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ISO 5135

Third edition
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Acoustics — Determination of sound power levels of noise from air-terminal devices, air-terminal units, dampers and valves by measurement in a reverberation test room

Acoustique — Détermination des niveaux de puissance acoustique du bruit émis par les bouches d'air, les unités terminales, les registres et clapets au moyen de mesurages en salle réverbérante

Reference number
ISO 5135:2020(E)

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Foreword

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

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO 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).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see www.iso.org/iso/foreword.html.

This document was prepared by ISO/TC 43, *Acoustics*, Subcommittee SC 1, *Noise*.

This third edition cancels and replaces the second edition (ISO 5135:1997), which has been technically revised. The main changes compared to the previous edition are as follows:

— replacement of rescinded and unavailable reference standards (ISO 5219:1984[1)] and ISO 5220:1981[2)]) with currently available and up to date standards (ANSI/ASHRAE 70 and ANSI/ASHRAE 130 or EN 12238, EN 12239 and EN 1751);

— a reference to a companion document (ISO 7235) was added to deal with transmission elements and physical elements used in the test setup;

— a clause on uncertainty was added.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

1) Withdrawn.

2) Withdrawn.

Introduction

This document defines requirements for acoustic testing of air-terminal devices, air-terminal units, dampers and valves used in air diffusion and air distribution systems in reverberation test rooms. It is based on the use of ISO 3741, which describes the acoustic test facilities, instrumentation and procedures to be used for precision grade determination of sound power levels in octave or one-third-octave bands of a noise source.

Acoustics — Determination of sound power levels of noise from air-terminal devices, air-terminal units, dampers and valves by measurement in a reverberation test room

1 Scope

This document establishes general rules for the acoustic testing of air-terminal devices, air-terminal units, dampers and valves used in air diffusion and air distribution systems in order to determine sound power levels as defined in ISO 3741.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 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 5167 (all parts), *Measurement of fluid flow by means of pressure differential devices inserted in circular cross-section conduits running full*

ISO 7235, *Acoustics — Laboratory measurement procedures for ducted silencers and air-terminal units — Insertion loss, flow noise and total pressure loss*

ANSI/ASHRAE 70, *Method of Testing the Performance of Air Outlets and Air Inlets*

ANSI/ASHRAE 130, *Laboratory Methods of Testing Air Terminal Units*

EN 1751, *Ventilation for buildings — Air terminal devices — Aerodynamic testing of damper and valves*

EN 12238, *Ventilation for buildings — Air terminal devices — Aerodynamic testing and rating for mixed flow application*

EN 12239, *Ventilation for buildings — Air terminal devices — Aerodynamic testing and rating for displacement flow applications*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

3.1
sound pressure level
L_p
ten times the logarithm to the base 10 of the ratio of the square of the sound pressure, p, to the square of a reference value, p_0, expressed in decibels

$$L_p = 10 \lg \frac{p^2}{p_0^2} \text{ dB}$$

where the reference value p_0 is 20 µPa

[SOURCE: ISO/TR 25417:2007, 2.2, modified — Notes 1 and 2 to entry have been deleted.]

3.2
sound power level
L_W
ten times the logarithm to the base 10 of the ratio of the sound power, P, to a reference value, P_0, expressed in decibels

$$L_W = 10 \lg \frac{P}{P_0} \text{ dB}$$

where the reference value, P_0, is 1 pW

Note 1 to entry: If a specific frequency weighting as specified in IEC 61672-1 and/or specific frequency bands are applied, this is indicated by appropriate subscripts; e.g. L_{WA} denotes the A-weighted sound power level.

Note 2 to entry: This definition is technically in accordance with ISO 80000-8:2020, 8-15.

[SOURCE: ISO/TR 25417:2007, 2.9, modified - In the Note 2 to entry, the reference to ISO 80000-8 has been updated to its latest edition.]

3.3
frequency range of interest
range that includes the octave bands with nominal mid-band frequencies between 125 Hz and 8 000 Hz (optional between 63 Hz and 8 000 Hz) or the one-third-octave bands with mid-band frequencies between 100 Hz and 10 000 Hz (optional between 50 Hz and 10 000 Hz)

Note 1 to entry: The user is encouraged to qualify the room in the 63 Hz octave band and include this sound. Some equipment can generate significant sound in the 63 Hz octave band.

4 Acoustic test facilities and procedures

The acoustic test facilities, instrumentation and procedures that shall be used, including room qualification tests, are described in ISO 3741.

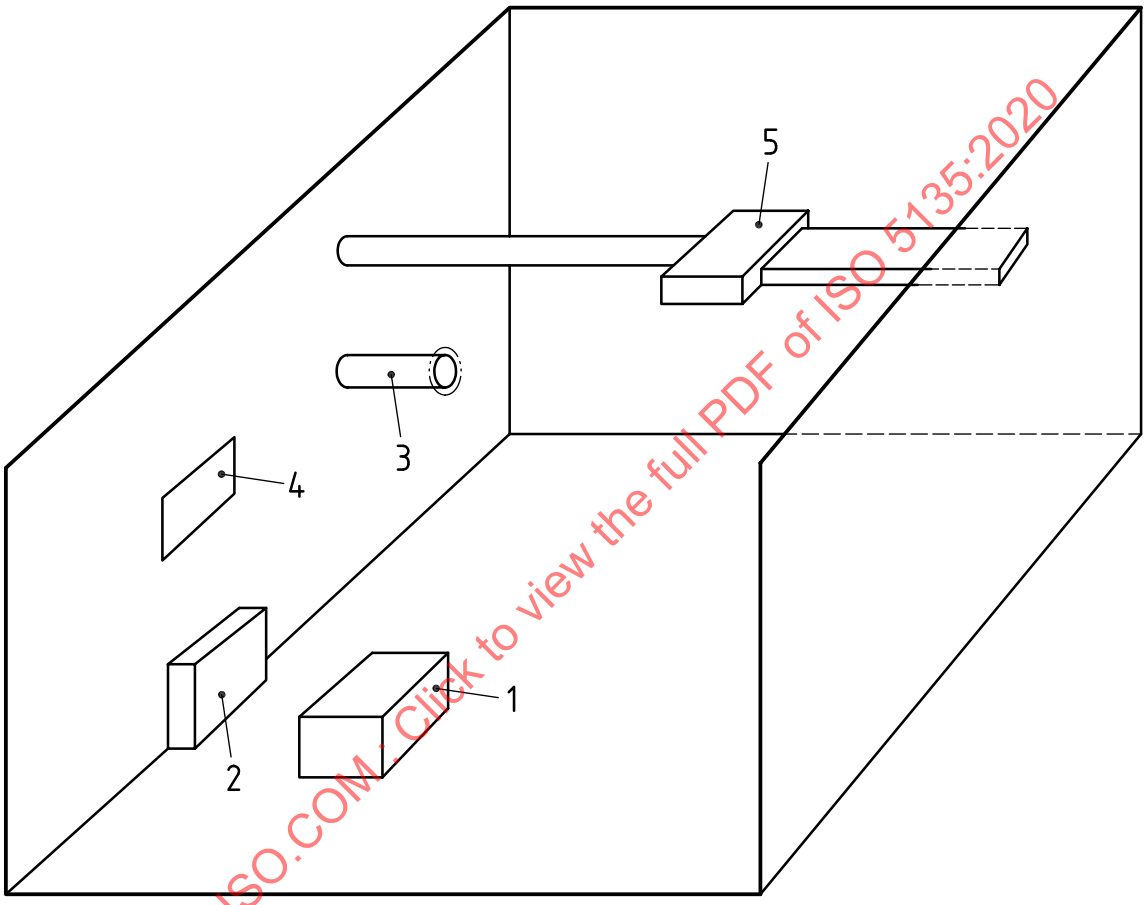
This document is applicable to equipment operating under steady state conditions and with a volume not greater than 5 % of the volume of the reverberation test room.

If the equipment is greater than 2 % up to 5 % of the room volume, then the test room shall be qualified according to ISO 3741 with all equipment present in the room. The test facilities shall be qualified for broad-band sound per the corresponding annex in ISO 3741.

5 Installation and operation of equipment to be tested

5.1 General

5.1.1 When the equipment is mounted closer than 1,0 m to one or more reflecting planes, the sound power level can depend strongly on the position of the equipment relative to these planes. Therefore, install the equipment to be tested in a position representative of normal usage. Figure 1 illustrates the overall test environment, with the specific details of each type shown in Figures 2 to 7.



Key

1 air-terminal device installed on or against a surface (see Figure 2)

2 air-terminal device installed at intersection of two surfaces (see Figure 3)

3 air-terminal device installed away from surface (see Figure 4)

4 air-terminal device installed outside room boundary (see Figures 5 and 6)

5 mounting detail for air-terminal unit to determine casing radiated sound (see Figure 7)

NOTE See 5.2, 5.3 and 5.4 for mounting details.

Figure 1 — Location of equipment in test room

Reflecting planes may, for practical reasons, be simulated by panels with an area-related mass greater than 7 kg/m^2. Such panels shall extend at least 1,0 m in all directions measured from any edge of the equipment under test. The distance of 1,0 m is a deviation from the required 1,5 m specified in ISO 3741. These panels shall be vibration isolated from the equipment under test. If such a panel is used, the room with the reflecting panel shall be qualified for broad-band sound per the corresponding annex in ISO 3741.

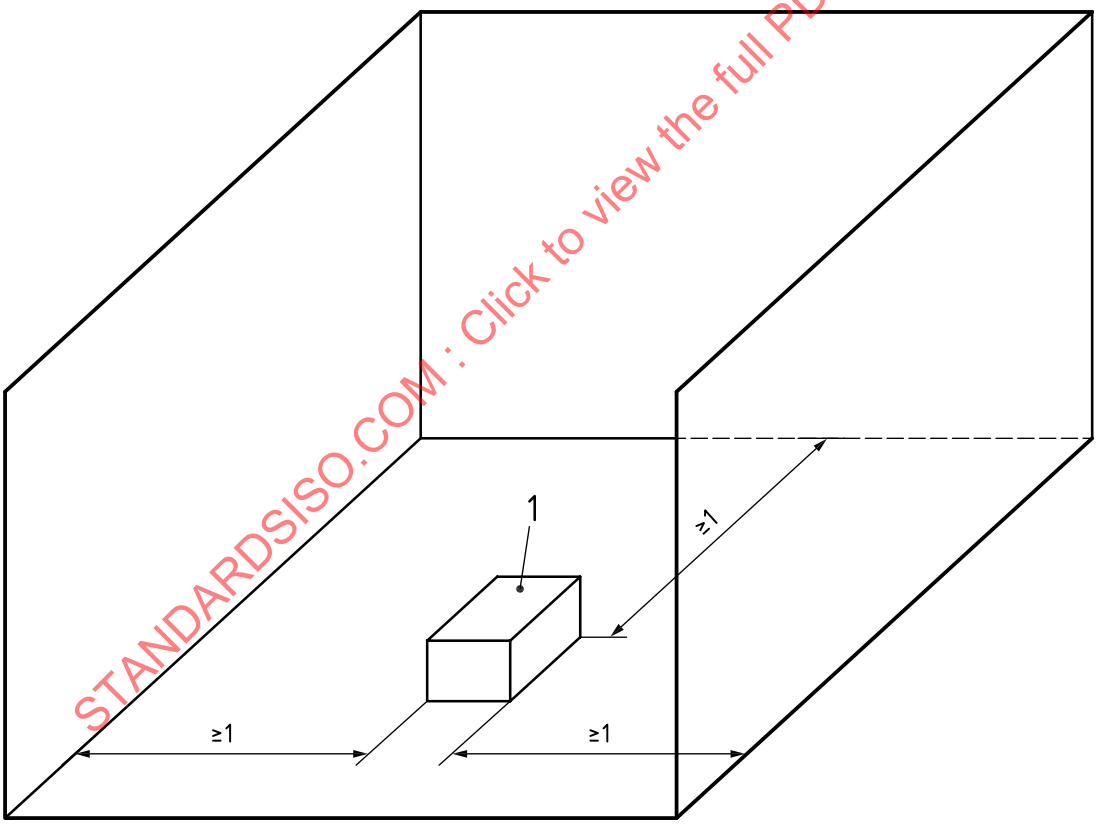
5.1.2 Supply air to the equipment under test or exhaust air from it through a test installation in accordance with either ANSI/ASHRAE 130 and ANSI/ASHRAE 70 or EN 12238, EN 12239 and EN 1751. If EN 12238, EN 12239 and EN 1751 are followed, the airflow rate shall be measured using instruments in accordance with the ISO 5167 series. Airflow measuring devices sometimes generate sound. If the sound generated by the device adds to the sound produced by the unit, it is recommended that a two-step process is used in which the airflow is measured first and then measure sound using the same static pressure or pressure differentials.

5.1.3 Include air-flow control accessories (dampers, deflectors, straighteners, equalizers, etc.) normally used in conjunction with the equipment under test in the test setup. Locate and set them in the same manner as recommended for the application of the equipment.

5.2 Test installation of air-terminal devices, air-terminal units, dampers and valves for measurement of the sound radiated to the reverberation test room

5.2.1 Position air-terminal devices normally installed in a boundary surface no closer than 1,0 m to the intersection of any adjacent surface and away from any position of boundary surface symmetry, as shown in Figure 2. The room surface on which the equipment is located can be the floor as shown, any wall, or the ceiling.

Dimensions in metres



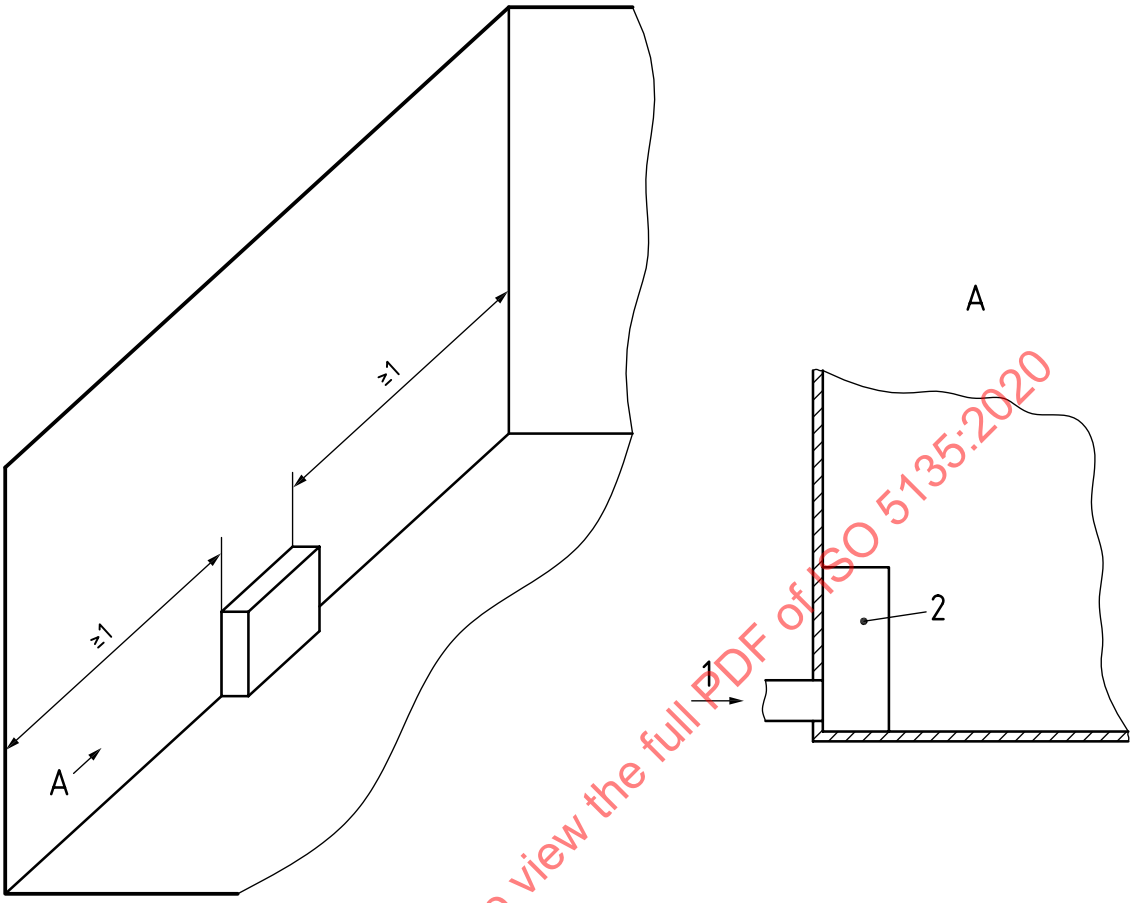
Key

1 air-terminal device installed on or against a surface

Figure 2 — Mounting detail for air-terminal device installed on or against a surface as described in ASHRAE 130, EN 12238 or EN 12239

5.2.2 Mount air-terminal devices normally used at the intersection of two surfaces at the intersection of the two surfaces not closer than 1,0 m to a third surface as shown in Figure 3.

Dimensions in metres



Key

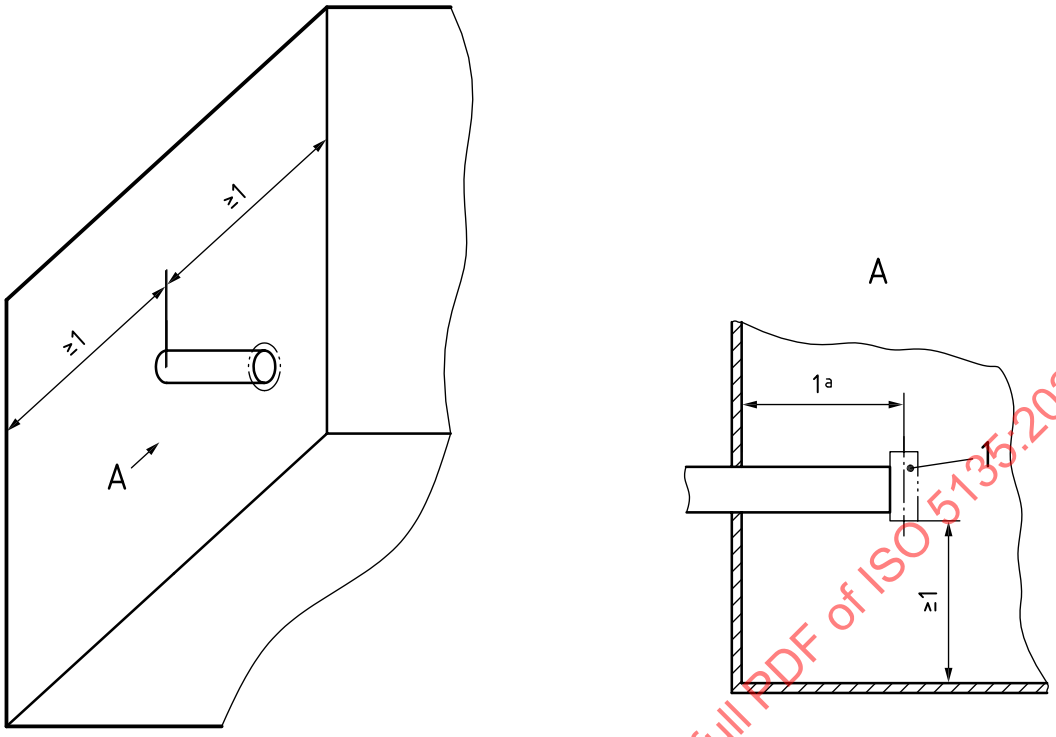
1 quiet air supply

2 equipment under test

Figure 3 — Mounting detail for equipment installed at intersection of two surfaces

5.2.3 Install air-terminal devices not normally positioned at any boundary surface within the test room no closer than 1,0 m to any surface and away from any position of room symmetry. Examples are shown in Figure 4. Diffusers installed on ducts without adjacent ceiling are typical examples.

Dimensions in metres



Key

1 equipment under test

[a] 1 m or as defined by the manufacturer.

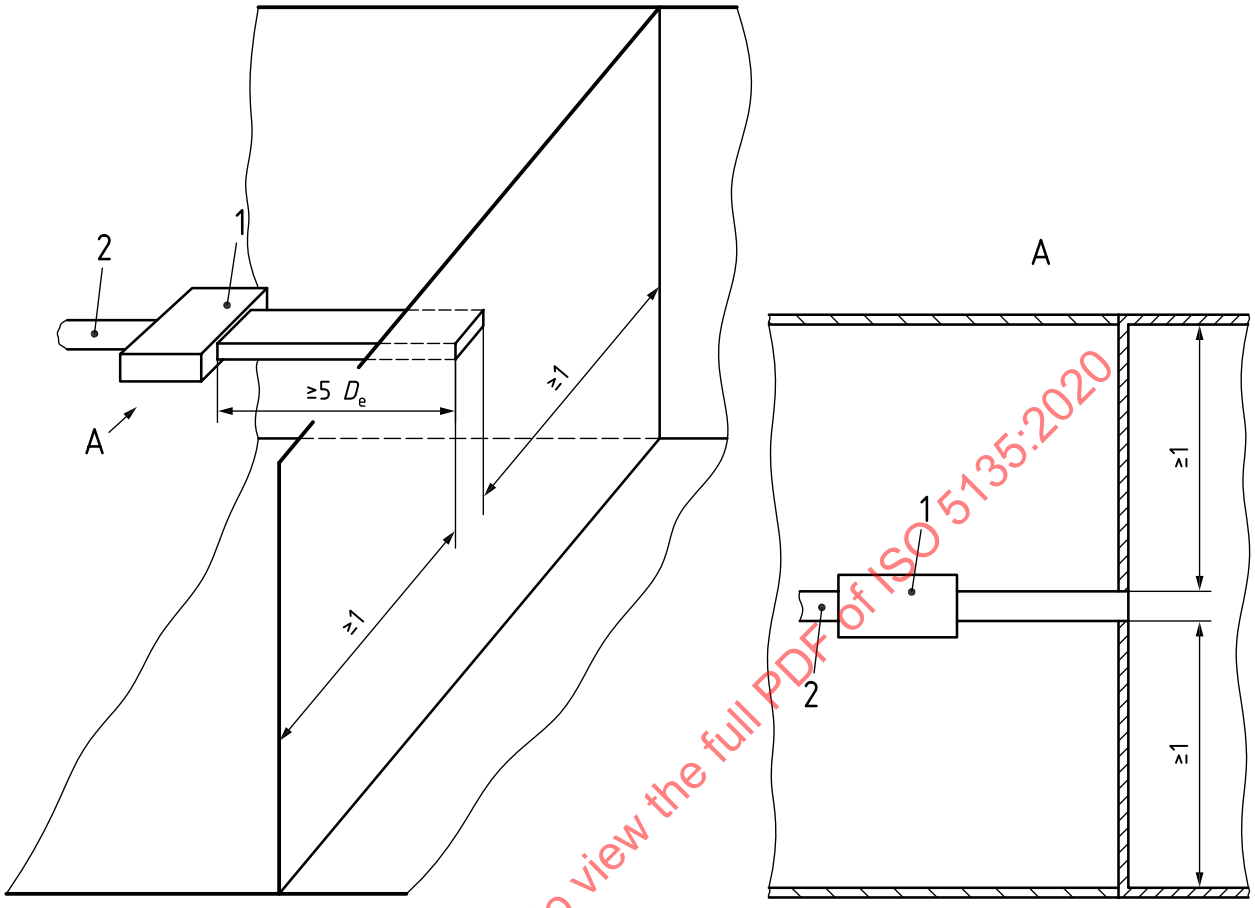
Figure 4 — Mounting detail for air-terminal device installed inside reverberation test room but away from a room surface

5.2.4 The installation details specified in 5.2.1 to 5.2.3 apply equally to air-terminal devices when integral with air-terminal units. In this case, measure a combined total of radiated sounds.

5.3 Test installation of air-terminal devices, air-terminal units, dampers and valves for the measurement of the sound radiated to the reverberation test room by the connecting duct

To measure equipment normally located above the ceiling or in another space adjacent to the room they serve, install the equipment outside the test room and connect it to the test room by an unlined duct 2 m long or 5 effective diameters, D_e, whichever is greater of the same cross-sectional shape and area as the equipment connection in the room (see Figure 5). Terminate the duct flush with a surface of the test room and no closer than 1,0 m to any adjacent surface and away from any position of room symmetry. Examples are shown in Figure 5.

Dimensions in metres



Key

1 equipment under test

2 quiet air supply or quiet exhaust

Figure 5 — Mounting detail for air-terminal units, dampers, and valves installed outside room boundary and ducted to the reverberation test room as described in ASHRAE 130, EN 1751

The diameter of a circular duct or the effective diameter of a rectangular duct, D_e, in meters, is given by Formula (1):

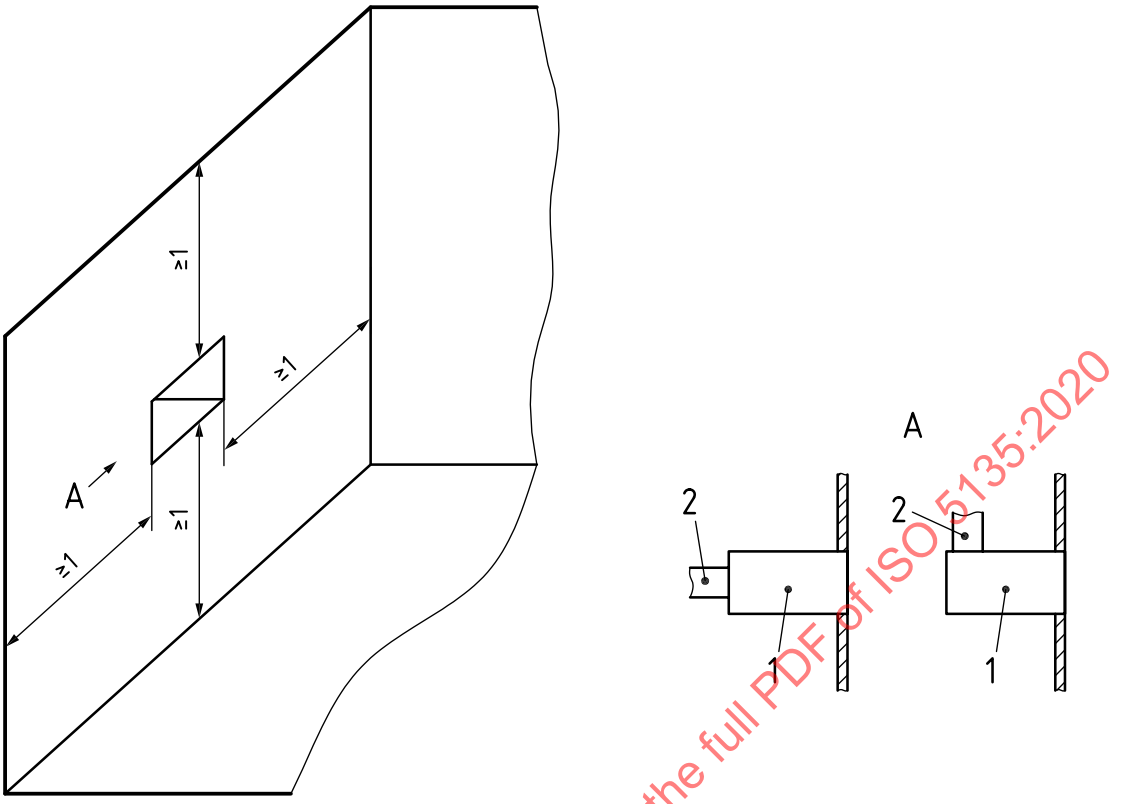
$$D_e = \left(\frac{4A}{\pi}\right)^{0.5} \tag{1}$$

where A is the cross sectional area of the duct, in m^2.

5.4 Test installation of air-terminal devices, air-terminal units, dampers and valves for the measurement of the sound radiated to the reverberation test room directly from the equipment under test

To measure equipment normally located above the ceiling or in another space adjacent to the room they serve, install the equipment outside the test room and connect it to the test room through an opening with same cross-sectional shape and area as the equipment connection to the room (see Figure 6). Locate the opening such that all surfaces of the test room are no closer than 1,0 m and away from any position of room symmetry. Examples are shown in Figure 6.

Dimensions in metres



Key

1 equipment under test

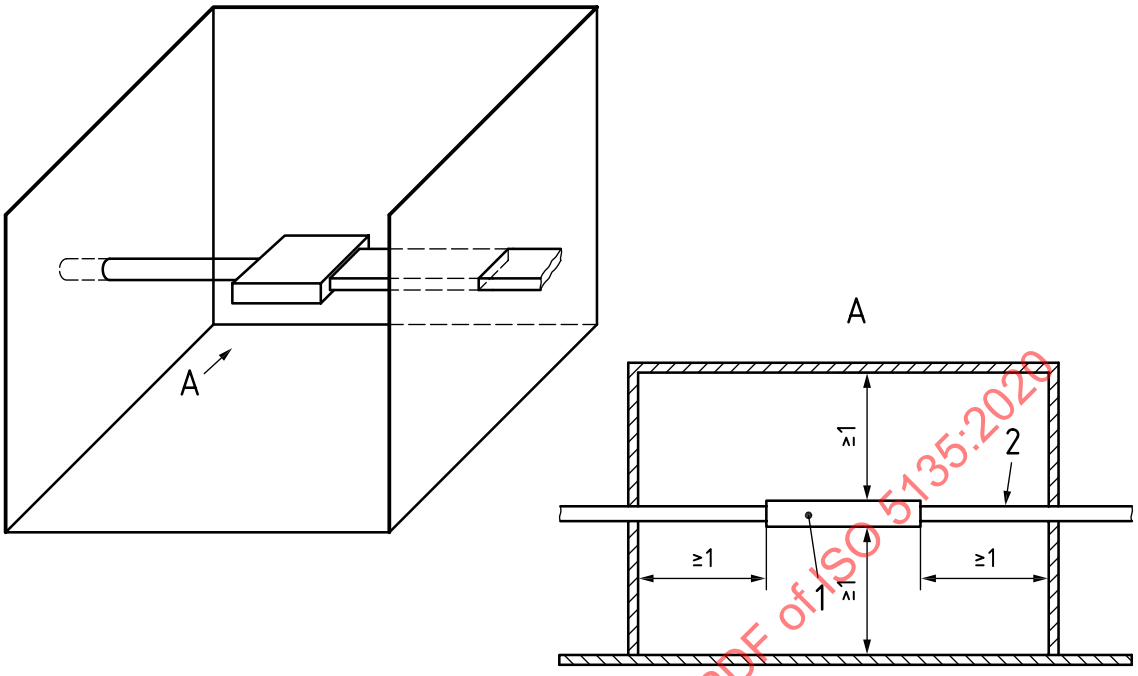
2 quiet air supply

Figure 6 — Mounting detail for an air-terminal device installed on or against a surface without a duct as described in ASHRAE 130, EN 12238, or EN 12239

5.5 Test installation of air-terminal units for the determination of casing radiated noise

To determine the sound radiated from the equipment casing, install the unit in the reverberation test room with suitable connecting ducts such that the background criteria for noise from sources other than the equipment under test through these ducts meets the ISO 3741 limits. Noise from the equipment under test can also break out of the ducts and care should be taken to minimize such breakout noise by using for example double wall ducts, high transmission loss walls, or other assemblies so that the breakout noise is at least 6 dB below the sound radiated by the equipment under test. Install the unit within the size limits as shown in Figure 7. Two ducts connecting the unit to the outside of the reverberation test room are required.

Dimensions in metres



Key

1 equipment under test

2 acoustically isolated duct

NOTE Duct can be circular or rectangular according to the device.

Figure 7 — Mounting detail for air-terminal unit to determine casing radiated sound

5.6 Test procedures

5.6.1 Carry out acoustic measurements while the equipment is operating over a range of conditions typical of its normal use as declared by the manufacturer.

5.6.1.1 For non-adjustable air-terminal devices, carry out sound measurements for a minimum of 4 air-flow rates over the upper half of the range used to determine the air-terminal device pressure requirements. The flow rates shall cover the minimum, maximum and at least two intermediate flow rates (for example minimum, 40 %, 70 %, and 100 % of maximum flow). These values were chosen because the sound is related to the logarithm of the airflow.

If the minimum flow results in sound levels below the background in the test facility, the minimum flow can start at 50 % of the maximum and then apply the method provided in 5.6.2. For this case, measure at 50 %, 63 %, 80 % and 100 % of the range maximum. To get evenly spaced noise levels, the airflow values should follow a logarithmic relationship to be calculated between the minimum and the maximum of the range of the air-flow rates considered.

5.6.1.2 For adjustable pattern air-terminal devices, carry out sound measurements per 5.6.1.1 for each of the adjustment positions for which the test data is required.

5.6.1.3 For air-terminal units with adjustable flow rate, carry out sound measurements for a minimum of four air-flow rates, each at the minimum, maximum and at least two intermediate flow rates. If the minimum flow results in levels too low to measure, the minimum flow can start at 50 % of the maximum and then apply the method provided in 5.6.2.

5.6.2 If the operation of equipment in its normal range generates sound pressure levels below the criteria for background noise in ISO 3741, then higher flow rates may be used and acoustic results recorded at least at the specified number of tests and extrapolated to the normal range. These additional flow rates shall not exceed 200 % of the maximum of the normal range.

The following procedure may be used for extrapolation.

a) In the case of tests made at a constant total pressure loss coefficient, plot values of sound power levels, L_W, for each octave band and of A-weighted sound power levels, L_{WA}, against $\lg(q_V)$, where q_V is the numerical value of the volume flow rate.

b) In the case of tests made at a constant flow rate, plot L_W for each octave or band and L_{WA} against $\lg(\Delta p_t)$, where Δp_t is the numerical value of the total pressure loss.

The octave band L_W values plotted against $\lg(q_V)$ or $\lg(\Delta p_t)$ shall be in a straight line. If necessary, remove the lower values corresponding to sound power levels which do not emerge from the background noise.

Determine best-fit straight lines through the points for each parameter using the least squares method. The maximum deviation between the measured points and a straight line shall be ±3 dB. Values of L_W or L_{WA} corresponding to specific values of q_V or Δp_t within the above range may be derived within the limit of 50 % of the lowest q_V or Δp_t for which a correct measurement has been carried out. The overall L_W and L_{WA} are deduced from the derived octave band values.

6 Auxiliary facilities for acoustic testing

6.1 Provide a quiet air system so that any noise produced by the system meets the criteria for background noise in ISO 3741. Correct for background noise sound pressure levels in accordance with ISO 3741.

For the purpose of this document, the background noise sound pressure level during test with air flow through the air-terminal device shall be checked by removing the air-terminal device and measuring the sound pressure levels at approximately the same volume rates of air flow used in the test.

6.2 Vent air to or from the test room in a manner that the background noise intruding into the room through the opening does not exceed the criteria for background noise. Carry out all sound measurements of the equipment under test, the reference sound source and background noise (see 6.1) with the openings as used during the sound power tests. Noise generated by flow through sound attenuators, if present, shall be in accordance with the requirements for background noise (see 6.1).

7 Measurements and calculations

The determination of the importance of discrete-frequency or narrow-band components, the qualification of the reverberation test room, the measurements of the sound pressure levels and the calculation of the sound power levels for all octave bands within the frequency range of interest and the calculation of A-weighted sound power level, L_{WA}, shall be carried out in accordance with ISO 3741.

In the case of the installation described in 5.3, calculate the sound power level in the connecting duct, $L_{W\text{duct}}$, by adding the end reflection loss of the open duct, $E_{1(n)}$, to the sound power level, L_W, radiated into the room according to Formula (2):

$$L_{W\text{duct}} = L_W + E_{1(n)} \tag{2}$$

For the sound power in a duct, the value for the duct end correction (see Reference [6]), $E_{1(n)}$, can be expressed by Formula (3):

$$E_{1(n)} = 10\lg\left[1+\left(\frac{c}{4\pi f_n}\right)^2 \frac{\Omega}{S}\right]\text{dB} \tag{3}$$

where

f_n is the band centre frequency, Hz;

c is the speed of sound in air, in metres per second, at the temperature, θ, in degrees Celsius, of the air in the reverberation test room at the time of test, $c = 20{,}05\,(273 + \theta)^{0,5}$;

S is the cross-section of the duct opening;

Ω is the solid angle of radiation, equal to 2π for a flush termination, and equal to 4π for a free termination which penetrative length is more than ½ wavelength of the lowest frequency;

(n) variable quantity

For ducted dampers and valves using a transmission element according to ISO 7235 and using a duct with a diameter greater than or equal to 1 m, it may be used without any correction per Formula (3). For ducted dampers and valves using a transmission element according to ISO 7235 with a duct having a diameter less than 1 m, a correction per Formula (3) based on the transition ending diameter shall be used.

8 Measurement uncertainty

The guidance on the development of information on measurement uncertainty contained in the relevant clauses of ISO 3741, as applicable, can be used for determining uncertainty of acoustic measurements.

The uncertainties of sound power levels, $u(L_W)$, in decibels, determined in accordance with this document are estimated by the total standard deviation, σ_{tot}, in decibels, as given in Formula (4):

$$u(L_W) \approx \sigma_{\text{tot}} \tag{4}$$

This total standard deviation is obtained by using the modelling approach described in ISO/IEC Guide 98-3. This requires a mathematical model, which in case of lack of knowledge, can be replaced by results from measurements, including results from round robin tests.

In the context of acoustic measurements, the total standard deviation, σ_{tot}, is expressed by the standard deviation of reproducibility of the method, σ_{R0}, in decibels, and the standard deviation, σ_{omc}, in decibels, describing the uncertainty due to the instability of the operating and mounting conditions of the equipment under test in accordance with Formula (5):

$$\sigma_{\text{tot}} = \left(\sigma_{R0}^2 + \sigma_{\text{omc}}^2\right)^{0,5} \tag{5}$$

For determination of the total standard deviation, see Table 1.