INTERNATIONAL STANDARD

ISO 3746

Third edition
2010-12-01

Acoustics — Determination of sound power levels and sound energy levels of noise sources using sound pressure — Survey method using an enveloping measurement surface over a reflecting plane

Acoustique — Détermination des niveaux de puissance acoustique et des niveaux d'énergie acoustique émis par les sources de bruit à partir de la pression acoustique — Méthode de contrôle employant une surface de mesure enveloppante au-dessus d'un plan réfléchissant

Reference number
ISO 3746:2010(E)

ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.org
Web www.iso.org

Published in Switzerland

Contents

Page

Foreword

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

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

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

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

ISO 3746 was prepared by Technical Committee ISO/TC 43, *Acoustics*, Subcommittee SC 1, *Noise*.

This third edition cancels and replaces the second edition (ISO 3746:1995), which has been technically revised. It also incorporates the Technical Corrigendum ISO 3746:1995/Cor.1:1995.

Introduction

This International Standard is one of the series ISO 3741[2] to ISO 3747[6], which specify methods for determining the sound power levels and sound energy levels of noise sources including machinery, equipment and their sub-assemblies. Guidelines to select one of those methods 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 test code for the individual noise source in order to select the appropriate sound measurement surface and microphone array from among those allowed in each of the ISO 3740[1] to ISO 3747[6] series, and to give requirements for 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 machine event is calculated from this sound power and the time over which it existed.

This International Standard specifies methods giving results of ISO 12001:1996, accuracy grade 3 (survey grade) when measurements are performed 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.

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

For applications where greater accuracy is required, reference can be made to ISO 3744, ISO 3745[5] or an appropriate part of ISO 9614[14]-[16]. If the relevant criteria for the measurement environment specified in this International Standard are not met, it might be possible to refer to another of the ISO 3741[2] to ISO 3747[6] series, or to an appropriate part of ISO 9614[14]-[16].

Acoustics — Determination of sound power levels and sound energy levels of noise sources using sound pressure — Survey method using an enveloping measurement surface over a reflecting plane

1 Scope

1.1 General

This International 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 a noise source (machinery or equipment) in a test environment for which requirements are given. The sound power level (or, in the case of noise bursts or transient noise emission, the sound energy level) produced by the noise source with frequency 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 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 International Standard are suitable for all types of noise (steady, non-steady, fluctuating, isolated bursts of sound energy, etc.) defined in ISO 12001.

This International 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 The conditions for measurements given in this International Standard can be impracticable for very tall or very long sources such as chimneys, ducts, conveyors, and multi-source industrial plants. A 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 International 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.

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 with frequency A-weighting applied. The uncertainty conforms with that of ISO 12001:1996, accuracy grade 3 (survey 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 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*

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

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 of measurement — Part 3: Guide to the expression of uncertainty in measurement* (*GUM:1995*)

IEC 60942:2003, *Electroacoustics — Sound calibrators*

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

3 Terms and definitions

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

3.1
sound pressure
p
difference between instantaneous pressure and static pressure

NOTE 1 Adapted from ISO 80000-8:2007[23], 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

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

where the reference value, p_0, is 20 µPa

[ISO/TR 25417:2007[22], 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[23], 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

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

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 $L_{p\mathrm{A},T}$, which is usually abbreviated to $L_{p\mathrm{A}}$.

NOTE 3 Adapted from ISO/TR 25417:2007[22], 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

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

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

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

NOTE 2 When used to measure sound immission, this quantity is usually called "sound exposure level" (see ISO/TR 25417:2007[22]).

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

3.7
frequency range of interest
frequency range of octave bands with nominal mid-band frequencies from 125 Hz to 8 000 Hz

3.8
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, the ISO 11201[18] to ISO 11204[21] series.

3.9
characteristic source dimension
d_0
distance from the origin of the co-ordinate system to the farthest corner of the reference box

NOTE Characteristic source dimension is expressed in metres.

3.10
measurement distance
d
distance from the reference box to a parallelepiped measurement surface

NOTE Measurement distance is expressed in metres.

3.11
measurement radius
r
radius of a hemispherical, half-hemispherical or quarter-hemispherical measurement surface

NOTE Measurement radius is expressed in metres.

3.12
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

3.13
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.

3.14
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-weighting is denoted K_{1A}.

3.15
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-weighting is denoted K_{2A}.

NOTE 3 In general, the environmental correction depends on the area of the measurement surface and usually K_{2A} increases with S.

3.16
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.

3.17
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.

3.18
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[23], 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.

3.19
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

$$L_W = 10 \lg \frac{P}{P_0} \text{ dB} \tag{4}$$

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 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[23], 8-23.

[ISO/TR 25417:2007[22], 2.9]

3.20
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[22], 2.10]

3.21
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 should be indicated by appropriate subscripts; e.g. L_{JA} denotes the A-weighted sound energy level.

[ISO/TR 25417:2007[22], 2.11]

4 Test environment

4.1 General

The test environments that are applicable for measurements in accordance with this International Standard are a room or a flat outdoor area which is adequately isolated from background noise (see 4.2) and which meets the qualification requirements of 4.3.

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 manufacturers 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 the sound generation over the frequency range of interest or on the background noise during the course of the measurements.

At altitudes above 1 500 m, sound power levels and sound energy levels shall be corrected to reference meteorological conditions in accordance with ISO 3744.

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 Criterion for background noise

The A-weighted sound pressure levels due to background noise averaged over the microphone positions, or traverses, on the measurement surface shall be at least 3 dB below the mean sound pressure level due to the noise source under test in operation when measured in the presence of this background noise (see 8.3.2).

4.3 Criterion for acoustic adequacy of test environment

Annex A specifies procedures for determining the magnitude of the environmental correction, K_{2A}, to account for deviations of the test environment from the ideal condition. Measurements in accordance with this International Standard are only valid where $K_{2A} \leqslant 7$ dB.

NOTE 1 If the environmental correction K_{2A} exceeds 7 dB, ISO 3747[6], ISO 9614-1[14] or ISO 9614-2[15] can be used.

NOTE 2 In some specific cases, the horizontal testing plane is only partially 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 source is mounted and indicates the possible consequences on the measurement uncertainty.

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 2.

Class 2 instrumentation is acceptable for steady noise but generally it is recommended to use class 1 instrumentation.

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 this series of measurements shall be discarded.

The calibration of the sound calibrator, and the compliance of the instrumentation system with the requirements of IEC 61672-1 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 and the compliance of the instrumentation system with the requirements of IEC 61672-1 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 practicable, 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 quietened, 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 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 International 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. Resilient mountings 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 on 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 centre of the top of a standard test table.

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

6.5 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 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.