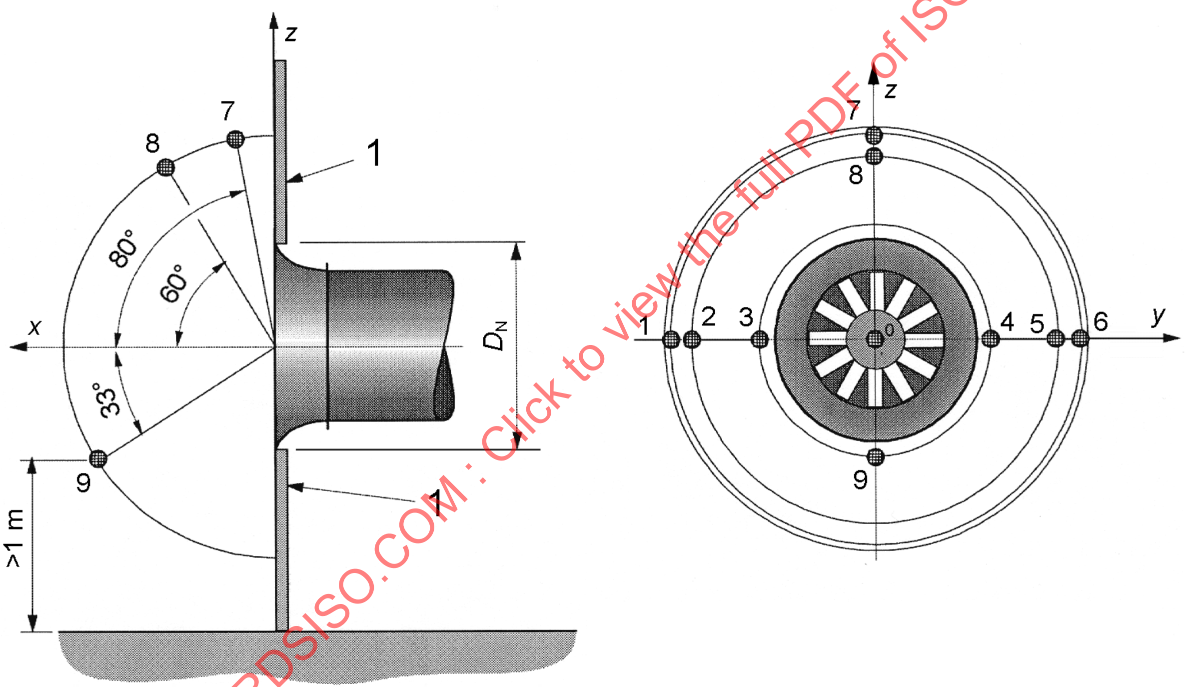
where

r and D_N are expressed in metres;

S is expressed in square metres.

Table 5 — Circular inlet — Measuring positions

Measuring positions reference	Cone half-angle in degrees	x	y	z
6	80	0,174r	0,985r	0
1			– 0,985r	
5	60	0,500r	0,866r	0
2			– 0,866r	
3	33	0,839r	0,545r	0
4			– 0,545r	
7	80	0,174r	0	0,985r
8	60	0,500r	0	0,866r
9	33	0,838r	0	– 0,545r



Key

1 reflecting plane

Figure 5 — Circular inlet — Measuring positions (see Table 5)