



**Acoustics — Determination of sound
power levels and sound energy levels of
noise sources using sound pressure —
Precision methods for anechoic rooms
and hemi-anechoic rooms**



AS 5336:2019

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Preface

This Standard was prepared by the Australian members of the Joint Standards Australia/Standards New Zealand Committee EV-010, Acoustics Community Noise.

After consultation with stakeholders in both countries, Standards Australia and Standards New Zealand decided to develop this Standard as an Australian Standard rather than an Australian/New Zealand Standard.

Changes to the Preface required by Amendment No. 1 of AS 5336:2019 are indicated in the text by a marginal bar.

The objective of this Standard is to specify methods for measuring the sound pressure levels on a measurement surface enveloping a noise source (machinery and equipment) in an anechoic room or a hemi-anechoic room, in order to determine the sound power level or sound energy level produced by the noise source. This Standard specifies requirements for the test environment and instrumentation, as well as techniques for obtaining the surface sound pressure level from which the sound power level or sound energy level is calculated, leading to results which have a grade 1 accuracy.

A1 | This Standard is identical with, and has been reproduced from, ISO 3745:2012, *Acoustics — Determination of sound power levels and sound energy levels of noise sources using sound pressure — Precision methods for anechoic rooms and hemi-anechoic rooms and its Amendment 1 (2017)* which is added following the source text.

This Amendment replaces Annex A with procedures for qualification of anechoic and hemi-anechoic rooms.

As this document has been reproduced from an International Standard, the following applies:

- (a) In the source text “this International Standard” should read “this Australian Standard”.
- (b) A full point substitutes for a comma when referring to a decimal marker.

Australian or Australian/New Zealand Standards that are identical adoptions of international normative references may be used interchangeably. Refer to the online catalogue for information on specific Standards.

The terms “normative” and “informative” are used in Standards to define the application of the appendices or annexes to which they apply. A “normative” appendix or annex is an integral part of a Standard, whereas an ‘informative’ appendix or annex is only for information and guidance.

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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 3745 was prepared by Technical Committee ISO/TC 43, *Acoustics*, Subcommittee SC 1, *Noise*.

This third edition cancels and replaces the second edition (ISO 3745:2003), which has been technically revised.

Introduction

This International Standard is one of the series ISO 3741^[3] to ISO 3747^[8], which specify various methods for determining the sound power levels and sound energy levels of noise sources including machinery, equipment and their sub-assemblies. The selection of one of the methods from the series for use in a particular application depends on the purpose of the test to determine the sound power level or sound energy level and on the facilities available. General guidelines to assist in the selection are provided in ISO 3740^[2]. ISO 3741^[3] to ISO 3747^[8] give only general principles regarding the operating and mounting conditions of the machinery or equipment for the purposes of the test. It is important that test codes be established for individual kinds of noise source, in order to give detailed requirements on mounting, loading and operating conditions under which the sound power levels or sound energy levels are to be obtained and to select the appropriate measurement surface and microphone array from among those specified in this International Standard.

The methods given in this International Standard require the source to be mounted in either an anechoic room or a hemi-anechoic room having specified acoustical characteristics. The methods are then based on the premise that the sound power or sound energy of the source is directly proportional to the mean-square sound pressure over a hypothetical measurement surface enclosing the source and otherwise depends on the physical constants of air.

The methods specified in this International Standard permit the determination of the sound power level and the sound energy level in frequency bands and/or with frequency A-weighting applied.

The methods give a precision grade of accuracy (grade 1) as defined in ISO 12001. The resulting sound power levels and sound energy levels include corrections to allow for any differences that might exist between the meteorological conditions under which the tests are conducted and reference meteorological conditions. For applications where there are large uncertainties due to operating conditions or where reduced accuracy is acceptable, reference can be made to the more practical methods of ISO 3744^[6] or ISO 3746^[7]. Guidance on evaluation of measurement uncertainty is given in Annex I.

Acoustics — Determination of sound power levels and sound energy levels of noise sources using sound pressure — Precision methods for anechoic rooms and hemi-anechoic rooms

1 Scope

1.1 General

This International Standard specifies methods for measuring the sound pressure levels on a measurement surface enveloping a noise source (machinery or equipment) in an anechoic room or a hemi-anechoic room. The sound power level (or, in the case of impulsive or transient noise emission, the sound energy level) produced by the noise source, in frequency bands of width one-third octave or with frequency weighting A applied, is calculated using those measurements, including corrections to allow for any differences between the meteorological conditions at the time and place of the test and those corresponding to a reference characteristic acoustic impedance.

In general, the frequency range of interest includes the one-third-octave bands with mid-band frequencies from 100 Hz to 10 000 Hz. In practice, the range is extended or restricted to frequencies beyond or within these limits, to those between which the test room is qualified for the purposes of the measurements.

1.2 Types of noise and noise sources

The methods specified in this International Standard are suitable for all types of noise (steady, non-steady, fluctuating, isolated bursts of sound energy, etc.) defined in ISO 12001.

The noise source under test can be a device, machine, component or sub-assembly. The maximum size of the noise source depends on specified requirements regarding the radius of the hypothetical sphere or hemisphere used as the enveloping measurement surface.

1.3 Test room

The test rooms that are applicable for measurements made in accordance with this International Standard are an anechoic room or hemi-anechoic room, also called, respectively, a free-field test room or hemi-free-field test room.

1.4 Measurement uncertainty

Information is given on the uncertainty of the sound power levels and sound energy levels determined in accordance with this International Standard, for measurements made in limited bands of frequency and with frequency weighting A applied. The uncertainty conforms to ISO 12001:1996, accuracy grade 1 (precision grade).

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 5725 (all parts), *Accuracy (trueness and precision) of measurement methods and results*

ISO 9613-1:1993, *Acoustics — Attenuation of sound during propagation outdoors — Part 1: Calculation of the absorption of sound by the atmosphere*

ISO 12001:1996, *Acoustics — Noise emitted by machinery and equipment — Rules for the drafting and presentation of a noise test code*

ISO/IEC Guide 98-3, *Uncertainty in measurement — Part 3: Guide to the expression of uncertainty in measurement (GUM:1995)*

IEC 60942:2003, *Electroacoustics — Sound calibrators*

IEC 61183, *Electroacoustics — Random-incidence and diffuse-field calibration of sound level meters*

IEC 61260:1995 + AM1:2001, *Electroacoustics — Octave-band and fractional-octave-band filters*

IEC 61672-1:2002, *Electroacoustics — Sound level meters — Part 1: Specifications*

3 Terms and definitions

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

3.1

sound pressure

p

difference between instantaneous pressure and static pressure

NOTE 1 Adapted from ISO 80000-8:2007^[22], 8-9.2.

NOTE 2 Sound pressure is expressed in pascals.

3.2

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

$$L_p = 10 \lg \frac{p^2}{p_0^2} \text{ dB} \quad (1)$$

where the reference value, p_0 , is 20 μPa

[ISO/TR 25417:2007^[20], 2.2]

NOTE 1 If specific frequency and time weightings as specified in IEC 61672-1 and/or specific frequency bands are applied, this should be indicated by appropriate subscripts; e.g. L_{pA} denotes the A-weighted sound pressure level.

NOTE 2 This definition is technically in accordance with ISO 80000-8:2007^[22], 8-22.

3.3

time-averaged sound pressure level

$L_{p,T}$

ten times the logarithm to the base 10 of the ratio of the time average of the square of the sound pressure, p , during a stated time interval of duration, T (starting at t_1 and ending at t_2), to the square of a reference value, p_0 , expressed in decibels

$$L_{p,T} = 10 \lg \left[\frac{\frac{1}{T} \int_{t_1}^{t_2} p^2(t) dt}{p_0^2} \right] \text{ dB} \quad (2)$$

where the reference value, p_0 , is 20 μPa

NOTE 1 In general, the subscript “ T ” is omitted since time-averaged sound pressure levels are necessarily determined over a certain measurement time interval.

NOTE 2 Time-averaged sound pressure levels are often A-weighted, in which case they are denoted by $L_{pA,T}$, which is usually abbreviated to L_{pA} .

NOTE 3 Adapted from ISO/TR 25417:2007^[20], 2.3.

3.4 single event time-integrated sound pressure level

L_E
ten times the logarithm to the base 10 of the ratio of the integral of the square of the sound pressure, p , of an isolated single sound event (burst of sound or transient sound) over a stated time interval T (starting at t_1 and ending at t_2) to a reference value, E_0 , expressed in decibels

$$L_E = 10 \lg \left[\frac{\int_{t_1}^{t_2} p^2(t) dt}{E_0} \right] \text{ dB} \quad (3)$$

where the reference value, E_0 , is $(20 \mu\text{Pa})^2 \text{ s} = 4 \times 10^{-10} \text{ Pa}^2 \text{ s}$

[ISO 3741:2010^[3], 3.4]

NOTE 1 This quantity can be obtained by $L_{p,T} + 10 \lg(T/T_0)$ dB, where $T_0 = 1 \text{ s}$.

NOTE 2 When used to measure sound immission (see ISO 11690-1^[19]), this quantity is usually called “sound exposure level” (see ISO/TR 25417:2007^[20], 2.7).

3.5 measurement time interval

T
portion or a multiple of an operational period or operational cycle of the noise source under test for which the time-averaged sound pressure level is determined

NOTE Measurement time interval is expressed in seconds.

[ISO 3741:2010^[3], 3.5]

3.6 free sound field

sound field in a homogeneous, isotropic medium free of boundaries

NOTE In practice, a free sound field is a field in which the influence of reflections at the boundaries or other disturbing objects is negligible over the frequency range of interest.

[ISO/TR 25417:2007^[20], 2.17]

3.7 anechoic room anechoic test room free-field test room

test room in which a free sound field is obtained

3.8 free sound field over a reflecting plane

free sound field in the half-space above an infinite reflecting plane in the absence of any other obstacles

3.9 reflecting plane

sound reflecting planar surface on which the noise source under test is located

3.10

hemi-anechoic room

hemi-anechoic test room

hemi-free-field test room

test room in which a free sound field over a reflecting plane is obtained

3.11

frequency range of interest

for general purposes, the frequency range of one-third-octave bands with nominal mid-band frequencies from 100 Hz to 10 000 Hz

NOTE For special purposes, the frequency range may be extended or reduced, provided that the test environment and instrument specifications are satisfactory for use over the modified frequency range. Changes to the frequency range of interest should be made clear in the test report. For sources in which the A-weighted sound power levels are determined by sound at predominantly high or low frequencies, the frequency range of interest should be extended to include these frequencies.

3.12

measurement radius

r

radius of a spherical or hemispherical measurement surface

NOTE Measurement radius is expressed in metres.

3.13

measurement surface

hypothetical surface of area, S , on which the microphone positions are located at which the sound pressure levels are measured, enveloping the noise source under test and, in the case of a hemi-anechoic room, terminating on the reflecting plane on which the source is located

NOTE The measurement surface area is expressed in metres squared.

3.14

characteristic source dimension

d_0

distance from the origin of the co-ordinate system to the farthest corner of the reference box, where the reference box is defined as a hypothetical rectangular parallelepiped that just encloses the source including all the significant sound radiating components and any test table on which the source may be mounted; in the case of a hemi-anechoic room the reference box terminates on the reflecting plane

NOTE 1 Characteristic source dimension is expressed in metres.

NOTE 2 For illustration see Figure 1.

3.15

background noise

noise from all sources other than the noise source under test

NOTE Background noise includes contributions from airborne sound, noise from structure-borne vibration, and electrical noise in the instrumentation.

3.16

background noise correction

K_1

correction applied to each of the measured sound pressure levels on the measurement surface to account for the influence of background noise

NOTE 1 Background noise correction is expressed in decibels.

NOTE 2 The background noise correction is frequency dependent; the correction in the case of a frequency band is denoted K_{1f} , where f denotes the relevant mid-band frequency; in the case of A-weighting, the quantity is denoted K_{1A} .

3.17**surface time-averaged sound pressure level** $\overline{L_p}$

mean (energy average) of the time-averaged sound pressure levels at all the microphone positions, or traverses, on the measurement surface, with the background noise corrections, K_1 , applied at each microphone position or traverse

$$\overline{L_p} = 10 \lg \left[\frac{\sum_{i=1}^{N_M} 10^{0,1 L_{pi}(\text{ST})}}{N_M} \right] \text{dB} \quad (4)$$

where

$L_{pi}(\text{ST})$ is the background noise corrected time-averaged sound pressure level for the i th microphone position or traverse on the measurement surface, with the noise source under test in operation, in decibels;

N_M is the number of microphone positions or traverses.

NOTE Surface time-averaged sound pressure level is expressed in decibels.

3.18**surface single event time-integrated sound pressure level** $\overline{L_E}$

mean (energy average) of the single event time-integrated sound pressure levels at all the microphone positions on the measurement surface, with the background noise correction, K_1 , applied at each microphone position

$$\overline{L_E} = 10 \lg \left[\frac{\sum_{i=1}^{N_M} 10^{0,1 L_{Ei}(\text{ST})}}{N_M} \right] \text{dB} \quad (5)$$

where

$L_{Ei}(\text{ST})$ is the background noise corrected single event time-integrated sound pressure level for the i th microphone position on the measurement surface, with the noise source under test in operation, in decibels;

N_M is the number of microphone positions.

NOTE Surface single event time-integrated sound pressure level is expressed in decibels.

3.19**sound power** P

through a surface, product of the sound pressure, p , and the component of the particle velocity, u_n , at a point on the surface in the direction normal to the surface, integrated over that surface

[ISO 80000-8:2007^[22], 8-16 reproduced in ISO/TR 25417:2007^[20], 2.8]

NOTE 1 Sound power is expressed in watts.

NOTE 2 The quantity relates to the rate per time at which airborne sound energy is radiated by a source.

3.20 sound power level

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

$$L_W = 10 \lg \frac{P}{P_0} \text{ dB} \quad (6)$$

where the reference value, P_0 , is 1 pW

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

NOTE 2 This definition is technically in accordance with ISO 80000-8:2007^[22], 8-23.

[ISO/TR 25417:2007^[20], 2.9]

3.21 sound energy

J
integral of the sound power, P , over a stated time interval of duration T (starting at t_1 and ending at t_2)

$$J = \int_{t_1}^{t_2} P(t) \, dt \quad (7)$$

NOTE 1 Sound energy is expressed in joules.

NOTE 2 The quantity is particularly relevant for non-stationary, intermittent sound events.

[ISO/TR 25417:2007^[20], 2.10]

3.22 sound energy level

L_J
ten times the logarithm to the base 10 of the ratio of the sound energy, J , to a reference value, J_0 , expressed in decibels

$$L_J = 10 \lg \frac{J}{J_0} \text{ dB} \quad (8)$$

where the reference value, J_0 , is 1 pJ

NOTE If a specific frequency weighting as specified in IEC 61672-1 and/or specific frequency bands are applied, this should be indicated by appropriate subscripts; e.g. L_{JA} denotes the A-weighted sound energy level.

[ISO/TR 25417:2007^[20], 2.11]

3.23

directivity index

D_{li}

measure of the extent to which a noise source under test radiates sound in the direction of the i th microphone position on a measurement surface, relative to the mean sound radiation over the measurement surface

$$D_{li} = L_{pi} - \overline{L_p} \quad (9)$$

where

L_{pi} is the background noise corrected sound pressure level (either time-averaged or single event time-integrated) for the i th microphone position on the measurement surface, with the noise source under test in operation, in decibels;

$\overline{L_p}$ is the surface sound pressure level (either time-averaged or single event time-integrated), in decibels.

3.24

surface sound pressure level non-uniformity index

V_l

measure of the variability of measured sound pressure levels over the measurement surface

$$V_l = \sqrt{\frac{1}{(N_M - 1)} \sum_{i=1}^{N_M} (L_{pi} - L_{pav})^2} \quad (10)$$

where

L_{pi} is the background noise corrected sound pressure level (either time-averaged or single event time-integrated) for the i th microphone position on the measurement surface with the noise source under test in operation, in decibels;

L_{pav} is the arithmetic average of the background noise corrected sound pressure levels (either time-averaged or single event time-integrated) over all the microphone positions on the measurement surface for the noise source under test, in decibels;

N_M is the number of microphone positions.

NOTE When V_l is determined at a particular measurement radius, the quantity is denoted V_{lr} .

4 Reference meteorological conditions

Reference meteorological conditions for the purpose of calculating the sound power level and sound energy level, corresponding to a reference characteristic acoustic impedance of air $\rho c = 411,5 \text{ N s/m}^3$ (where ρ is the density of air and c is the speed of sound) are:

- air temperature: 23,0 °C;
- static pressure: 101,325 kPa;
- relative humidity: 50 %.

5 Test rooms

5.1 Acoustic criterion for adequacy of the test room

Anechoic or hemi-anechoic rooms that are applicable for measurements in accordance with this International Standard either satisfy:

- a) Annex A over the frequency range of interest, for use in general purpose measurements; or
- b) Annex B over the frequency range of interest, for determination of sound power levels of a specific noise source.

Annex A and Annex B specify procedures for determining the extent of deviations of the test room from the ideal free-field condition or the ideal hemi-free-field condition, and criteria are given to assess the adequacy of the test room. Qualification procedures for the test room shall be in accordance with Annex A or Annex B.

For sources in which the A-weighted sound levels are determined by sound at predominantly high or low frequencies, outside the nominal frequency range of interest (see 3.11), the frequency range of interest shall be extended to include these frequencies, and this shall be clearly stated in the test report.

NOTE If it is necessary to make measurements in test rooms or spaces within test rooms where the requirements of Annex A or Annex B are exceeded, see ISO 3744^[6], ISO 3746^[7], ISO 9614-1^[15] or ISO 9614-2^[16].

5.2 Criteria for background noise

5.2.1 Relative criteria

5.2.1.1 General

The difference between the level of the background noise and that of the noise source under test (when measured in the presence of this background noise) averaged (see 9.4.3) over all microphone positions or traverses, shall be at least 6 dB for all frequency bands, and for one-third-octave bands of mid-band frequency from 250 Hz to 5 000 Hz shall be at least 10 dB. If this requirement is met, the background noise criteria of this International Standard are satisfied.

NOTE 1 The same criteria are applied to single event levels, where the measurement time interval used to measure the background noise is the same as the measurement time interval associated with the measurement of the single event.

NOTE 2 The noise associated with the microphone traversing mechanism, if one is used for the measurements, is considered to be part of the background noise. In such cases, the background noise should be measured with the traversing mechanism operating.

5.2.1.2 Frequency band measurements

The requirements of 5.2.1.1 may not be achievable in all frequency bands, even when the background noise levels in the test room are extremely low and well controlled. Therefore, for the purposes of determining compliance with the background noise criteria given in 5.2.1.1, any band may be excluded from the frequency range of interest if the A-weighted sound power level (see Annex C) of that band (after correcting for background noise) is at least 15 dB below the highest A-weighted sound power level in any frequency band.

5.2.1.3 A-weighted measurements

If the A-weighted sound power level or sound energy level is to be determined from frequency band levels and reported, the following steps shall be followed to determine whether this quantity meets the background noise criteria of this International Standard:

- a) the A-weighted sound power level or sound energy level is computed in accordance with the procedures in this International Standard using the data from every frequency band within the frequency range of interest;

- b) the computation is repeated, but excluding those bands for which $\Delta L_p < 6$ dB for one-third-octave bands of mid-band frequency 200 Hz and below and 6 300 Hz and above, and for which $\Delta L_p < 10$ dB for one-third-octave bands of mid-band frequency from 250 Hz to 5 000 Hz.

If the difference between these two levels is less than 0,5 dB, the A-weighted sound power level or sound energy level determined from the data for all bands shall be considered as conforming to the background noise criteria of this International Standard.

5.2.2 Absolute criteria

If it can be demonstrated that the background noise levels in the test room at the time of the measurements are less than or equal to those given in Table 1 for all bands within the frequency range of interest, the measurements can be taken as having met the background noise requirements of this International Standard, even if the 6 dB and 10 dB requirements (see 5.2.1.1) are not met for all bands. It can be assumed that the source emits little or no measurable noise in these frequency bands, and that the data reported represent an upper bound to the sound power level or sound energy level in these bands.

If levels of noise measured at the smallest possible distance from the source (see Clause 8) are less than or equal to those given in Table 1, the frequency range of interest may be restricted to a contiguous range of frequencies that includes both the lowest and highest frequencies at which the sound pressure level from the noise source exceeds the corresponding value in Table 1. In such cases, the applicable frequency range of interest shall be reported.

NOTE The absolute background criteria are intended for general sound power measurements; they exceed the threshold of audibility and may not be suitable for all uses.

5.2.3 Statement of non-conformity with criteria

If the above background noise criteria are not satisfied, the report shall clearly state that the background noise requirements of this International Standard have not been met, and, in the case of frequency band measurements, shall identify the particular frequency bands that do not meet the criteria. Furthermore, the report shall not state or imply that the measurements have been made “in full conformity” with ISO 3745.

5.3 Criterion for air temperature

The air temperature in the test room shall be within the range 15 °C to 30 °C.

NOTE The equations in Clause 9 used for the calculation of the sound power level and the sound energy level include a multiplication factor which is an approximation to cover a variety of possible sound-generating mechanisms (monopole, dipole, quadrupole, etc.) which pertain to different kinds of noise source; the range of air temperature is limited in order to guarantee a deviation smaller than 0,2 dB in the result.

6 Instrumentation

6.1 Instruments for acoustical measurements

6.1.1 General

The instruments for measuring sound pressure levels, including microphone(s) as well as cable(s), windscreen(s), recording devices and other accessories, if used, shall meet the requirements of IEC 61672-1:2002, class 1. Filters shall meet the requirements of IEC 61260:1995, class 1.

The microphone shall be oriented so that the reference direction of the microphone (as specified in IEC 61672-1) is normal to the measurement surface.

6.1.2 Calibration

At the beginning and the end of every measurement session and at least at the beginning and the end of each measurement day, the entire sound pressure level measuring system shall be checked at one or more

frequencies by means of a sound calibrator meeting the requirements of IEC 60942:2003, class 1. Without any further adjustment, the difference between the readings of two consecutive checks shall be less or equal to 0,3 dB. If this value is exceeded, the results of measurements obtained after the previous satisfactory check shall be discarded.

Table 1 — Maximum background noise levels in test room for absolute criteria

One-third-octave mid-band frequency	Maximum band sound pressure level
Hz	dB
50	44
63	38
80	32
100	27
125	22
160	16
200	13
250	11
315	9
400	8
500	7
630	7
800	7
1 000	7
1 250	7
1 600	7
2 000	7
2 500	8
3 150	8
4 000	8
5 000	8
6 300	8
8 000	12
10 000	14
12 500	11
16 000	46
20 000	46

6.1.3 Verification

Compliance of the sound pressure level measuring instrument, the filters and the sound calibrator with the relevant requirements shall be verified by the existence of a valid certificate of compliance. If applicable, random incidence response of the microphone shall be verified by a procedure from IEC 61183. All compliance testing shall be conducted by a laboratory being accredited or otherwise nationally authorized to perform the relevant tests and calibrations and ensuring metrological traceability to the appropriate measurement standards.

Unless national regulations dictate otherwise, it is recommended that the sound calibrator should be calibrated at intervals not exceeding 1 year, the compliance of the instrumentation system with the requirements of IEC 61672-1 should be verified at intervals not exceeding 2 years, and the compliance of the filter set with the requirements of IEC 61260 should be verified at intervals not exceeding 2 years.

6.2 Instruments for meteorological measurements

6.2.1 General

The maximum permissible error for instruments used for meteorological measurements shall be

- a) ± 1 K for temperature measuring devices;
- b) ± 10 % for relative humidity measuring devices;
- c) ± 2 kPa for static pressure measuring devices.

NOTE It is not necessary to specify values for these uncertainties if their influence on the final measured value is determined to be within acceptable limits using ISO/IEC Guide 98-3.

6.2.2 Verification

For instruments used for monitoring meteorological conditions, e.g. to ensure that any of these parameters is within a specified interval, manufacturer's specifications are deemed sufficient to verify these requirements.

If any of the meteorological parameters has a direct influence on the measurement result, the compliance of the measuring instrument with the relevant requirement has to be verified by a valid calibration certificate from a laboratory being accredited or otherwise nationally authorized to perform the relevant calibration and ensuring metrological traceability to the appropriate measurement standards.

7 Definition, location, installation and operation of noise source under test

7.1 General

The manner in which the noise source under test is installed and operated may have a significant influence on the sound power or sound energy emitted by a noise source. This clause specifies conditions that are intended to minimize variations in the noise emission due to the installation and operating conditions of the noise source under test. Relevant instructions of a noise test code, if any exists for the family of machinery or equipment to which the noise source under test belongs, shall be followed. The same installation, mounting and operating conditions of the noise source under test shall be used for the determination of emission sound pressure levels and sound power levels.

Particularly for large machines, it is necessary to decide which components, sub-assemblies, auxiliary equipment, power sources; etc., belong to the noise source under test.

7.2 Auxiliary equipment

Care shall be taken to ensure that any electrical conduits, piping or air ducts connected to the noise source under test do not radiate significant amounts of sound energy into the test environment.

If possible, all auxiliary equipment necessary for the operation of the noise source under test that is not a part of it shall be located outside the test room. If this is impractical, care shall be taken to minimize any sound radiated into the test environment from such equipment. The noise source under test shall be taken to include all significant sources of sound emission, including auxiliary equipment which cannot either be removed or adequately quietened.

7.3 Noise source location

In locating the source within the test room, it is important to allow sufficient space around the source so that the measurement surface can envelop it in accordance with the requirements of Clause 8.

Detailed information on installation conditions shall be based upon the general requirements of this International Standard and particular requirements of the relevant noise test code, if one exists.

7.4 Mounting of the noise source

7.4.1 General

In many cases, the sound power or sound energy emitted by a noise source under test depends upon the support or mounting conditions of the noise source. Whenever a typical mounting condition exists for a noise source, that condition shall be used or simulated, if practicable.

Mounting conditions specified or recommended by the manufacturer of the noise source under test shall be used unless otherwise specified in any relevant noise test code. If a typical mounting condition does not exist, cannot be utilized for the test or if there are several alternative possibilities, care shall be taken to ensure that the mounting arrangement does not induce a variability in the sound output of the source which is atypical. Precautions shall be taken to reduce any sound radiation from the structure on which the noise source is mounted.

Many small noise sources, although themselves poor radiators of low-frequency sound, can, as a result of the method of mounting, radiate more low-frequency sound when their vibrational energy is transmitted to surfaces large enough to be efficient radiators. Resilient mounting shall be interposed, if possible, between the noise source to be tested and the supporting surfaces, so that the transmission of vibration to the support and the reaction of the source are both minimized. In this case, the mounting base should be rigid (i.e. have a sufficiently high mechanical impedance) to prevent it from vibrating excessively and radiating sound. However, resilient mounts shall be used only if the noise source under test is resiliently mounted in typical field installations.

Coupling conditions, e.g. between prime movers and driven machines, can exert a considerable influence on the sound radiation of the noise source under test.

7.4.2 Hand-held machinery and equipment

Such machinery and equipment shall be suspended or guided by hand, so that no structure-borne sound is transmitted via any attachment that does not belong to the noise source under test. If the noise source under test requires a support for its operation during testing, the support structure shall be small, considered to be a part of the noise source under test, and comply with the requirements of the relevant noise test code, if any exists.

7.4.3 Base-mounted, wall-mounted and table-top machinery and equipment

Such machinery and equipment shall be placed on a reflecting (acoustically hard) plane (floor or wall). Base-mounted machinery or equipment intended exclusively for mounting in front of a wall shall be installed on an acoustically hard surface in front of an acoustically hard wall. Table-top machinery or equipment shall be placed on the floor at least 1,5 m from any wall of the room, unless a table or stand is required for operation in accordance with the noise test code for the machinery or equipment under test. The table or stand shall be at least 1,5 m from any absorptive surface of the test room. Such machinery or equipment shall be placed at the centre of the top of a standard test table.

NOTE An example of a test table is given in ISO 11201^[18].

7.5 Operation of source during test

The sound power or sound energy emitted by a source, whether stationary or moving, can be affected by the load applied, the running speed, and the conditions under which it is operating. The source shall be tested, wherever possible, under conditions that are reproducible and representative of the noisiest operation in typical usage. The specifications given in a noise test code, if any exists, shall be followed, but in the absence of a noise test code one or more of the following modes of operation shall be selected for the test(s):

- a) source under specified load and conditions;
- b) source under full load [if different from a)];
- c) source under no load (idling);
- d) source at maximum operating speed under defined conditions;

- e) source operating under conditions corresponding to maximum sound generation representative of normal use;
- f) source with simulated loading, under defined conditions;
- g) source undergoing a characteristic work cycle under defined conditions.

The source shall be stabilized in the desired operating condition, with any power source or transmission system running at a stable temperature, prior to the start of measurements for sound power level or sound energy level determination. The load, speed and operating conditions shall either be held constant during the test or varied through a defined cycle in a controlled manner.

If the sound power or sound energy emission depends on secondary operating parameters, e.g. the type of material being processed, the design of cutting tool or the humidity, those parameters shall be selected, as far as is practicable, that give the smallest variations and that are typical of normal use. If simulated loading conditions are used, they shall be chosen such that the sound power levels or sound energy levels of the source under test are representative of normal use.

8 Measurement surface

8.1 Spherical measurement surface for use in an anechoic room

The spherical measurement surface shall be centred on the acoustic centre of the noise source under test, either the actual acoustic centre if known or an assumed acoustic centre such as the geometric centre of the source. The measurement radius, r , shall satisfy all of the following conditions:

- a) $r \geq 2d_0$, where d_0 is the characteristic dimension of the noise source under test (see 3.14 and Figure 1);
- b) $r \geq \lambda/4$, where λ is the wavelength of sound at the lowest frequency of interest;
- c) $r \geq 1$ m.

The measurement surface shall be wholly contained within the region of the anechoic room which is qualified for measurements in accordance with Annex A or Annex B.

For small, low-noise sources to be measured over a limited range of frequencies, the measurement radius may be less than 1 m, but not less than 0,5 m. However, conditions a) and b) are relevant and a radius less than 1 m could itself impose limits on the frequency range over which tests are performed.

The area of a spherical measurement surface, $S_1 = 4\pi r^2$ (see 9.4.4.1 and 9.5.3.1).

8.2 Hemispherical measurement surface for use in a hemi-anechoic room

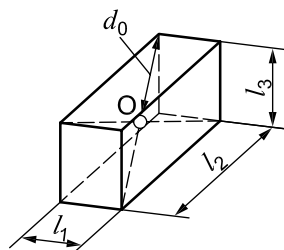
The hemispherical measurement surface shall be centred on a point on the floor of the test room vertically beneath the assumed acoustic centre of the noise source under test, either the actual acoustic centre if known or the geometric centre if the acoustic centre is unknown. The measurement radius, r , shall satisfy all of the following conditions:

- a) $r \geq 2d_0$ or $r \geq 3h_0$, whichever is the larger, where d_0 is the characteristic dimension of the noise source under test (see 3.14 and Figure 1), and h_0 is the distance from the acoustic centre of the source to the floor;
- b) $r \geq \lambda/4$, where λ is the wavelength of sound at the lowest frequency of interest;
- c) $r \geq 1$ m.

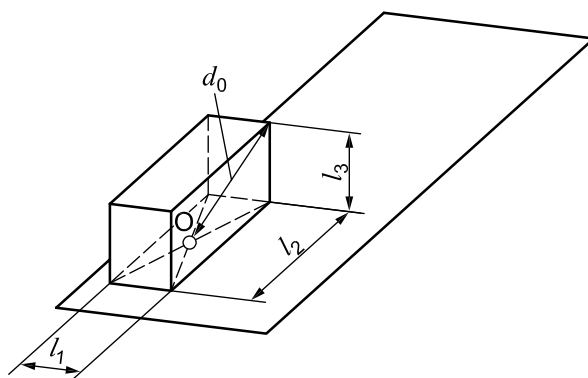
The measurement surface shall be wholly contained within the region of the hemi-anechoic room which is qualified for measurements in accordance with Annex A or Annex B.

For small, low-noise sources to be measured over a limited range of frequencies, the measurement radius may be less than 1 m, but not less than 0,5 m. However, conditions a) and b) are relevant and a radius less than 1 m could itself impose limits on the frequency range over which tests are performed.

The area of a hemispherical measurement surface, $S_2 = 2\pi r^2$ (see 9.4.4.2 and 9.5.3.2).



a) **Anechoic room**, $d_0 = \sqrt{(l_1/2)^2 + (l_2/2)^2 + (l_3/2)^2}$



b) **Hemi-anechoic room**, $d_0 = \sqrt{(l_1/2)^2 + (l_2/2)^2 + l_3^2}$

Figure 1 — Reference box, centre for the measurement surface (when using the geometric centre of the source) and characteristic source dimensions for application in an anechoic and a hemi-anechoic room

9 Determination of sound power levels and sound energy levels

9.1 Measurements in the test room

Procedures are specified for measurements in both an anechoic room and a hemi-anechoic room. In both kinds of test rooms, the procedures are applicable provided that the rooms are qualified in accordance with either Annex A or Annex B (see 5.1).

For sources in which the A-weighted sound levels are determined by sound at predominantly high or low frequencies outside the frequency range of interest (see 3.11), the frequency range of interest shall be extended to include these frequencies in the calculation of L_{WA} or L_{JA} , and this shall be made clear in the test report.

9.2 Measurement of meteorological conditions

The meteorological conditions (air temperature, static pressure and relative humidity) around the noise source at the time of the test shall be measured.

9.3 Microphone positions

9.3.1 General

Environmental conditions can have an adverse effect on microphones used for the measurements. The effect of such conditions (e.g. strong electric or magnetic fields, wind impingement of air discharge, if any, from

the noise source under test) shall be avoided by proper selection or placement of the microphones. The attenuation of the air at frequencies above 10 000 Hz (if measurements are made at these frequencies) shall be compensated in accordance with ISO 9613-1.

To obtain the sound pressure levels on the spherical or hemispherical measurement surface, one of the following four arrangements or a user-defined arrangement that meets the requirements of 9.3.7 shall be used:

- a) an array of fixed microphone positions, the positions being distributed over the measurement surface, see 9.3.2 and 9.3.3;

NOTE It is possible either to move a single microphone from one position to the next sequentially or to use a number of fixed microphones and to sample their outputs sequentially or simultaneously.

- b) a single microphone moved along multiple circular paths regularly spaced on the measurement surface (or a microphone held fixed while the noise source under test is rotated through 360° or multiples thereof) see 9.3.4;
- c) a single microphone moved along multiple meridional arcs regularly spaced on the measurement surface, see 9.3.5;
- d) a single microphone moved along a spiral path around the vertical axis of the measurement surface, see 9.3.6.

9.3.2 Fixed positions for measurements on a spherical measurement surface in an anechoic room

The array of 20 microphone positions shown in Annex D numbered from 1 to 20 shall be used. In general, the number of microphone positions is sufficient if the difference, in decibels, between the highest and lowest sound pressure levels measured in all frequency bands of interest is numerically less than half the number of microphone positions. Frequency bands excluded in 5.2.1 are exempt from this requirement. If this requirement is not satisfied using points 1 to 20 from Annex D, an additional 20 point array shown in Annex D numbered from 21 to 40 shall be used. The 20 positions and the 40 positions on the two arrays are associated with equal areas on the surface of the sphere of Annex D.

If the requirement on the sufficiency of the number of microphone positions is not satisfied by the 40 positions on the two arrays, a detailed investigation is necessary of the sound pressure levels over a restricted area of the sphere where “beaming” from a highly directional source is observed. This detailed investigation is necessary to determine the highest and lowest values of the sound pressure level in the frequency band of interest. If this procedure is followed, the microphone positions are not usually associated with equal areas on the measurement surface and proper allowance shall be made (see 9.4.3.2).

9.3.3 Fixed positions for measurements on a hemispherical measurement surface in a hemi-anechoic room

The array of 20 microphone positions shown in Annex E numbered from 1 to 20 shall be used. In general, the number of microphone positions is sufficient if the difference in decibels between the highest and lowest sound pressure levels measured in all frequency bands of interest is numerically less than half the number of microphone positions. Frequency bands excluded in 5.2.1 are exempt from this requirement. If this requirement is not satisfied using points 1 to 20 from Annex E, an additional 20 point array shown in Annex E numbered from 21 to 40 shall be used. The 20 positions and the 40 positions on the two arrays are associated with equal areas on the surface of the hemisphere of Annex E.

If the requirement on the sufficiency of the number of microphone positions is not satisfied by the 40 positions on the two arrays, a detailed investigation is necessary of the sound pressure levels over a restricted area of the hemisphere where “beaming” from a highly directional source is observed. This detailed investigation is necessary to determine the highest and lowest values of the sound pressure level in the frequency band of interest. If this procedure is followed, the microphone positions are not usually associated with equal areas on the measurement surface and proper allowance shall be made (see 9.4.3.2).

9.3.4 Coaxial circular paths in parallel planes on a sphere or hemisphere (for measurements in a hemi-anechoic room)

The sound pressure level shall be averaged in space and time by moving microphones along at least 10 circular paths as shown in Annex F, with heights corresponding to those specified for the upper half-space in Table D.1. For noise sources which emit sound at discrete frequencies, and preferably for other noise sources as well, the sound pressure level shall be averaged by moving the microphones along at least 20 circular paths with heights specified in Table E.1.

The circular paths may be achieved by uniformly rotating either the microphone or the noise source slowly through 360°. If a turntable is used to rotate the noise source, its surface shall be at a height of not more than 10 % of the height of the noise source from the reflecting plane and shall preferably be flush with the reflecting plane. The coaxial circular paths may be measured simultaneously or successively using one or more microphones.

9.3.5 Meridional arc traverses on a sphere or hemisphere

A single microphone shall be traversed along a semi-circular arc about a horizontal axis through the centre of the noise source, see Figure G.1. The vertical velocity (dz/dt) shall be held constant, i.e. the angular velocity of the microphone support is accelerated to be proportional to $1/\cos \gamma$, where γ is the angle above the horizontal. The microphone output is squared and averaged by electronic means, giving suitable weight to the surface area of the sphere or hemisphere. Alternatively, a constant angular velocity may be used, but with electronic weighting in accordance with $\cos \gamma$ (see Figure G.1).

At least eight such microphone traverses at equal increments of azimuth angle around the noise source shall be used. This may be accomplished by rotating the noise source.

9.3.6 Spiral path on a sphere or hemisphere

A single microphone shall be traversed along one meridional path as in 9.3.5, and simultaneously through an integral number of at least five circular paths, thus forming a spiral path around the vertical axis of the measurement surface. Alternatively, the spiral path shall be generated by slowly rotating the noise source under test at a constant rotational speed through at least five complete turns while traversing the microphone along a meridional path. An example of a spiral path is shown in Annex H. Angular weighting is described in 9.3.5.

9.3.7 Other microphone arrangements

Other microphone arrangements and measurement surfaces which provide improved accuracy in determination of sound power levels or sound energy levels are not excluded by the above requirements. However, it shall be demonstrated that the deviation between the sound power level or sound energy level in each one-third-octave band of frequency throughout the frequency range of interest and that determined with one of the above arrangements does not exceed $\pm 0,5$ dB.

NOTE An alternative arrangement is defined to improve accuracy and not simply to reduce the number of microphone positions or otherwise compromise one of the specified arrays in 9.3.2 to 9.3.6. An example of an alternative cylindrical measurement surface and microphone arrangement can be found in Reference [23].

9.4 Determination of sound power levels of a noise source which emits steady or non-steady noise

9.4.1 Measurement of sound pressure levels

Time-averaged sound pressure levels from the noise source under test, $L'_{pi(ST)}$ (either in one-third-octave frequency bands or A-weighted), shall be obtained at each microphone position or over each microphone traverse, i ($i = 1, 2 \dots N_M$) over a typical period of operation of the source for each mode of operation selected (see 7.5). Where the sound pressure levels at individual microphone positions vary with time, it is important to select carefully the measurement time interval and the interval chosen shall be stated in the test report. For frequency bands centred on or below 160 Hz, the measurement time interval shall be at least 30 s. For frequency bands centred on or above 200 Hz, the measurement time interval shall be at least 10 s. When using