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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 à partir de la pression acoustique — Méthode de contrôle employant une surface de mesure enveloppante au-dessus d'un plan réfléchissant

[Revision of second edition (ISO 3746:1995 and ISO 3746:1995/Cor 1:1995)]

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ISO/CEN PARALLEL ENQUIRY

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Pour accélérer la distribution, le présent document est distribué tel qu'il est parvenu du secrétariat du comité. Le travail de rédaction et de composition de texte sera effectué au Secrétariat central de l'ISO au stade de publication.

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

This third edition cancels and replaces the second edition (ISO 3746:1995), which has been technically revised.

Introduction

0.1 This International Standard is one of the series ISO 3740 to ISO 3747, that specifies methods to determine the emitted sound power level and sound energy level of noise sources including machinery, equipment and their sub-assemblies. Guidelines to select one of those methods are provided in ISO 3740:2001. The selection will depend 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 standard, 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 machine event is calculated from this sound power and the time over which it existed.

0.2 This International Standard provides a survey grade of accuracy (grade 3) as defined in ISO 12001 when 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.

0.3 The method specified in this International Standard permits the determination of the sound power level and the sound energy level with frequency weighting 'A' applied.

0.4 For applications where greater accuracy is required, reference can be made to ISO 3744, ISO 3745 or an appropriate part of ISO 9614. If the relevant criteria for the measurement environment specified in this International Standard are not met, it might be possible to refer to another standard from this series, or to an appropriate part of ISO 9614.

0.5 This International Standard cancels and replaces ISO 3746:1995.

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 determining the sound power levels 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-weighting A 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 a test code should give 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 could 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 may 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 weighting A applied. The uncertainty conforms with that of the survey grade of accuracy (grade 3) defined in ISO 12001.

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 7574-1, *Acoustics – Statistical methods for determining and verifying stated noise emission values of machinery and equipment – Part 1: General considerations and definitions*

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

IEC 60942:2003, *Electroacoustics – Sound calibrators*

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

Guide to the expression of uncertainty in measurement (GUM). International Organization for Standardization, Geneva, Switzerland. ISBN 92-67-10188-9, First Edition 1993, corrected and reprinted 1995.

3 Terms and definitions

For the purposes of this International Standard, the following definitions apply.

3.1
sound pressure
p
a fluctuating pressure superimposed on the static pressure by the presence of sound, 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

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

The reference value, p_0, is 20 µPa (2×10^{-5} Pa).

3.3
time-averaged sound pressure level
$L_{p,T}$
level of the time-averaged square of the sound pressure over the measurement time interval T, expressed in decibels

$$L_{p,T} = 10 \lg \left[\frac{1}{T} \int_0^T \frac{p^2(t)}{p_0^2} \mathrm{d}t \right] \text{dB} \quad (2)$$

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}.

3.4
single-event sound pressure level
L_E
level of the time-integrated square of the sound pressure of an isolated single sound event (burst of sound or transient sound) of specified duration T (or specified measurement time interval $T = t_2 - t_1$) normalized to reference time interval T_0 = 1 s, expressed in decibels

$$L_E = 10 \lg \left[\frac{1}{T_0} \int_{t_1}^{t_2} \frac{p^2(t)}{p_0^2} \mathrm{d}t \right] \mathrm{dB} = L_{p,T} + 10 \lg \left[\frac{T}{T_0} \right] \mathrm{dB} \quad (3)$$

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, expressed in seconds

3.6
reflecting plane
reflecting planar surface on which the noise source under test is located

3.7
frequency range of interest
the range of octave bands with nominal midband frequencies from 125 Hz to 8000 Hz

3.8
reference box
hypothetical rectangular 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 (see 6.3)

3.9
characteristic source dimension
d_0
distance from the origin of the co-ordinate system to the farthest corner of the reference box (see 7.1), expressed in metres

3.10
measurement distance
d
distance from the reference box to a parallelepiped measurement surface, expressed in metres

3.11
measurement radius
r
radius of a hemispherical measurement surface, 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 may include contributions from airborne sound, 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 at all the microphone positions on the measurement surface, to account for the influence of background noise, expressed in decibels

NOTE The background noise correction is frequency dependent, and 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 at all the microphone positions on the measurement surface, to account for the influence of reflected or absorbed sound, expressed in decibels

NOTE 1 The environmental correction is frequency dependent, and in the case of A-weighting is denoted K_{2A}.

NOTE 2 In general, the environmental correction depends on the area of the measurement surface and usually K_2 increases with S.

3.16
surface time-averaged sound pressure level
$\overline{L_p}$
mean (energy average) of the time-averaged sound pressure levels at all the microphone positions on the measurement surface, with the background noise correction, K_1, and the environmental correction, K_2, applied, expressed in decibels

3.17
surface single-event sound pressure level
$\overline{L_E}$

mean (energy average) of the single-event sound pressure levels at all the microphone positions on the measurement surface, with the background noise correction, K_1, and the environmental correction, K_2, applied, expressed in decibels

3.18
sound power
W
rate per unit time at which airborne sound energy is radiated by a source, expressed in watts

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, W, to a reference value, W_0, expressed in decibels

$$L_W = 10 \lg \frac{W}{W_0} \text{ dB} \quad (4)$$

The reference value, W_0, is 1 pW (10^{-12} W).

NOTE The frequency weighting is indicated in the symbol, so the A-weighted sound power level is L_{WA}.

3.20
sound energy
J
energy of a single burst of sound or transient sound emitted by a source, expressed in joules

3.21
sound energy level
L_J
ten times the logarithm to the base 10 of the ratio of the sound energy of a source, J, to a reference value, J_0, expressed in decibels

$$L_J = 10 \lg \frac{J}{J_0} \text{ dB} \quad (5)$$

The reference value, J_0, is 1 pJ (10^{-12} J).

NOTE The frequency weighting is indicated in the symbol, so the A-weighted sound energy level is L_{JA}.

4 Test environment

4.1 General

The test environments that are applicable for measurements according to 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 (for example, 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 (for example, 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 exceeding 1500 m sound power levels and sound energy levels shall be corrected to reference meteorological conditions according to ISO 3744.

NOTE 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 on the measurement surface shall be at least 3 dB below the mean sound pressure level due to the noise source under test (see 8.3.2).

4.3 Criterion for acoustic adequacy of test environment

Annex A describes procedures for determining the magnitude of the environmental correction, K_{2A}, to account for deviations of the test environment from the ideal condition. Measurements according to this International Standard are only valid where K_{2A} is numerically less than or equal to 7 dB (see 8.1).

NOTE 1 If the environmental correction K_{2A} exceeds 7 dB, ISO 3747, ISO 9614-1 or ISO 9614-2 may be used.

NOTE 2 In some specific cases, the horizontal plane is only partially reflecting (e.g. lawnmowers, some types of earth-moving machines). In such cases, the relevant noise test code should describe in detail the nature of the plane on which the source is mounted and indicate 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 for a Class 2 instrument given in IEC 61672-1:2002.

NOTE 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 Class 1 requirements given in IEC 60942:2003 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 further adjustment, the difference between the readings at each end of the series of measurements shall be less than or equal to 0,5 dB. If the difference exceeds 0,5 dB, the results of the series of measurements shall be discarded.

The sound calibrator shall be calibrated, 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.

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

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

6.1 General

It is important to decide which components, sub-assemblies, auxiliary equipment, power sources, etc., constitute integral parts of the noise source under test and are defined as part of the source, the sound power or sound energy of which is to be determined. It is important also to define the manner in which the noise source is installed and operated for the test, since both these factors can have a significant influence on the sound power or sound energy emitted. This clause describes the approach to be adopted in setting up the source for testing and in defining the conditions, so as to achieve an arrangement which is reproducible and which can be related clearly to the results obtained.

This International Standard gives general specifications relating to noise source definition, installation and operation, but these are superseded by the instructions and specifications of a noise test code, if any exists, for the particular type of source.

6.2 Auxiliary equipment

If practicable, all auxiliary equipment necessary for the operation of the noise source under test, but which is not an integral part of the source itself, including any electrical conduits, piping, air ducts, etc., connected to the source under test, shall be located outside the test environment. If this is not possible, care shall be taken to minimise 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, or driven on, the reflecting plane or planes, as if it were in normal usage. The 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. However, in use, some types of machinery and equipment are located adjacent to a hard reflecting wall. Other types operate in free space (e.g. a hoist), or in an opening in a vertical wall with free space on both sides, and some types are mobile in use. The source location for testing shall simulate that for normal use, within the constraints imposed by the method of testing specified in this International Standard. Table-top equipment shall be placed on the hard floor of the test room, unless a table or stand is considered essential for normal operation. In the latter case the equipment shall be placed at the centre of the table top, and the source and table shall be regarded as an integral whole for the purpose of the test.

6.4 Installation and mounting conditions

In many cases, the sound power or sound energy emitted by a source is affected by the support or mounting conditions. Whenever a typical condition of mounting exists for the 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 there is no typical condition of mounting, or one which 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 untypical. Precautions shall be taken to reduce any sound radiated from the structure on which the noise source may be mounted.

NOTE 1 Many small sound 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 vibration energy is transmitted to surfaces large enough to be efficient radiators. In such cases, resilient mountings should, if practicable, be interposed 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 minimised. In this case, the mounting base should have a sufficiently low mobility to prevent it from vibrating and radiating sound excessively. Such resilient mounts should not be used if the noise source under test is not resiliently mounted in typical usage.

NOTE 2 Coupling conditions, e.g. between prime movers and driven machines, can exert considerable influence on the sound radiation of the item under test. It might be appropriate to use a flexible coupling, but similar considerations apply to these as to resilient mounts.

Noise sources that are hand-held in normal usage shall either be held by hand for the purpose of test, or suspended in such a way that no structure-borne sound is transmitted via any attachment that is not an integral part of the source itself. If the noise source requires a support for its operation during testing, the support structure shall be relatively small and considered as part of the source itself.

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 which are typical of normal use. 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):

— source under specified load and conditions;

— source under full load (if different from above);

— source under no load (idling);

— source at maximum operating speed under defined conditions;