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AMERICAN NATIONAL STANDARD

Acoustics – Determination of sound power levels and sound energy levels of noise sources using sound pressure – Engineering methods for an essentially free field over a reflecting plane

(a Nationally Adopted International Standard)

ANSI/ASA S12.54-2011 / ISO 3744:2010

Accredited Standards Committee S12, Noise

Standards Secretariat
Acoustical Society of America
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Acoustics — Determination of sound power levels and sound energy levels of noise sources using sound pressure — Engineering methods for an essentially free field over a reflecting plane

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Secretariat:

Acoustical Society of America

Approved March 1, 2011 by:

American National Standards Institute, Inc.

Abstract

This American National Standard specifies methods for determining the sound power level or sound energy level of a noise source from sound pressure levels measured on a surface enveloping the noise source (machinery or equipment) in an environment that approximates to an acoustic free field near one or more reflecting planes. The sound power level (or, in the case of noise bursts or transient noise emission, the sound energy level) produced by the noise source, in frequency bands or with A-weighting applied, is calculated using those measurements.

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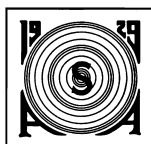
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Foreword

[This Foreword is for information only, and is not a part of the American National Standard ANSI/ASA S12.54-2011 / ISO 3744:2010 American National Standard Acoustics — Determination of sound power levels and sound energy levels of noise sources using sound pressure — Engineering methods for an essentially free field over a reflecting plane.]

This standard comprises a part of a group of definitions, standards, and specifications for use in noise. It was developed and approved by Accredited Standards Committee S12, Noise, under its approved operating procedures. Those procedures have been accredited by the American National Standards Institute (ANSI). The Scope of Accredited Standards Committee S12 is as follows:

Standards, specifications, and terminology in the field of acoustical noise pertaining to methods of measurement, evaluation, and control, including biological safety, tolerance, and comfort, and physical acoustics as related to environmental and occupational noise.

This standard is a revision of ANSI S12.54-1999 / ISO 3744:1994, which has been technically revised.

This Standard is identical to International Standard ISO 3744, Acoustics — Determination of sound power levels and sound energy levels of noise sources using sound pressure — Engineering methods for an essentially free field over a reflecting plane, which was prepared by Technical Committee ISO/TC 43 Subcommittee SC 1, Noise. However, in conformance with ANSI and ISO rules, the words "American National Standard" replace the words "International Standard" where they appear in the ISO document, decimal points were substituted in place of the decimal commas used in ISO documents, and American English spelling is used in place of British English spelling.

The ANSI or ANSI/ASA equivalents for the ISO standards in the ISO 3740 series and other referenced nationally adopted standards are given below:

- ANSI S12.5 / ISO 6926 is an identical national adoption of ISO 6926;
- ANSI/ASA S12.50/ISO 3740 is an identical national adoption of ISO 3740;
- ANSI/ASA S12.51/ISO 3741 is an identical national adoption of ISO 3741;
- ANSI/ASA S12.53/Part 1/ISO 3743-1 is an identical national adoption of ISO 3743-1;
- ANSI/ASA S12.53/Part 2/ISO 3743-2 is an identical national adoption of ISO 3743-2;
- ANSI/ASA S12.54/ISO 3744 is an identical national adoption of ISO 3744;
- ANSI S12.55/ISO 3745 is an identical national adoption of ISO 3745;
- ANSI S12.56/ISO 3746 is an identical national adoption of ISO 3746; and
- ANSI/ASA S12.57/ISO 3747 is an identical national adoption of ISO 3747.

At the time this Standard was submitted to Accredited Standards Committee S12, Noise for approval, the membership was as follows:

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Suggestions for improvements of this standard will be welcomed. They should be sent to Accredited Standards Committee S12, Noise, in care of the Standards Secretariat of the Acoustical Society of America, 35 Pinelawn Road, Suite 114E, Melville, New York 11747-3177. Telephone: 631-390-0215; FAX: 631-390-0217; E-mail: asastds@aip.org.

Introduction

This American National Standard is a national adoption of one of the series ISO 3741^[2] to ISO 3747^[6], which specify various methods for determining the sound power levels and sound energy levels of noise sources including machinery, equipment and their sub-assemblies. General guidelines to assist in the selection are provided in ISO 3740^[1]. The selection depends on the environment of the available test facility and on the precision of the sound power level or sound energy level values required. It may be necessary to establish a noise test code (see ISO 12001) for the individual noise source in order to select the appropriate sound measurement surface and microphone array from among those allowed in each member of the ISO 3741^[2] to ISO 3747^[6] series, and to give requirements on test unit mounting, loading and operating conditions under which the sound power levels or sound energy levels are to be obtained. The sound power emitted by a given source into the test environment is calculated from the mean square sound pressure that is measured over a hypothetical measurement surface enclosing the source, and the area of that surface. The sound energy for a single sound event is calculated from this sound power and the time over which it existed.

The methods specified in this American National Standard permit the determination of the sound power level and the sound energy level in frequency bands optionally with frequency A-weighting applied.

For applications where greater accuracy is required, reference can be made to ISO 3745, ISO 3741^[2] or ISO 9614^{[13]-[15]}. If the relevant criteria for the measurement environment specified in this American National Standard are not met, it might be possible to refer to another standard from this series, or to ISO 9614^{[13]-[15]}.

This American National Standard describes methods of accuracy grade 2 (engineering grade) as defined in ISO 12001, when the measurements are performed in a space that approximates an acoustically free field over a reflecting plane. Such an environment can be found in a specially designed room, or within industrial buildings or outdoors. Ideally, the test source should be mounted on a sound-reflecting plane located in a large open space. For sources normally installed on the floor of machine rooms, corrections are defined to account for undesired reflections from nearby objects, walls and the ceiling, and for the residual background noises that occur there.

American National Standard

Acoustics — Determination of sound power levels and sound energy levels of noise sources using sound pressure — Engineering methods for an essentially free field over a reflecting plane

1 Scope

1.1 General

This American National Standard specifies methods for determining the sound power level or sound energy level of a noise source from sound pressure levels measured on a surface enveloping the noise source (machinery or equipment) in an environment that approximates to an acoustic free field near one or more reflecting planes. The sound power level (or, in the case of noise bursts or transient noise emission, the sound energy level) produced by the noise source, in frequency bands or with A-weighting applied, is calculated using those measurements.

NOTE Differently shaped measurement surfaces can yield differing estimates of the sound power level of a given noise source and an appropriately drafted noise test code (see ISO 12001) gives detailed information on the selection of the surface.

1.2 Types of noise and noise sources

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

This American National Standard is applicable to all types and sizes of noise source (e.g. stationary or slowly moving plant, installation, machine, component or sub-assembly), provided the conditions for the measurements can be met.

NOTE It is possible that the conditions for measurements given in this American National Standard are impracticable for very tall or very long sources such as chimneys, ducts, conveyors and multi-source industrial plants. A noise test code for the determination of noise emission of specific sources can provide alternative methods in such cases.

1.3 Test environment

The test environments that are applicable for measurements made in accordance with this American National Standard can be located indoors or outdoors, with one or more sound-reflecting planes present on or near which the noise source under test is mounted. The ideal environment is a completely open space with no bounding or reflecting surfaces other than the reflecting plane(s) (such as that provided by a qualified hemi-anechoic chamber), but procedures are given for applying corrections (within limits that are specified) in the case of environments that are less than ideal.

1.4 Measurement uncertainty

Information is given on the uncertainty of the sound power levels and sound energy levels determined in accordance with this American National Standard, for measurements made in limited bands of frequency and with frequency A-weighting applied. The uncertainty conforms to ISO 12001:1996, accuracy grade 2 (engineering 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 3382-2, *Acoustics — Measurement of room acoustic parameters — Part 2: Reverberation time in ordinary rooms*

ISO 3745, *Acoustics — Determination of sound power levels and sound energy levels of noise sources using sound pressure — Precision methods for anechoic test rooms and hemi- anechoic test rooms*

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

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

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 61260:1995, *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^[21], 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 is 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^[21], 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 $(20 \mu\text{Pa})^2 \text{ s} = 4 \times 10^{-10} \text{ Pa}^2 \text{ s}$

NOTE 1 This quantity can be obtained by $L_{p,T} + 10 \lg \left[\frac{T}{T_0} \right] \text{ dB}$, where $T_0 = 1 \text{ s}$.

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

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.

3.6 acoustic free field

sound field in a homogeneous, isotropic medium free of boundaries

NOTE In practice, an acoustic free 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.

3.7 acoustic free field over a reflecting plane

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

3.8 reflecting plane

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

3.9 frequency range of interest

for general purposes, the frequency range of octave bands with nominal mid-band frequencies from 125 Hz to 8,000 Hz (including one-third octave bands with mid-band frequencies from 100 Hz to 10,000 Hz)

NOTE For special purposes, the frequency range can 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 are included in the test report.

3.10**reference box**

hypothetical right parallelepiped terminating on the reflecting plane(s) on which the noise source under test is located, that just encloses the source including all the significant sound radiating components and any test table on which the source is mounted

NOTE If required, the smallest possible test table can be used for compatibility with emission sound pressure measurements at bystander positions in accordance with, for example, ISO 11201^[18].

3.11**characteristic source dimension**

d_O

distance from the origin of the co-ordinate system to the farthest corner of the reference box

NOTE Characteristic source dimension is expressed in meters.

3.12**measurement distance**

d

distance from the reference box to a parallelepiped measurement surface

NOTE Measurement distance is expressed in meters.

3.13**measurement radius**

r

radius of a hemispherical, half-hemispherical or quarter-hemispherical measurement surface

NOTE Measurement radius is expressed in meters.

3.14**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 terminating on the reflecting plane(s) on which the source is located

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 the mean (energy average) of the time-averaged sound pressure levels over all the microphone positions 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, and that in the case of A-weighting is denoted K_{1A} .

3.17 environmental correction

K_2

correction applied to the mean (energy average) of the time-averaged sound pressure levels over all the microphone positions on the measurement surface, to account for the influence of reflected or absorbed sound

NOTE 1 Environmental correction is expressed in decibels.

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

NOTE 3 In general, the environmental correction depends on the area of the measurement surface and usually K_2 increases with S .

3.18 surface time-averaged sound pressure level

$\overline{L_p}$

mean (energy average) of the time-averaged sound pressure levels over all the microphone positions, or traverses, on the measurement surface, with the background noise correction, K_1 , and the environmental correction, K_2 , applied

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

3.19 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, or traverses, on the measurement surface, with the background noise correction, K_1 , and the environmental correction, K_2 , applied

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

3.20 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^[21], 8-16]

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.

3.21 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

$$L_W = 10 \lg \frac{P}{P_0} \text{ dB} \quad (4)$$

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 is 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^[21], 8-23.

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

3.22 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)

$$J = \int_{t_1}^{t_2} P(t) dt \quad (5)$$

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]

3.23 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

$$L_J = 10 \lg \frac{J}{J_0} \text{ dB} \quad (6)$$

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 is indicated by appropriate subscripts; e.g. L_{JA} denotes the A-weighted sound energy level.

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

3.24 apparent 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

$$D_{li}^* = L_{pi(ST)} - \left[\overline{L'_{p(ST)}} - K_1 \right] \quad (7)$$

where

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

$\overline{L'_{p(ST)}}$ is the mean (energy average) time-averaged (or single event time-integrated) sound pressure level over all the microphone positions on the measurement surface for the noise source under test, in decibels;

K_1 is the background noise correction, in decibels.

NOTE 1 Apparent directivity index is expressed in decibels.

NOTE 2 The apparent directivity index is determined using measured sound pressure levels from the noise source under test corrected for background noise, but with no corrections for the influence of the acoustic environment.

3.25

apparent surface sound pressure level non-uniformity index

V_I^*

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

$$V_I^* = \sqrt{\frac{1}{N_M - 1} \sum_{i=1}^{N_M} [L_{pi(ST)} - L_{pav}]^2} \quad (8)$$

where

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

L_{pav} is the arithmetic average of the background noise-corrected time-averaged (or single event time-integrated) sound pressure levels 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 1 Apparent surface sound pressure level non-uniformity index is expressed in decibels.

NOTE 2 When V_I^* is determined over the specific measurement surface given by the measurement radius, r , or measurement distance, d , the value is denoted V_{Ir}^* or V_{Id}^* , respectively.

NOTE 3 The apparent surface sound pressure level non-uniformity index is determined using measured sound pressure levels from the noise source under test, corrected for background noise, but with no corrections for the influence of the acoustic environment.

4 Test environment

4.1 General

The test environments that are applicable for measurements in accordance with this American National Standard are:

- a) a laboratory room or a flat outdoor area which is adequately isolated from background noise (see 4.2) and which provides an acoustic free field over a reflecting plane;
- b) a room or a flat outdoor area which is adequately isolated from background noise (see 4.2) and in which an environmental correction can be applied to allow for a limited contribution from the reverberant field to the sound pressures on the measurement surface.

Environmental conditions having an adverse effect on the microphones used for the measurements (e.g. strong electric or magnetic fields, wind, impingement of air discharge from the noise source being tested, high or low temperatures) shall be avoided. The instructions of the manufacturer of the measuring instrumentation regarding adverse environmental conditions shall be followed.

In an outdoor area, care shall be taken to minimize the effects of adverse meteorological conditions (e.g. temperature, humidity, wind, precipitation) on the sound propagation and on sound generation over the frequency range of interest or on the background noise during the course of the measurements.

When a reflecting surface is not a ground plane or is not an integral part of a test room surface, particular care should be exercised to ensure that the plane does not radiate any appreciable sound due to vibrations.

4.2 Criteria for background noise

4.2.1 Relative criteria

4.2.1.1 General

The time-averaged sound pressure level of the background noise measured and averaged (see 8.2.2) over the microphone positions, or traverses, on the measurement surface, shall be at least 6 dB, and preferably more than 15 dB, below the corresponding uncorrected time-averaged sound pressure level of the noise source under test when measured in the presence of this background noise. For measurements in frequency bands, this requirement shall be met in each frequency band within the frequency range of interest.

If this requirement is met, the background noise criteria of this American National Standard are satisfied.

NOTE 1 A similar criterion is applied to single event sound pressure levels: the measurement time interval for the time average is the same as the measurement time interval associated with 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 is measured with the traversing mechanism operating.

4.2.1.2 Frequency band measurements

The requirements of 4.2.1.1 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, any band within the frequency range of interest in which the A-weighted sound power level or sound energy level of the noise

source under test is at least 15 dB below the highest A-weighted band sound power level may be excluded from the frequency range of interest for the purposes of determining compliance with the criteria for background noise.

4.2.1.3 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 American National Standard:

- a) the A-weighted sound power level or sound energy level is computed in accordance with the procedures in this American National 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.

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 may be considered as conforming to the background noise criteria of this American National Standard.

NOTE If it is necessary to make measurements where the difference between the sound pressure levels of the background noise and the source together with the background noise is less than 6 dB, ISO 9614-1^[13] or ISO 9614-2^[14] can be used to give results of accuracy grade 2.

4.2.2 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 American National Standard, even if the 6 dB requirement (see 4.2.1.1) is 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 in these bands.

In the case where some of the measured (either time-averaged or single event time-integrated) levels from the source under test 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.

4.2.3 Statement of non-conformity with criteria

If neither the relative criteria of 4.2.1 nor the absolute criteria in 4.2.2 are met, the report shall clearly state that the background noise requirements of this American National 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 this American National Standard.

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

One-third-octave mid-band frequency Hz	Maximum band sound pressure level 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

4.3 Criterion for acoustic adequacy of test environment

4.3.1 General

A test room shall provide a measurement surface that lies inside a sound field that is essentially free of undesired sound reflections from the room boundaries or nearby objects (apart from the floor).

As far as is practicable, the test environment shall be free from reflecting objects other than the reflecting plane(s).

NOTE 1 An object in the proximity of the noise source under test can be considered to be sound reflecting if its width (e.g. diameter of a pole or supporting member) exceeds one-tenth of its distance from the reference box.

The reflecting plane(s) shall extend at least 0.5 m beyond the projection of the measurement surface on the plane(s). The sound absorption coefficient of the reflecting plane(s) shall be less than 0.1 over the frequency range of interest.

NOTE 2 Smooth concrete or smooth sealed asphalt surface(s) are generally satisfactory.

Annex A specifies procedures for determining the magnitude of the environmental correction, K_2 , to account for deviations of the test environment from the ideal condition. Measurements in accordance with this American National Standard are only valid where $K_{2A} \leq 4$ dB (see 4.3.2, Reference [25]).

NOTE 3 If the environmental correction K_{2A} exceeds 4 dB, ISO 3743^{[3][4]}, ISO 3747^[6], ISO 9614-1^[13] or ISO 9614-2^[14] can be used for results of accuracy grade 2, or ISO 3746^[5] can be used for results of accuracy grade 3.

NOTE 4 In some specific cases, the horizontal testing plane cannot be reflecting (e.g. lawnmowers, some types of earth-moving machines). In such cases, a relevant noise test code describes in detail the nature of the plane on which the noise source is mounted and indicates the possible consequences on the measurement uncertainty.

The environmental correction, K_2 , is assumed to be zero for measurements made in hemi-anechoic rooms which meet the requirements of ISO 3745.

For an outdoor space which consists of a hard, flat ground surface, such as asphalt or concrete, with no sound-reflecting objects within a distance from the noise source equal to 10 times the greatest distance from the geometric center of the source to the lowest measurement points, it shall be assumed that the environmental correction K_2 is less than 0.5 dB and can be neglected.

4.3.2 Criterion for environmental correction

The environmental correction, K_{2A} , shall first be determined without reference to frequency band data, using one of the procedures of Annex A. Then:

- a) if $K_{2A} > 4$ dB, this American National Standard is not applicable (see 4.3.1);
- b) if $K_{2A} \leq 4$ dB, measurements may be made in accordance with this American National Standard, either in frequency bands or A-weighted, using measurement surfaces described in Annexes B, C and D — in addition, for direct measurement of A-weighted sound pressure levels, the alternative microphone array described in Annex F may be used.

Where it is decided to make measurements in frequency bands, the relevant environmental correction K_2 shall be determined in each band over the frequency range of interest in accordance with A.2 or A.3.4

and all measurements to determine L_W or L_J of a noise source shall be made in frequency bands. L_{WA} or L_{JA} shall be calculated using the frequency-band levels, see Annex E.

5 Instrumentation

5.1 General

The instrumentation system, including the microphones, cables and windscreen, if used, shall meet the requirements of IEC 61672-1:2002, class 1, and the filters shall meet the requirements of IEC 61260:1995, class 1.

5.2 Calibration

Before and after each series of measurements, a sound calibrator meeting the requirements of IEC 60942:2003, class 1 shall be applied to each microphone to verify the calibration of the entire measuring system at one or more frequencies within the frequency range of interest. Without any adjustment, the difference between the readings made before and after each series of measurements shall be less than or equal to 0.5 dB. If this value is exceeded, the results of the series of measurements shall be discarded.

The calibration of the sound calibrator, the compliance of the instrumentation system with the requirements of IEC 61672-1, the compliance of the filter set with the requirements of IEC 61260, and, if used, the compliance of the reference sound source with the requirements of ISO 6926, shall be verified at intervals in a laboratory making calibrations traceable to appropriate standards.

Unless national regulations dictate otherwise, it is recommended that the sound calibrator should be calibrated at intervals not exceeding 1 year, the reference sound source should be calibrated at intervals not exceeding 2 years, 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 Definition, location, installation, and operation of noise source under test

6.1 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. A noise test code for the noise source under test, if any exists, describes the installation, mounting and operating conditions in detail.

Particularly for large machines, it is necessary to decide which components, sub-assemblies, auxiliary equipment, power sources, etc., constitute integral parts of the noise source.

6.2 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 practical, 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 environment. 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 quieted, and the reference box (see 7.1) shall be extended appropriately.

6.3 Noise source location

The noise source to be tested shall be installed with respect to, or driven on, the reflecting plane or planes, as if it were in normal use. The noise source shall be located at a sufficient distance from any reflecting wall or ceiling or any reflecting object so that the requirements given in Annex A are satisfied on the measurement surface.

Typical installation conditions for some machines involve two or more reflecting surfaces (e.g. an appliance installed against a wall), or free space (e.g. a hoist), or an opening in an otherwise reflecting plane (so that radiation may occur on both sides of the vertical plane). Detailed information on installation conditions should be based on the general requirements of this American National Standard and on the relevant noise test code, if one exists.

6.4 Mounting of the noise source

6.4.1 General

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

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, or 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. In such cases, resilient mounting shall be interposed, if possible, between the noise source under test and the supporting structure, 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. It may be appropriate to use a flexible coupling, but similar considerations apply to these as to resilient mounts.

6.4.2 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.

6.4.3 Base-mounted, wall-mounted, and tabletop 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. Tabletop 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 center of the top of a standard test table.

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

6.5 Installation and mounting conditions for moving noise sources

The sound power emitted by a moving noise source is determined with the source traversing a defined segment of a straight path. The wheels, tracks or other supports on which the source runs, together with the suspension system, shall be the same for the purpose of test as in normal use.

6.6 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 or the design of cutting tool, 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

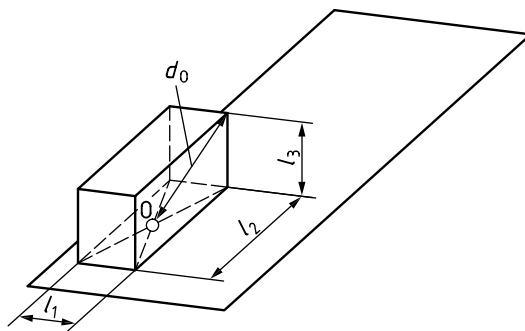
conditions are used, they shall be chosen such that the sound power levels or sound energy levels of the source under test are representative of normal use.

7 Reference box and measurement surface

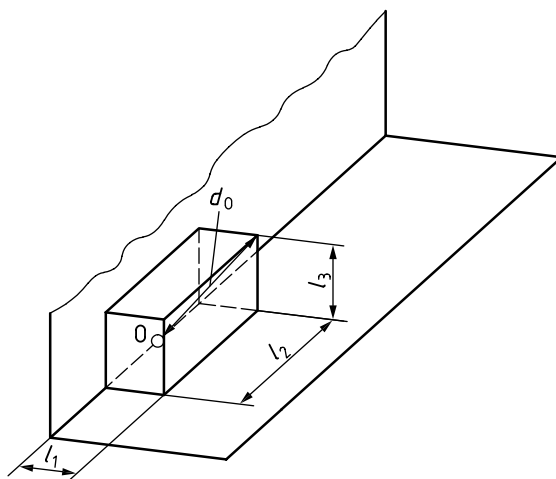
7.1 Reference box

In order to facilitate the selection of the shape and dimensions of the measurement surface, the reference box shall first be delineated. The reference box is a hypothetical surface defined by the smallest right parallelepiped that just encloses the source under test. When defining the dimensions of the reference box, elements protruding from the source which are known not to be significant radiators of sound may be disregarded.

The locations of the reference box, the measurement surface and the microphone positions for measurements, are defined with respect to a co-ordinate system with origin O in the ground plane, shown in Figure 1. The point O is the middle point of a box consisting of the reference box and its images in the adjoining reflecting plane(s). The horizontal axes x and y of the co-ordinate system also lie in the ground plane, parallel to the length and width of the reference box. The characteristic source dimension, d_O , used to determine the dimensions of the measurement surface, is shown in Figure 1 for reference boxes on one, two and three reflecting planes.



a) Reference box on one reflecting plane, $d_O = \sqrt{(l_1/2)^2 + (l_2/2)^2 + l_3^2}$



b) Reference box on two reflecting planes, $d_O = \sqrt{l_1^2 + (l_2/2)^2 + l_3^2}$