BRITISH STANDARD

BS EN ISO 3746 : 1996

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

The European Standard EN ISO 3746 : 1995 has the status of a British Standard

ICS 17.140.10

Committees responsible for this British Standard

The preparation of this British Standard was entrusted to Technical Committee EH/1, Acoustics, upon which the following bodies were represented:

Association of Consulting Engineers
British Broadcasting Corporation
British Occupational Hygiene Society
British Telecommunications plc
Department of the Environment (Building Research Establishment)
Department of Health
Department of Trade and Industry (National Physical Laboratory)
Health and Safety Executive
Institute of Acoustics
Institute of Occupational Hygienists
Institute of Sound and Vibration Research
Institution of Electrical Engineers
Royal Institute of British Architects
Society of Environmental Engineers

The following bodies were also represented in the drafting of the standard, through subcommittees and panels:

Advanced Manufacturing Technology Research Institute
Agricultural Engineers Association
British Cement Association
British Compressed Air Society
British Industrial Truck Association
British Iron and Steel Producers Association
Construction Industry Research and Information Association
Department of Trade and Industry (National Engineering Laboratory)
Engineering Industries Association
Fan Manufacturers Association
Federation of the Electronics Industry
Federation of Manufacturers of Construction Equipment and Cranes
Federation of Piling Specialists
Hevac Association
Institution of Engineering Designers
Institution of Mechanical Engineers
National Specialist Contractors Council
Rotating Electrical Machines Association
University of Liverpool
University of Manchester

This British Standard, having been prepared under the direction of the Health and Environment Sector Board, was published under the authority of the Standards Board and comes into effect on 15 November 1996

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Contents

National foreword

This British Standard has been prepared by Technical Committee EH/1 and is the English language version of EN ISO 3746 : 1995 *Acoustics — Determination of sound power levels of noise sources using sound pressure — Survey method using an enveloping measurement surface over a reflecting plane*, published by the European Committee for Standardization (CEN). It is identical with ISO 3746 : 1995 including Technical Corrigendum 1 : 1995 published by the International Organization for Standardization (ISO).

This British Standard supersedes BS 4196 : Part 6 : 1981 which is withdrawn.

Cross-references

Publication referred to	Corresponding British Standard
ISO 354 : 1985	BS EN 20354 : 1993 *Acoustics. Measurement of sound absorption in a reverberation room*
ISO 3744 : 1994	BS EN ISO 3744 : 1995 *Acoustics. Determination of sound power levels of noise sources using sound pressure. Engineering method in an essentially free field over a reflecting plane*
	BS 4196 *Sound power levels of noise sources*
ISO 3745 : 1977	Part 5 : 1981 *Precision methods for determination of sound power levels for sources in anechoic and semi-anechoic rooms*
ISO 3747 : 1987	Part 7 : 1988 *Survey method for determination of sound power levels of noise sources using a reference sound source*
ISO 6926 : 1990	Part 8 : 1991 *Specification for the performance and calibration of reference sound sources*
	BS 6805 *Statistical methods for determining and verifying stated noise emission values for machinery and equipment*
ISO 7574-1 : 1985	Part 1 : 1987 *Glossary of terms*
ISO 7574-4 : 1985	Part 4 : 1987 *Methods for determining and verifying stated values for batches of machines*
IEC 651 : 1979	BS EN 60651 : 1994 *Specification for sound level meters*
IEC 804 : 1985	BS EN 60804 : 1994 *Specification for integrating-averaging sound level meters*
IEC 942 : 1988	BS 7189 : 1989 *Specification for sound calibrators*

Compliance with a British Standard does not of itself confer immunity from legal obligations.

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English version

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

(ISO 3746 : 1995)

Acoustique — Détermination des niveaux de puissance 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
(ISO 3746 : 1995)

Akustik — Bestimmung der Schalleistungspegel von Geräuschquellen aus Schalldruckmessungen — Hüllflächenverfahren der Genauigkeitsklasse 3 über einer reflektierenden Ebene
(ISO 3746 : 1995)

This European Standard was approved by CEN on 1995-05-12. CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Central Secretariat or to any CEN member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the Central Secretariat has the same status as the official versions.

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CEN

European Committee for Standardization
Comité Européen de Normalisation
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Foreword

The text of the International Standard ISO 3746 : 1995 has been prepared by Technical Committee ISO/TC 43, Acoustics, in collaboration with CEN/TC 211, Acoustics.

This European Standard shall be given the status of a National Standard, either by publication of an identical text or by endorsement, at the latest by February 1996, and conflicting national standards shall be withdrawn at the latest by February 1996.

This European Standard has been prepared under a Mandate given to CEN by the Commission of the European Commission and the European Free Trade Association, and supports essential requirements of EC Directive(s).

According to the CEN/CENELEC Internal Regulations, the following countries are bound to implement this European Standard: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom.

Introduction

0.1 This International Standard is one of the ISO 3740 series, which specifies various methods for determining the sound power levels of machines, equipment and their sub-assemblies. When selecting one of the methods of the ISO 3740 series, it is necessary to select the most appropriate for the conditions and purposes of the noise test. General guidelines to assist in the selection are provided in ISO 3740. The ISO 3740 series gives only general principles regarding the operating and mounting conditions of the machine or equipment under test. Reference should be made to the test code for a specific type of machine or equipment, if available, for specifications on mounting and operating conditions.

0.2 This International Standard specifies a method for measuring the sound pressure levels on a measurement surface enveloping the source and for calculating the sound power level produced by the source. The enveloping surface method can be used for any of three grades of accuracy (see table 0.1), and is used in this International Standard for grade 3 accuracy.

The use of this International Standard requires certain qualification criteria to be fulfilled as described in table 0.1. If the relevant qualification criteria cannot be met, it might be possible to use ISO 3747 or ISO 9614.

Noise test codes for specific families of machines or equipment should be based without any contradiction on the requirements of one or more of the basic documents of the ISO 3740 or ISO 9614 series.

If measurements are made in typical machine rooms, where sources are normally installed, corrections may be required to account for background noise or undesired reflections.

The methods specified in this International Standard permit the determination of sound power level as an A-weighted value directly from the A-weighted sound pressure level measurements.

0.3 In this International Standard, the computation of sound power level from sound pressure level measurements is based on the premise that the sound power output of the source is directly proportional to the mean-square sound pressure averaged in time and space.

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Table 0.1 — Overview of International Standards for determination of sound power levels of noise sources using enveloping surface methods over a reflecting plane and giving different grades of accuracy

Parameter	ISO 3745 Precision method Grade 1	ISO 3744 Engineering method Grade 2	ISO 3746 Survey method Grade 3
Test environment	Hemi-anechoic room	Outdoors or indoors	Outdoors or indoors
Criterion for suitability of test environment 1)	$K_2 \leqslant$ 0,5 dB	$K_2 \leqslant$ 2 dB	$K_2 \leqslant$ 7 dB
Volume of sound source	Preferably less than 0,5 % of test room volume	No restriction: limited only by available test environment	No restriction: limited only by available test environment
Character of noise	Any (broad-band, narrow-band, discrete-frequency, steady, non-steady, impulsive)		
Limitation for background noise 1)	$\Delta L \geqslant$ 10 dB (if possible, exceeding 15 dB) $K_1 \leqslant$ 0,4 dB	$\Delta L \geqslant$ 6 dB (if possible, exceeding 15 dB) $K_1 \leqslant$ 1,3 dB	$\Delta L \geqslant$ 3 dB $K_1 \leqslant$ 3 dB
Number of measurement points	$\geqslant$ 10	$\geqslant$ 9 2)	$\geqslant$ 4 2)
Instrumentation: a) Sound level meter at least complying with b) Integrating sound level meter at least complying with c) Frequency band filter set at least complying with	 a) type 1 as specified in IEC 651 b) type 1 as specified in IEC 804 c) class 1 as specified in IEC 1260	 a) type 1 as specified in IEC 651 b) type 1 as specified in IEC 804 c) class 1 as specified in IEC 1260	 a) type 2 as specified in IEC 651 b) type 2 as specified in IEC 804 —
Precision of method for determining L_{WA} expressed as standard deviation of reproducibility	$\sigma_R \leqslant$ 1 dB	$\sigma_R \leqslant$ 1,5 dB	$\sigma_R \leqslant$ 3 dB (if $K_2 <$ 5 dB) $\sigma_R \leqslant$ 4 dB (if 5 dB $\leqslant K_2 \leqslant$ 7 dB) If discrete tones are predominant, the value of σ_R is 1 dB greater

1) The values of K_1 and K_2 given shall be met in each frequency band within the frequency range of interest for determining the sound power spectrum. For determining A-weighted sound power levels, the same criteria apply to K_{1A} and K_{2A}.

2) Under given circumstances, it is permissible to use a reduced number of microphone positions.

Acoustics — Determination of sound power 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 a method for measuring the sound pressure levels on a measurement surface enveloping the source in order to calculate the sound power level produced by the noise source. It gives requirements for the test environment and instrumentation as well as techniques for obtaining the surface sound pressure level from which the sound power level of the source is calculated, leading to results which have a grade 3 accuracy.

It is important that specific noise test codes for various types of equipment be established and used in accordance with this International Standard. For each type of equipment, such noise test codes will give detailed requirements on mounting, loading and operating conditions for the equipment under test as well as a selection of the measurement surface and the microphone array as specified in this International Standard.

NOTE 1 The noise test code for a particular type of equipment should give detailed information on the particular surface that is selected, as the use of differently shaped measurement surfaces may yield differing estimates of the sound power level of a source.

1.2 Types of noise and noise sources

The method specified in this International Standard is suitable for measurements of all types of noise.

NOTE 2 A classification of different types of noise (steady, non-steady, quasi-steady, impulsive, etc.) is given in ISO 12001.

This International Standard is applicable to noise sources of any type and size (e.g. device, machine, component, sub-assembly).

NOTE 3 Measurements according to this International Standard may be impracticable for very tall or very long sources such as chimneys, ducts, conveyors and multi-source industrial plants.

1.3 Test environment

The test environment that is applicable for measurements made in accordance with this International Standard may be located indoors or outdoors, with one or more reflecting planes present, meeting specified requirements.

1.4 Measurement uncertainty

For sources which radiate steady broad-band noise, determinations made in accordance with this International Standard result, with few exceptions, in standard deviations of reproducibility of the A-weighted sound power level equal to or less than 3 dB (if K_{2A} determined in accordance with annex A is lower than 5 dB) or 4 dB (if K_{2A} is within the range of 5 dB to 7 dB). For discrete-tone sources, the standard deviation of reproducibility is normally 1 dB greater (see table 1).

A single value of the sound power level of a noise source determined in accordance with the procedures given in this International Standard is likely to differ from the true value by an amount within the range of the measurement uncertainty. The uncertainty in determinations of the sound power level arises from several factors which affect the results, some associated with environmental conditions at the test site and others with experimental techniques.

If a particular noise source were to be transported to each of a number of different test sites, and if, at each test site, the sound power level of that source were to be determined in accordance with this International Standard, the results would show a scatter. The standard deviation of the measured levels could be calculated (see examples in ISO 7574-4:1985, annex B). With few exceptions, these standard deviations would not exceed those listed in table 1. The values given in table 1 are standard deviations of reproducibility, σ_R, are defined in ISO 7574-1. The values of table 1 take into account the cumulative effects of measurement uncertainty in applying the procedures of this International Standard, but exclude variations in the sound power output caused by changes in operating conditions (e.g. rotational speed, line voltage) or mounting conditions.

The measurement uncertainty depends on the standard deviation of reproducibility tabulated in table 1 and on the degree of confidence that is desired. As examples, for a normal distribution of sound power levels, there is a 90 % confidence that the expected value of the sound power level of a source lies within the range $\pm$ 1,656σ_R of the measured value and a 95 % confidence that it lies within the range $\pm$ 1,96σ_R of the measured value. For further examples, reference should be made to the ISO 7574 series and ISO 9296.

Table 1 — Estimated upper values of the standard deviations of reproducibility of A-weighted sound power levels determined in accordance with this International Standard

Application	Highest standard deviation of reproducibility, σ_R dB
For a source which emits noise with a relatively "flat" spectrum over the frequency range of interest	3
For a source which emits noise that contains predominant discrete tones	4

NOTES

4 If K_{2A} is greater than or equal to 5 dB, σ_R may be 1 dB greater than the values given in table 1.

5 A noise test code for a particular family of sound sources may have lower values of the standard deviation of reproducibility (see note 8).

6 The standard deviations listed in table 1 are associated with the test conditions and procedures defined in this International Standard and not with the noise source itself. They arise in part from variations between test sites, changes in atmospheric conditions if outdoors, the geometry of the test room or outdoor environment, the acoustical properties of the reflecting plane, absorption at the test room boundaries if indoors, background noise, and the type and calibration of instrumentation. They are also due to variations in experimental techniques, including the size and shape of the measurement surface, number and location of microphone positions, sound source location, integration times, and determination of environmental corrections, if any. The standard deviations are also affected by errors associated with measurements taken in the near field of the source; such errors depend upon the nature of the sound source, but generally increase for smaller measurement distances and lower frequencies (below 250 Hz).

7 If measurements are made at several test sites, the results of sound power determinations on a given source may be in better agreement than would be implied by the standard deviations of table 1.

8 For a particular family of sound sources, a similar size with similar sound power spectra and similar operating conditions, the standard deviations of reproducibility may be smaller than the values given in table 1. Hence, a noise test code for a particular type of machinery or equipment making reference to this International Standard may state standard deviations smaller than those listed in table 1, if substantiation is available from the result of suitable interlaboratory tests.

9 The standard deviations of reproducibility, as tabulated in table 1, include the uncertainty associated with repeated measurements on the same noise under the same conditions (standard deviation of repeatability, see ISO 7574-1). This uncertainty is usually much smaller than the uncertainty associated with variability from one test site to another. However, if it is difficult to maintain stable operating or mounting conditions for a particular source, the standard deviation of repeatability may not be small compared with the values given in table 1. In such cases, the fact that it was difficult to obtain repeatable sound power level data on the source should be recorded and stated in the test report.

10 The procedures of this International Standard and the standard deviations given in table 1 are applicable to measurements on an individual machine. Characterization of the sound power levels of batches of machines of the same family or type involves the use of random sampling techniques in which confidence intervals are specified, and the results are expressed in terms of statistical upper limits. In applying these techniques, the total standard deviation must be known or estimated, including the standard deviation of production, as defined in ISO 7574-1, which is a measure of the variation in sound power output between individual machines within the batch. Statistical methods for the

characterization of batches of machines are described in ISO 7574-4.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 354:1985, *Acoustics — Measurement of sound absorption in a reverberation room.*

ISO 3744:1994, *Acoustics — Determination of sound power levels of noise sources using sound pressure — Engineering method in an essentially free field over a reflecting plane.*

ISO 3745:1977, *Acoustics — Determination of sound power levels of noise sources — Precision methods for anechoic and semi-anechoic rooms.*

ISO 3747:1987, *Acoustics — Determination of sound power levels of noise sources — Survey method using a reference sound source.*

ISO 4871:—[1], *Acoustics — Declaration and verification of noise emission values of machinery and equipment.*

ISO 6926:1990, *Acoustics — Determination of sound power levels of noise sources — Requirements for the performance and calibration of reference sound sources.*

ISO 7574-1:1985, *Acoustics — Statistical methods for determining and verifying stated noise emission values of machinery and equipment — Part 1: General considerations and definitions.*

ISO 7574-4:1985, *Acoustics — Statistical methods for determining and verifying stated noise emission values of machinery and equipment — Part 4: Methods for stated values for batches of machines.*

IEC 651:1979, *Sound level meters*, and Amendment 1:1993.

1) To be published. (Revision of ISO 4871:1984)

IEC 804:1985, *Integrating-averaging sound level meters*, and Amendment 1:1989 and Amendment 2:1993.

IEC 942:1988, *Sound calibrators.*

3 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. It is expressed in pascals.

NOTE 11 The magnitude of the sound pressure can be expressed in several ways, such as instantaneous sound pressure, maximum sound pressure, or as the square root of the mean-square sound pressure over designated time and space (i.e. over the measurement surface).

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 to the square of the reference sound pressure. Sound pressure levels are expressed in decibels.

The frequency weighting or the width of the frequency band used and the time weighting (S, F, or I, see IEC 651) shall be indicated. The reference sound pressure is 20 µPa (2×10^{-5} Pa).

NOTE 12 For example, the A-weighted sound pressure level with time weighting S is L_{pAS}.

3.2.1 time-averaged sound pressure level, $L_{peq,T}$: Sound pressure level of a continuous steady sound that, within a measurement time interval T, has the same mean-square sound pressure as a sound under consideration which varies with time:

$$L_{peq,T} = 10 \lg \left[\frac{1}{T} \int_0^T 10^{0,1L_p(t)} \, dt \right] \text{dB}$$

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

Time-averaged sound pressure levels are expressed in decibels and shall be measured with an instrument which complies with the requirements of IEC 804.

NOTES

13 Time-averaged sound pressure levels are usually A-weighted and denoted by $L_{pAeq,T}$ which is usually abbreviated to L_{pA}.

14 In general, the subscripts "eq" and "T" are omitted since time-averaged sound pressure levels are necessarily determined over a certain measurement time interval.

3.2.2 single-event sound pressure level, $L_{p,1s}$: Time-integrated sound pressure level of an isolated single sound event of specified duration T (or specified measurement time T) normalized to $T_0 = 1$ s. It is expressed in decibels and is given by the following formula:

$$L_{p,1s} = 10 \lg \left[\frac{1}{T_0} \int_0^T \frac{p^2(t)}{p_0^2} \mathrm{d}t \right] \mathrm{dB}$$

$$= L_{peq,T} + 10 \lg \frac{T}{T_0} \mathrm{dB} \quad \ldots (2)$$

3.2.3 measurement time interval: A portion or a multiple of an operational period or operational cycle for which the time-averaged sound pressure level is determined.

3.3 measurement surface: A hypothetical surface of area S, enveloping the source on which the measurement points are located. The measurement surface terminates on one or more reflecting planes.

3.4 surface sound pressure level, $\overline{L_{pf}}$: The 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 (3.13) and the environmental correction K_2 (3.14) applied. It is expressed in decibels.

3.5 sound power, W: The rate per unit time at which airborne sound energy is radiated by a source. It is expressed in watts.

3.6 sound power level, L_W: Ten times the logarithm to the base 10 of the ratio of the sound power radiated by the sound source under test to the reference sound power. It is expressed in decibels.

The frequency weighting or the width of the frequency band used shall be indicated. The reference sound power is 1 pW (10^{-12} W).

NOTE 15 For example, the A-weighted sound power level is L_{WA}.

3.7 frequency range of interest: For general purposes, the frequency range of interest includes the octave bands with centre frequencies from 125 Hz to 8 000 Hz.

3.8 reference box: A hypothetical surface which is the smallest rectangular parallelepiped that just encloses the source and terminates on the reflecting plane or planes.

3.9 characteristic source dimension, d_0: Half the length of the diagonal of the box consisting of the reference box and its images in adjoining reflecting planes.

3.10 measurement distance, d: The distance from the reference box to a box-shaped measurement surface.

3.11 measurement radius, r: The radius of a hemispherical measurement surface.

3.12 background noise: Noise from all sources other than the source under test.

NOTE 16 Background noise may include contributions from airborne sound, structure-borne vibration, and electrical noise in instrumentation.

3.13 background noise correction, K_1: A correction term to account for the influence of background noise on the surface sound pressure level; K_1 is frequency dependent and is expressed in decibels. The correction in the case of A-weighting is denoted K_{1A}.

3.14 environmental correction, K_2: A correction term to account for the influence of reflected or absorbed sound on the surface sound pressure level; K_2 is frequency dependent and is expressed in decibels. The correction in the case of A-weighting is denoted K_{2A}.

3.15 impulsive noise index (impulsiveness)**:** A quantity by means of which the noise emitted by a source can be characterized as "impulsive". (See annex D.) It is expressed in decibels.

4 Acoustic environment

4.1 General

Test environments that are suitable for measurements in accordance with this International Standard include a flat outdoor area or a room which meets the qualification requirements of 4.2 and which is adequately isolated from background noise in accordance with the requirements of 4.3.

4.2 Criterion for adequacy of the 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. For this International Standard, the environmental correction K_{2A} (see table 0.1 and 8.3) shall be numerically less than or equal to 7 dB.

NOTE 17 If the environmental correction K_{2A} exceeds 7 dB, it is recommended that either a reference sound source method (ISO 3747) or the method of ISO 9614 be used.

4.3 Criterion for background noise

Averaged over the microphone positions, the A-weighted sound pressure level of the background noise shall be at least 3 dB below the sound pressure level to be measured (see table 0.1 and 8.2).

5 Instrumentation

5.1 General

The instrumentation system, including the microphones and cables, shall meet the requirements for a type 2 instrument specified in IEC 651 or, in the case of integrating-averaging sound level meters, the requirements for a type 2 instrument specified in IEC 804.

5.2 Calibration

During each series of measurements, a sound calibrator with an accuracy of $\pm$ 0,3 dB (class 1 as specified in IEC 942) shall be applied to the microphone to verify the calibration of the entire measuring system at one or more frequencies over the frequency range of interest.

The compliance of the calibrator shall be verified with the requirements of IEC 942 once a year and the compliance of the instrumentation system with the requirements of IEC 651 (and IEC 804 in the case of integrating systems) at least every 2 years in a laboratory making calibrations traceable to appropriate measurement standards.

The date of the last verification of the compliance with the relevant IEC standards shall be recorded.

5.3 Microphone windscreen

If measurements are to be made outdoors, a windscreen is recommended. Ensure that the windscreen does not affect the accuracy of the instrumentation.

6 Installation and operation of source under test

6.1 General

The manner in which the source under test is installed and operated may have a significant influence on the sound power emitted by the source. This clause specifies conditions that minimize variations in the sound power output due to installation and operating conditions of the source under test. The instructions of a noise test code, if any exists, shall be followed in so far as installation and operation of the source under test is concerned.

Particularly for large sources, it is important that a noise test code specify which components, subassemblies, auxiliary equipment, power sources, etc. are to be included in the reference box.

6.2 Source location

The source to be tested shall be installed with respect to the reflecting plane or planes in one or more locations as if it were being installed for normal usage. If several possibilities exist, or if typical installation conditions are unknown, special arrangements shall be made and described in the test report. If the location of the source within the test environment can be selected, sufficient space shall be allowed so that the measurement surface can develop the source under test in accordance with the requirements of 7.1.

6.3 Source mounting

In many cases, the sound power emitted will depend upon the support or mounting conditions of the source under test. Whenever a typical condition of mounting exists for the equipment under test, that condition shall be used or simulated, if feasible.

If a typical condition of mounting does not exist or cannot be utilized for the test, care shall be taken to avoid changes in the sound output of the source caused by the mounting system employed for the test. Steps shall be taken to reduce any sound radiation from the structure on which the equipment may be mounted.

NOTES

18 Many small sound sources, although themselves poor radiators of low-frequency sound, may, 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, if practicable, resilient mountings should be interposed be-

tween the device to be measured and the supporting surfaces 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 have a sufficiently high mechanical impedance to prevent it from vibrating and radiating sound excessively. Such resilient mounts should not be used if the device under test is not resiliently mounted in typical field installations.

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

6.3.1 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 machine under test. If the source under test requires a support for its operation, the support structure shall be small, considered to be a part of the source under test, and described in the machine test code.

6.3.2 Base-mounted and wall-mounted machinery and equipment

Such machinery and equipment shall be placed on a reflecting (acoustically hard) plane (floor, wall). Base-mounted machines intended exclusively for mounting in front of a wall shall be installed on an acoustically hard floor surface in front of an acoustically hard wall. Table-top 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 test code for the equipment under test. Such equipment shall be placed in the centre of the top of the test table.

6.4 Auxiliary equipment

Care shall be taken to ensure that any typical electrical conduits, piping or air ducts connected to the 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 source under test and which is not a part of the source (see 6.1) shall be located outside the test environment.

If impracticable, the auxiliary equipment shall be included in the reference box and its operating conditions described in the test report.

6.5 Operation of source during test

During the measurements, the operating conditions specified in the relevant test code, if one exists for the particular type of machinery or equipment under test, shall be used. If there is no test code, the source shall be operated, if possible, in a manner which is typical of normal use. In such cases, one or more of the following operating conditions shall be selected:

— device under specified load and operating conditions;

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

— device under no load (idling);

— device under operating conditions corresponding to maximum sound generation representative of normal use;

— device with simulated load operating under carefully defined conditions;

— device under operating conditions with characteristic work cycle.

The sound power level of the source may be determined for any desired set of operating conditions (i.e. loading, device speed, temperature, etc.). These test conditions shall be selected beforehand and shall be held constant during the test. The source shall be in the desired operating condition before any noise measurements are made.

If the noise emission depends on secondary operating parameters, such as the type of material being processed or the type of tool being used, as far as is practicable, those parameters shall be selected that give rise to the smallest variations and that are typical of the operation. The noise test code for a specific family of machines shall specify the tool and the material for the test.

For special purposes it is appropriate to define one or more operating conditions in such a way that the noise emission of machines of the same family is highly reproducible and that the operating conditions which are most common and typical for the family of machines are covered. These operating conditions shall be defined in specific test codes.

If simulated operating conditions are used, they shall be chosen to give sound power levels representative of normal usage of the source under test.

If appropriate, the results for several separate operating conditions, each lasting for defined periods of time, shall be combined by energy-averaging to yield the result for a composite overall operating procedure.

The operating conditions of the source during the acoustical measurements shall be fully described in the test report.

7 Measurement of sound pressure levels

7.1 Selection of the measurement surface

To facilitate the location of the microphone positions on the measurement surface, a hypothetical reference box shall be defined. When defining the dimensions of this reference box, elements protruding from the source which are not significant radiators of sound energy may be disregarded. These protruding elements should be identified in specific noise test codes for different types of equipment. The microphone positions lie on the measurement surface, a hypothetical surface of area S which envelops the source as well as the reference box and terminates on the reflecting plane(s).

The location of the source under test, the measurement surface and the microphone positions are defined by a coordinate system with the horizontal axes x and y in the ground plane parallel to the length and width of the reference box. The characteristic source dimension d_0 is shown in figure 1.

One of the following two shapes shall be used for the measurement surface:

a) a hemispherical surface or partial hemispherical surface of radius r;

b) a rectangular parallelepiped whose sides are parallel to those of the reference box; in this case, the measurement distance d is the distance between the measurement surface and the reference box.

For sources usually mounted and/or to be measured in rooms or spaces under unfavourable acoustical conditions (for example, many reflecting objects and high levels of background noise), the selection of a small measurement distance is appropriate and usually dictates the selection of a parallelepiped measurement surface. For sources usually mounted and/or to be measured in large open areas under satisfactory acoustical conditions, a large measurement distance is usually selected and in this case the hemispherical measurement surface is preferred.

For measurements on a series of similar sources (for example, machines of the same type or a given family of equipment), the use of the same shape of measurement surface is required.

NOTE 20 The specific noise test code pertinent to the particular source under investigation should be consulted for detailed information.

The construction of the reference box, the size and shape of the measurement surface, as well as the measurement distance d or the radius of the hemisphere r, shall be described in the test report.

7.2 Hemispherical measurement surface

The hemisphere shall be centred in the middle of the box consisting of the reference box and its images in adjoining reflecting planes, point Q in figure 1. The radius r of the hemispherical measurement surface shall be equal to or greater than twice the characteristic source dimension d_0 and not less than 1 m.

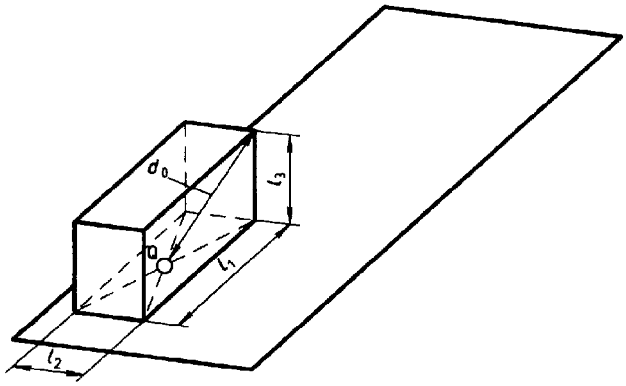
The radius of the hemisphere should be one of the following values (in metres): 1, 2, 4, 6, 8, 10, 12, 14 or 16. Some of these radii may be so large that the environmental requirements given in annex A cannot be satisfied; such large values of the radii shall not be used.

7.2.1 Area and key microphone positions on the hemispherical measurement surface

If there is only one reflecting plane, the microphone positions lie on the hypothetical hemispherical surface of area $S = 2\pi r^2$, enveloping the source and terminating on the reflecting plane. If the source under test is in front of a wall, $S = \pi r^2$. If it is in the corner, $S = 0{,}5\pi r^2$. The key microphone positions of the hemispherical surface are shown in figures B.1 and B.2 in annex B. Figure B.1 specifies the locations of four key microphone positions, each associated with equal areas on the surface of the hemisphere of radius r.

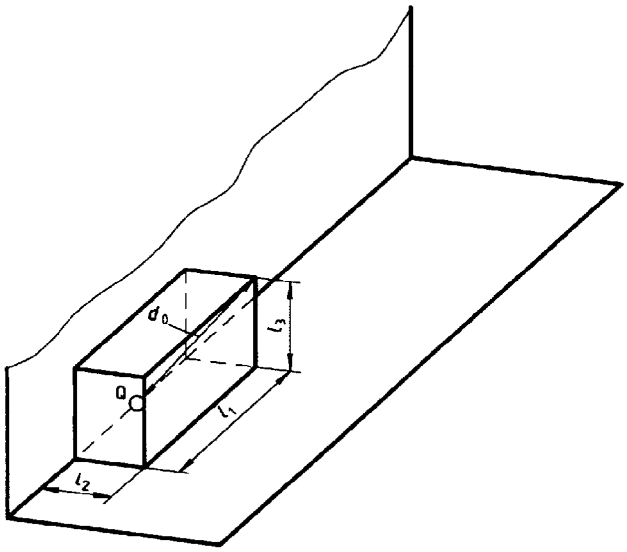
If a source is installed adjacent to more than one reflecting plane, reference shall be made to figure B.3 in annex B to define a suitable measurement surface and the microphone positions.

In special cases (i.e. for families of machines, such as construction equipment or earth-moving machinery, which are to be measured in a moving state or in a driving mode), a different number and arrangement of microphone positions can be used. However, this is only possible if preliminary investigation has shown that the resulting sound power level value is equal to or larger by less than 1 dB than that determined with the array specified in this International Standard.



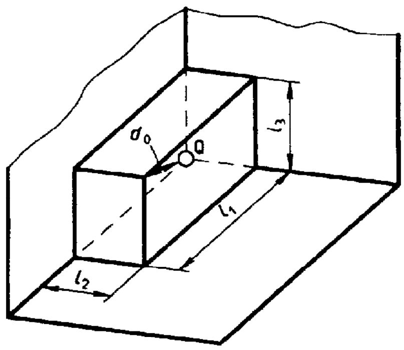
a) Reference box on one reflecting plane

$$d_0 = \sqrt{(l_1/2)^2 + (l_2/2)^2 + l_3^2}$$



b) Reference box on two reflecting planes

$$d_0 = \sqrt{(l_1/2)^2 + l_2^2 + l_3^2}$$



c) Reference box on three reflecting planes

$$d_0 = \sqrt{l_1^2 + l_2^2 + l_3^2}$$

Figure 1 — Examples illustrating reference boxes and characteristic source dimensions d_0 with respect to the origin of the coordinate system Q

7.2.2 Additional microphone positions on the hemispherical measurement surface

Sound pressure level measurements are required at additional microphone positions on the hemispherical measurement surface if

a) the range of sound pressure level values measured at the key microphone positions (i.e. the difference in decibels between the highest and lowest sound pressure levels) exceeds twice the number of key measurement points, or

b) the source radiates noise with a high directivity, or

c) the noise from a large source is radiated only from a small portion of the source, for example, the openings of an otherwise enclosed machine.

For the microphone array on the hemisphere, an additional 4-point array is defined by rotating the original array of figure B.1 through 180° about the z-axis (see table B.1 and figure B.2). Note that the top point on the z-axis of the new array is coincident with the top point of the original array. The total number of microphone positions is increased from 4 to 7.

If conditions b) or c) exist, additional measurement positions on the measurement surface in the region of high noise radiation shall be used (see 7.4.1).

7.3 Parallelepiped measurement surface

The measurement distance d is the perpendicular distance between the reference box and the measurement surface. The preferred value of d is 1 m and it shall be at least 0,15 m.

The value of d should be one of the following values (in metres): 0,15, 0,25, 0,5, 1, 2, 4 or 8. Measurement distances larger than 1 m may be selected for large sources. The environmental requirements given in annex A should be satisfied for the value of d selected.

7.3.1 Area and microphone positions on the parallelepiped measurement surface

The microphone positions lie on the measurement surface, a hypothetical surface of area S enveloping the source whose sides are parallel to the sides of the reference box and spaced out a distance d (measurement distance) from the box.

The microphone positions on the parallelepiped measurement surface are shown in figures C.1 to C.8 in annex C. The area S of the measurement surface according to figures C.2 to C.6 is given by the formula

$$S = 4(ab + bc + ca) \qquad \ldots (3)$$

where

$a = 0{,}5l_1 + d$

$b = 0{,}5l_2 + d$

$c = l_3 + d$

l_1, l_2 and l_3 are the length, width and height of the reference box.

If a source is installed adjacent to more than one reflecting plane, reference shall be made to figures C.7 and C.8 in annex C to define a suitable measurement surface. The calculation of the area S of the measurement surfaces under these conditions is given in the respective figures. The microphone positions shall be located according to figures C.1 to C.8.

7.3.2 Additional microphone positions on the parallelepiped measurement surface

Sound pressure level measurements are required at additional microphone positions on the parallelepiped measurement surface if

a) the range of sound pressure level values measured at the key microphone positions (i.e. the difference in decibels between the highest and the lowest sound pressure levels) exceeds twice the number of measurement points, or

b) the source radiates noise with a high directivity, or

c) the noise from a large source is radiated only from a small portion of the source, for example, the openings of an otherwise enclosed machine.

For the microphone array on the parallelepiped, the number of measurement points is increased as shown in figure C.1, annex C, by increasing the number of equally sized rectangular partial areas.

If conditions b) or c) exist, additional measurement positions on the measurement surface in the region of high noise radiation shall be used (see 7.4.1).

7.4 Additional procedures for selection of microphone positions

7.4.1 Additional localized microphone positions on the measurement surface

If additional localized microphone positions are required in accordance with 7.2.2 or 7.3.2, a detailed investigation is necessary of the sound pressure levels over a restricted portion of the measurement surface. The purpose of this detailed investigation is to determine the highest and lowest values of the sound pressure level in the frequency bands of interest. The additional microphone positions will usually not be associated with equal areas on the measurement surface.

In this case, the calculation procedure of ISO 3745:1977, 8.1.2 (unequal areas) for the determination of L_W shall be used.

7.4.2 Reduction in the number of microphone positions

The number of microphone positions can be reduced if preliminary investigations for a particular family of machines show that, by using the reduced number of microphone positions, the determined surface sound pressure levels do not deviate by more than 1 dB from those determined from measurements over the complete set of microphone positions in accordance with 7.2 and 7.3. An example is when the radiation pattern is shown to be symmetrical.

NOTE 21 The overhead position(s) may be deleted for safety reasons, if so stated in the relevant noise test code.

7.5 Measurement

7.5.1 Environmental conditions

Environmental conditions having an adverse effect on the microphone used for the measurements (for example, strong electric or magnetic fields, wind, impingement of air discharge from the equipment being tested, high or low temperatures) shall be avoided by proper selection or positioning of the microphone. The instructions of the manufacturers of the measurement instruments regarding adverse environmental conditions shall be followed.

7.5.2 Measuring instruments

In addition to the requirements given in clause 5, the following apply.

The microphone shall always be oriented in such a way that the angle of incidence of the sound waves is that for which the microphone is calibrated.

The time-averaged sound pressure level (see 3.2.1) shall be measured using an integrating sound level meter complying with IEC 804, unless it is shown that the sound pressure fluctuations measured with time-weighting characteristic S are less than $\pm$ 1 dB; in this case it is also permissible to use a sound level meter complying with IEC 651. In the latter case, express the time-averaged sound pressure level as the average of the maximum and minimum levels during the period of measurement.

7.5.3 Procedure

Observe the A-weighted sound pressure level over a typical period of operation of the source. Take readings of the A-weighted sound pressure level at each microphone position.

Determine the following:

a) the A-weighted sound pressure levels L'_{pA} during operation of the source under test;

b) the A-weighted sound pressure levels L''_{pA} produced by the background noise.

The period of observation shall be at least 30 s unless otherwise stated in the noise test code for the specific family of machinery or equipment.

For the measurement of isolated single-sound events, determine the single-event sound pressure level $L_{p,1s}$ (see 3.2.2).

For noise that varies with time, it is important to specify carefully the period of observation, and this will usually depend on the purpose of the measurements. For a machine with modes of operation having different noise levels, select an appropriate measuring period for each mode and state this in the test report.

8 Calculation of A-weighted surface sound pressure level and A-weighted sound power level

8.1 Calculation of A-weighted sound pressure level averaged over the measurement surface

Calculate average A-weighted sound pressure levels over the measurement surface, i.e. $\overline{L'_{pA}}$ from the measured A-weighted sound pressure levels L'_{pAi}, and $\overline{L''_{pA}}$ from the A-weighted sound pressure levels of the background noise L''_{pAi}, using the following equations:

$$\overline{L'_{pA}} = 10 \lg \left[\frac{1}{N} \sum_{i=1}^{N} 10^{0,1L'_{pAi}} \right] \text{ dB} \quad \ldots (4)$$

$$\overline{L''_{pA}} = 10 \lg \left[\frac{1}{N} \sum_{i=1}^{N} 10^{0,1L''_{pAi}} \right] \text{ dB} \quad \ldots (5)$$

where

$\overline{L'_{pA}}$ is the A-weighted sound pressure level averaged over the measurement surface, in decibels, with the source under test in operation;

$\overline{L''_{pA}}$ is the A-weighted sound pressure level of the background noise averaged over the measurement surface, in decibels;

L'_{pAi} is the A-weighted sound pressure level measured at the ith microphone position, in decibels;

L''_{pAi} is the A-weighted sound pressure level of the background noise measured at the ith microphone position, in decibels;

N is the number of microphone positions.

NOTE 22 The averaging procedure in equations (4) and (5) is based on a uniform distribution of the microphone positions on the measurement surface.

8.2 Corrections for background noise

Calculate the correction K_{1A} from measured A-weighted values by using the following equation:

$$K_{1A} = -10 \lg\left(1 - 10^{-0,1\Delta L_A}\right) \text{ dB} \quad \ldots (6)$$

where

$$\Delta L_A = \overline{L'_{pA}} - \overline{L''_{pA}}$$

If $\Delta L_A > 10$ dB, in this International Standard no correction is made. If $\Delta L_A \geqslant 3$ dB, the measurement is valid according to this International Standard (see table 0.1).

For values of ΔL_A between 3 dB and 10 dB, make corrections according to equation (6).

If $\Delta L_A < 3$ dB, the accuracy of the result(s) is reduced. The maximum correction to be applied to these measurements is 3 dB. The result may, however, be reported and may be useful for determining an upper boundary to the sound power level of the source under test. If such data are reported, it shall be clearly stated in the text of the report, as well as in graphs and tables of results, that the background noise requirements of this International Standard have not been fulfilled.

8.3 Corrections for test environment

The environmental correction K_{2A} is determined by one of the procedures described in annex A.

Measurements in accordance with this International Standard are valid if $K_{2A} \leqslant 7$ dB (see table 0.1).

8.4 Calculation of the A-weighted surface sound pressure level

Determine the A-weighted surface sound pressure level $\overline{L_{pfA}}$ by correcting the value $\overline{L'_{pA}}$ for background noise and for reflected sound by using the following equation with corrections K_{1A} and K_{2A}:

$$\overline{L_{pfA}} = \overline{L'_{pA}} - K_{1A} - K_{2A} \quad \ldots (7)$$

8.5 Calculation of the A-weighted sound power level

The A-weighted sound power level L_{WA} shall be calculated as follows:

$$L_{WA} = \overline{L_{pfA}} + 10 \lg \frac{S}{S_0} \text{ dB} \quad \ldots (8)$$

where

$\overline{L_{pfA}}$ is the A-weighted surface sound pressure level according to equation (7);

S is the area of the measurement surface, in square metres;

S_0 = 1 m^2.

8.6 Determination of optional quantities

The following optional quantities may be required by noise test codes for specific types of sources.

a) Information on impulsive noise in accordance with one of the methods of annex D; and/or the presence of discrete tones determined by listening.

b) The sound pressure spectrum at a single microphone position on the measurement surface or averaged over the measurement surface.

c) The variation of the A-weighted sound pressure level with time at a defined microphone position.

d) The sound pressure level with different time and/or frequency weighting at individual microphone position(s) on the measurement surface.

9 Information to be recorded

The information listed in 9.1 to 9.6, when applicable, shall be compiled and recorded for all measurements made in accordance with this International Standard.

9.1 Sound source

Description of the sound source, including its

— type,
— technical data,
— dimensions,
— manufacturer,
— machine serial number,
— year of manufacture.

9.2 Test conditions

a) Operating conditions.

b) Mounting conditions.

c) Location of sound source in test environment.

d) If the test object has multiple noise sources, a description of the source(s) in operation during the measurements.

9.3 Acoustic environment

a) Description of the test environment:

- if indoors, description of physical treatment of walls, ceiling and floor; sketch showing the location of the source and room contents;

- if outdoors, sketch showing the location of the source with respect to surrounding terrain, including a physical description of the test environment.

b) Acoustical qualification of the test environment in accordance with annex A.

9.4 Instrumentation

a) Equipment used for measurements, including name, type, serial number and manufacturer.

b) Method used for checking the calibration of the microphones and other system components; the date, place and result of calibration shall be given.

c) Characteristics of windscreen (if any).

9.5 Acoustical data

a) A-weighted sound power level.

NOTE 23 ISO 9296 requires that the declared A-weighted sound power level, L_{WAd}, of computers and business equipment be expressed in bels, using the identity 1 B = 10 dB.

b) The shape of the measurement surface, the measurement distance or radius, and the location of microphone positions.

c) The area S of the measurement surface.

d) The background noise correction K_{1A} for the A-weighted surface sound pressure level.

e) The environmental correction K_{2A} and the method by which it was determined in accordance with one of the procedures of annex A.

f) A-weighted sound pressure levels L'_{pAi} (respectively $L'_{pA,1s,i}$) at each measuring point i.

g) The A-weighted surface sound pressure level $\overline{L_{pfA,x}}$, where x is the measurement distance d or the measurement radius r.

h) Place, date when the measurements were performed, and the name of the person responsible for the test.

9.6 Optional data

a) The value of the A-weighted sound pressure level at a specified microphone position on the measurement surface.

b) Information on impulsive noise in accordance with one of the methods of annex D, and/or the presence of discrete tones determined by listening.

c) Variation of the A-weighted sound pressure level with time at a specified microphone position or over the measurement surface.

d) Wind speed and direction.

e) Any noise data required by the noise test code.

f) Where it is not possible to apply a method of higher grade of accuracy, information on frequency band pressure levels may also be of interest.

10 Information to be reported

Only those recorded data (see clause 9) are to be reported which are required for the purpose of the measurements (see ISO 4871).

The report shall state whether or not the reported sound power levels have been obtained in full conformity with the requirements of this International Standard.

The A-weighted sound power level of the source under test shall be reported to the nearest whole decibel.

Annex A
(normative)

Qualification procedures for the acoustic environment

A.1 General

A test area outdoors or an ordinary room will provide a suitable environment if the requirements given in this annex are satisfied.

Reflecting objects other than reflecting plane(s) shall be removed to the maximum extent possible from the vicinity of the machine under test. A test site shall ideally provide a measurement surface which lies

a) inside a sound field that is essentially undisturbed by reflections from nearby objects and the room boundaries, and

b) outside the near field of the sound source under test.

For the purposes of the survey method, the measurement surface is considered to lie outside the near field if the measurement distance from the source under test is equal to or greater than 0,15 m.

For outdoor measurements, the specified conditions of A.2 shall be satisfied. For indoor measurements, one of the alternative qualification procedures of A.3 shall be followed. Otherwise, the measurement will not be in conformity with the requirements of this International Standard.

NOTE 24 Alternatively, the test environment qualification procedures of ISO 3744 may be followed in place of this annex.

A.2 Environmental conditions

A.2.1 Types of reflecting planes

Examples of permitted reflecting planes outdoors include compacted earth, artificial surfaces such as concrete or sealed asphalt, and for indoor measurements the reflecting plane is usually the floor. Take care to ensure that the reflecting surface does not radiate any appreciable sound energy due to vibration.

A.2.1.1 Shape and size

The reflecting surface shall be larger than the projection of the measurement surface on it.

A.2.1.2 Sound absorption coefficient

The sound absorption coefficient (see ISO 354) of the reflecting plane should preferably be less than 0,1 over the frequency range of interest. This requirement is usually fulfilled when outdoor measurements are made over concrete, sealed asphalt or stone surfaces. For reflecting planes with higher sound absorption coefficient, for example, grass- or snow-covered ground, the measurement distance shall be not greater than 1 m. For indoor measurements, wooden and tile floors are also permitted.

A.2.2 Reflecting objects

No reflecting objects that are not part of the source under test shall be located inside the measurement surface.

A.2.3 Precautions for outdoor measurements

Avoid adverse meteorological conditions during the measurements, for example, temperature gradients, wind gradients, precipitation and high humidity.

In all cases, observe the precautions of the manufacturer as stated in the instruction manuals for the instruments.

A.3 Qualification procedure and requirements for test sites

A.3.1 Test procedure using a reference sound source

The correction K_{2A} may be determined by calculating the sound power level of a reference sound source (see ISO 6926) which has previously been calibrated in a free field over a reflecting plane. In this case, K_{2A} is given by the expression

$$K_{2A} = L^{*}_{WA} - L_{WAr} \quad \ldots (A.1)$$

where

L^{*}_{WA} is the environmentally uncorrected A-weighted sound power level of the reference sound source, determined in accordance with clauses 7 and 8 when using the value 0 for K_{2A};

L_{WAr} is the calibrated A-weighted sound power level of the reference sound source [reference 1 pW$\left(=10^{-12}\text{ W}\right)$], in decibels.

NOTE 25 Guidelines for the location of the reference sound source in the test environment are to be found in ISO 3744:1994, annex A.

A.3.2 Other procedures

The environmental correction K_{2A} in equation (7) of 8.4 accounts for the influence of undesired sound reflections from room boundaries and/or reflecting objects near the source under test. The magnitude of this environmental correction K_{2A} depends principally on the ratio of the sound absorption area A of the test room to the area S of the measurement surface. The magnitude does not depend strongly on the location of the source in the test room.

In this International Standard, the environmental correction K_{2A} is given by

$$K_{2A} = 10 \lg[1 + 4(S/A)] \text{ dB} \quad \ldots (A.2)$$

where

A is the equivalent sound absorption area of the room at 1 kHz, in square metres;

S is the area of the measurement surface, in square metres.

Environmental corrections as a function of A/S calculated using equation (A.2) are illustrated in figure A.1.

Alternative methods are given in A.3.2.1 and A.3.2.2 to determine the equivalent sound absorption area A of the test room.

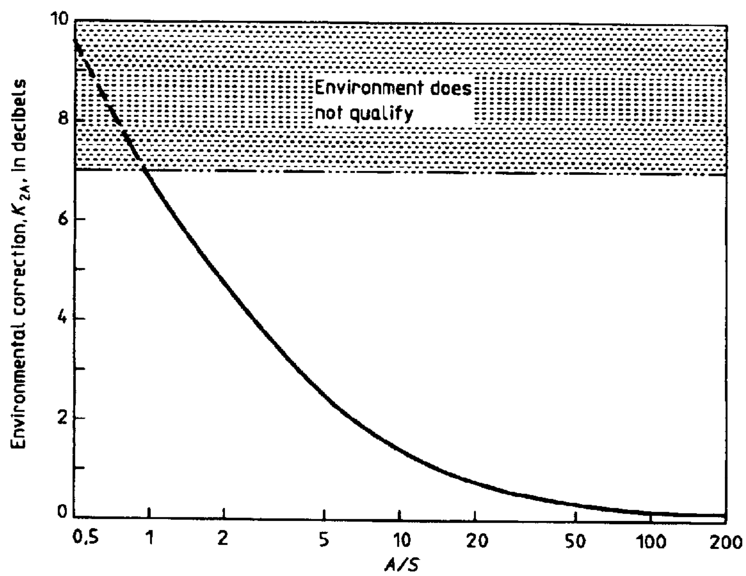


Figure A.1 — Environmental correction K_{2A}, in decibels

A.3.2.1 Approximate method

The mean sound absorption coefficient α of the surface of the room is estimated by using table A.1. The value of A is given, in square metres, by the formula

$$A = \alpha \cdot S_V \qquad \ldots (A.3)$$

where

α is the mean sound absorption coefficient, given for A-weighted quantities in table A.1;

S_V is the total area of the boundary surfaces of the test room (walls, ceiling and floor), in square metres.

Table A.1 — Approximate values of the mean sound absorption coefficient α

Mean sound absorption coefficient α	Description of room
0,05	Nearly empty room with smooth hard walls made of concrete, brick, plaster or tile
0,1	Partly empty room; room with smooth walls
0,15	Room with furniture; rectangular machinery room; rectangular industrial room
0,2	Irregularly shaped room with furniture; irregularly shaped machinery room or industrial room
0,25	Room with upholstered furniture; machinery or industrial room with a small amount of sound-absorbing material on ceiling or walls (for example, partially absorptive ceiling)
0,35	Room with sound-absorbing materials on both ceiling and walls
0,5	Room with large amounts of sound-absorbing materials on ceiling and walls

A.3.2.2 Reverberation method

If it is required, determine a value of the sound absorption area A by measuring the reverberation time of the test room which is excited by broad-band noise or an impulsive sound with A-weighting on the receiving system (see ISO 354). The value of A is given, in square metres, by the expression

$$A = 0{,}16(V/T) \qquad \ldots (A.4)$$

where

V is the volume of the test room, in cubic metres;

T is the reverberation time of the test room, in seconds.

NOTE 26 For the purpose of determining K_{2A} directly from A-weighted measured values, it is more convenient to use the reverberation time measured in the frequency band with a centre frequency of 1 kHz.

A.3.3 Qualification requirements for test rooms

For the measurement surface in a test room to be satisfactory for measurements in accordance with the requirements of this International Standard, the ratio of the sound absorption area A to the area S of the measurement surface shall be equal to or greater than 1, that is

$$A/S \geqslant 1 \qquad \ldots (A.5)$$

The larger the ratio A/S is, the better.

If the above requirement cannot be satisfied, a new measurement surface shall be chosen. The new measurement surface shall have a smaller total area, but shall still lie outside the near field (see A.1). Alternatively, the ratio A/S may be increased by introducing additional sound-absorbing materials into the test room and then redetermining the value of the ratio A/S under the new conditions.

If the requirement of this clause cannot be satisfied for any measurement surface which lies outside the near field of the source under test, the particular environment cannot be used for measurements on the source under test in accordance with the requirements of this International Standard.

For outdoor test sites, the environmental correction K_{2A} usually has very small values.

NOTE 27 In some special outdoor cases, the value of K_{2A} may be negative, but for the purposes of this International Standard K_{2A} is then assumed to be zero.

Annex B
(normative)

Microphone array on the hemispherical measurement surface

B.1 Key microphone positions and additional microphone positions

Four key microphone positions associated with equal areas of the measurement surface are numbered 4, 5, 6 and 10 in figures B.1 and B.2, and their coordinates according to the coordinate system defined in 7.1 are listed in table B.1. Four additional microphone positions are numbered 14, 15, 16 and 20 in figure B.2 and their coordinates are also listed in table B.1.

NOTE 28 The numbering of the microphone positions is the same in ISO 3744.

Table B.1 — Coordinates of key microphone positions (4, 5, 6, 10) and additional microphone positions (14, 15, 16, 20)

Microphone position	$\frac{x}{r}$	$\frac{y}{r}$	$\frac{z}{r}$
4	− 0,45	0,77	0,45
5	− 0,45	− 0,77	0,45
6	0,89	0	0,45
10	0	0	1,0
14	0,45	− 0,77	0,45
15	0,45	0,77	0,45
16	− 0,89	0	0,45
20	0	0	1,0

NOTE — The overhead positions 10 and 20 coincide and it is permissible to omit these if so indicated in the relevant noise test code.

B.2 Microphone positions for sources emitting discrete tones

If the source emits discrete tones, strong interference effects can occur if several microphone positions are placed at the same height above the reflecting plane. In such a case, the use of a microphone array with the coordinates numbered 4, 5, 6 and 10 in table B.2 is recommended.

Table B.2 — Coordinates of microphone positions (4, 5, 6, 10) for sources emitting discrete tones

Microphone position	$\frac{x}{r}$	$\frac{y}{r}$	$\frac{z}{r}$
4	0,16	0,90	0,41
5	− 0,83	0,32	0,45
6	− 0,83	− 0,40	0,38
10	0,10	− 0,10	0,99

B.3 Microphone positions for sources adjacent to two reflecting planes

For a source installed adjacent to two reflecting planes, reference shall be made to figure B.3 for the purposes of defining a suitable measurement surface and microphone positions. The radius r of the spherical measurement surface shall be at least 3 m.

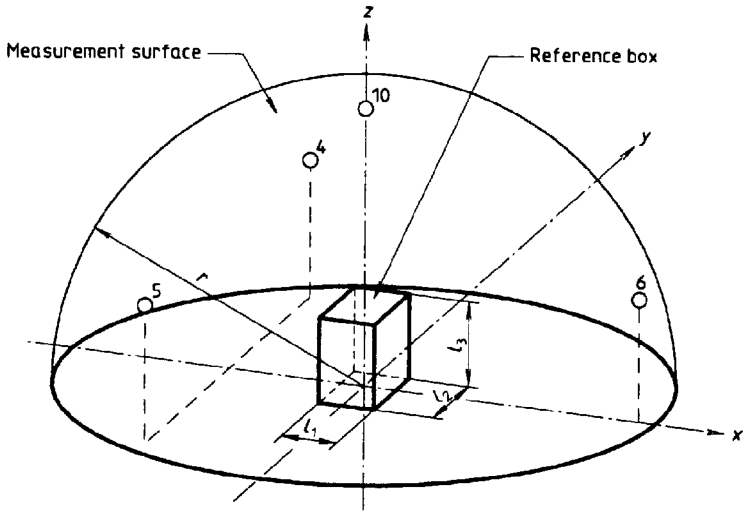
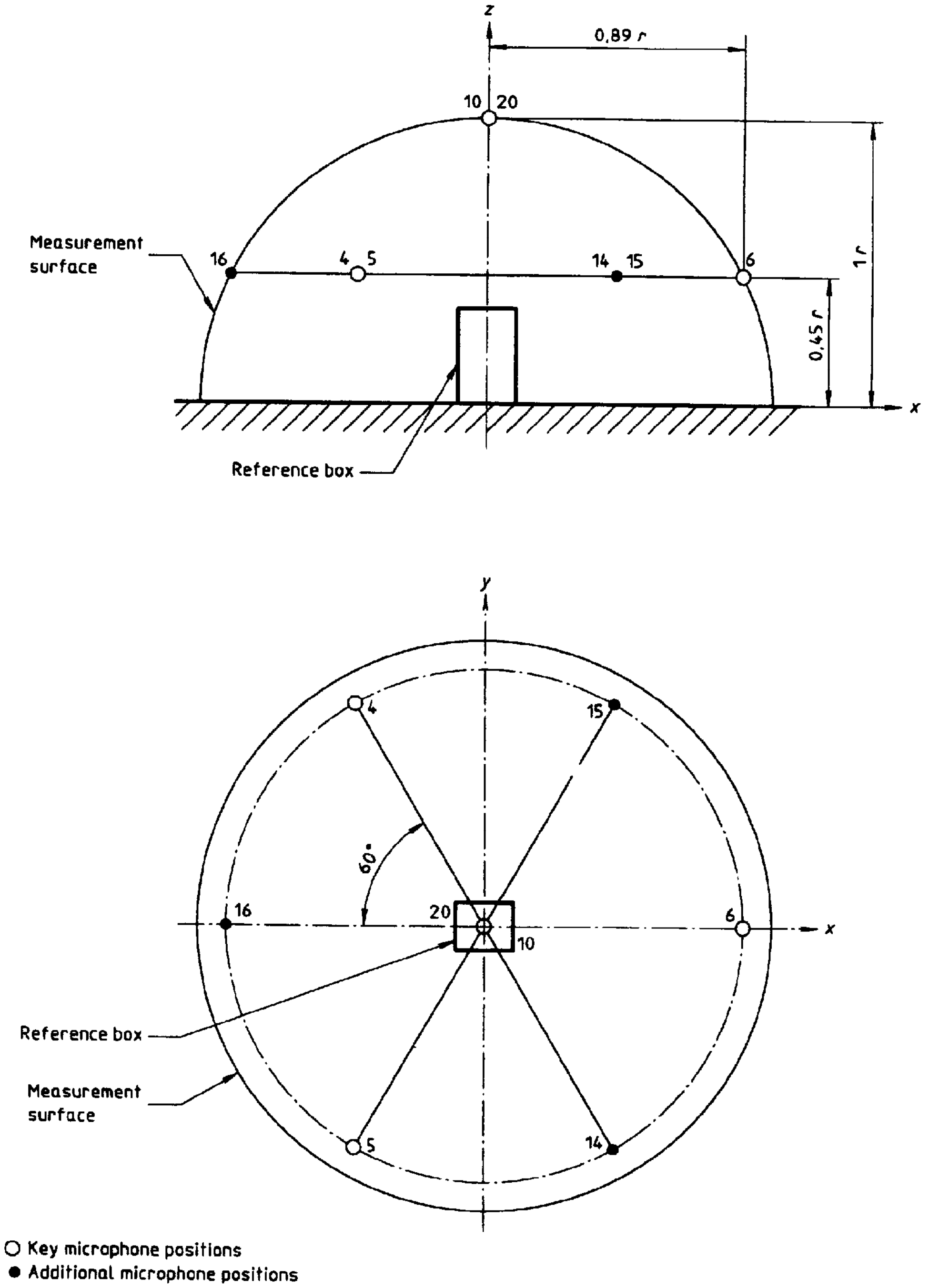


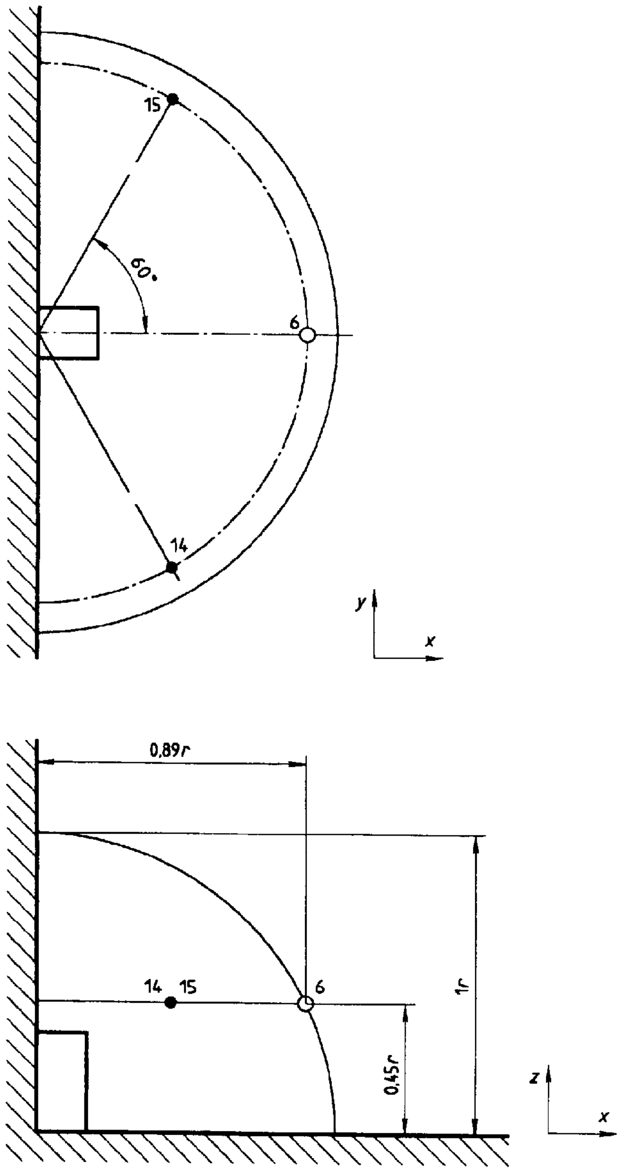
Figure B.1 — Microphone array on the hemisphere — Key microphone positions



NOTE — Key microphone positions are numbered 4, 5, 6 and 10; additional microphone positions are numbered 14, 15, 16 and 20.

Figure B.2 — Microphone array on the hemisphere

Dimensions in meters



O Key microphone positions
● Additional microphone positions

Figure B.3 — Plan view of a spherical measurement surface and microphone positions around a reference box adjacent to two reflecting planes

Annex C
(normative)

Microphone array on the parallelepiped measurement surface

C.1 Microphone positions for sources mounted on one reflecting plane

Each plane of the measurement surface shall be considered on its own and so subdivided that the result is the smallest possible number of equal-sized rectangular partial areas with a maximum length of side equal to $3d$ (see figure C.1). The microphone positions are in the centre of each partial area. In this way the microphone positions for figures C.2 to C.6 are obtained.

NOTE 29 The overhead position(s) may be replaced by positions at the corners of the measurement surface or may be omitted if so indicated in the relevant noise test code.

C.2 Microphone positions for sources adjacent to two or three reflecting planes

For a source installed adjacent to more than one reflecting plane, reference shall be made to figures C.7 to C.8 for the purpose of defining a suitable measurement surface. The microphone positions shall be as shown in figures C.2 to C.8.

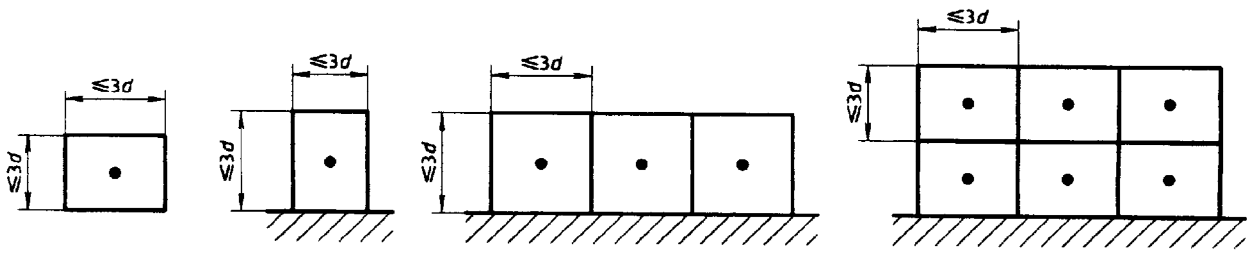


Figure C.1 — Procedure for fixing the specified microphone positions where a side of the measurement surface exceeds $3d$

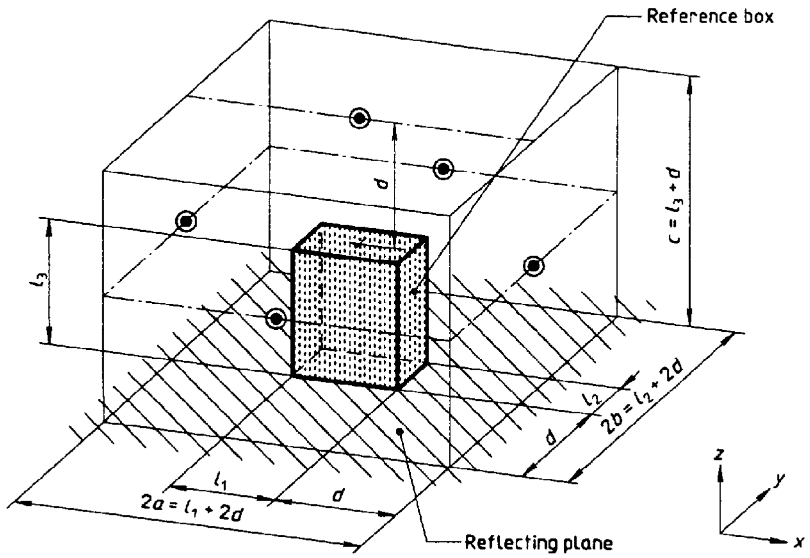


Figure C.2 — Example of a measurement surface and microphone positions for a small machine
($l_1 \leqslant d$, $l_2 \leqslant d$, $l_3 \leqslant 2d$, where d is the measurement distance, normally 1 m)

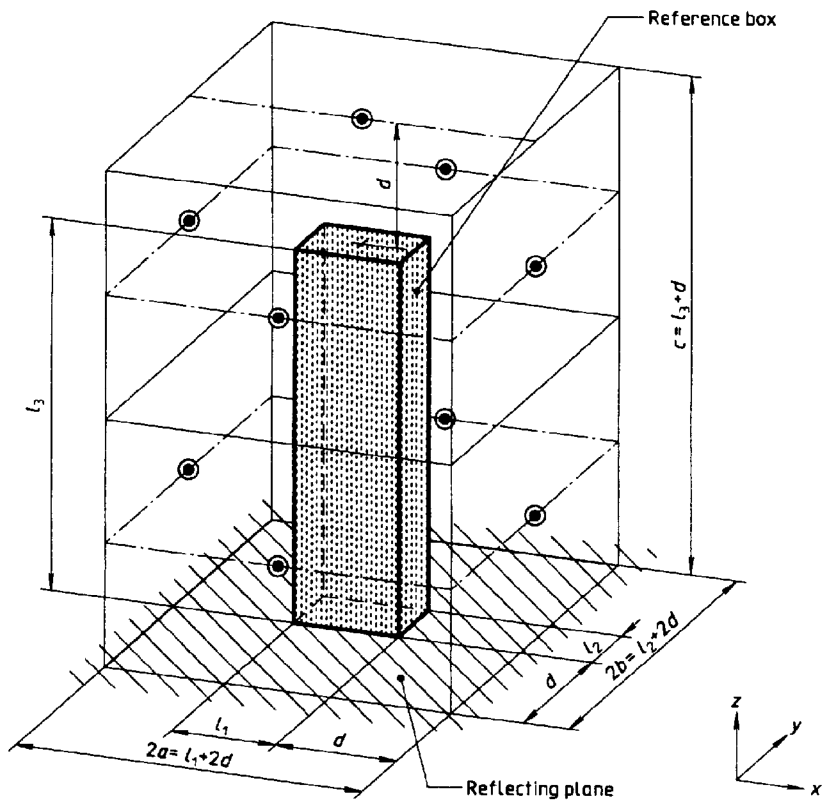


Figure C.3 — Example of a measurement surface and microphone positions for a tall machine with a small base area ($l_1 \leqslant d$, $l_2 \leqslant d$, $2d < l_3 \leqslant 5d$)

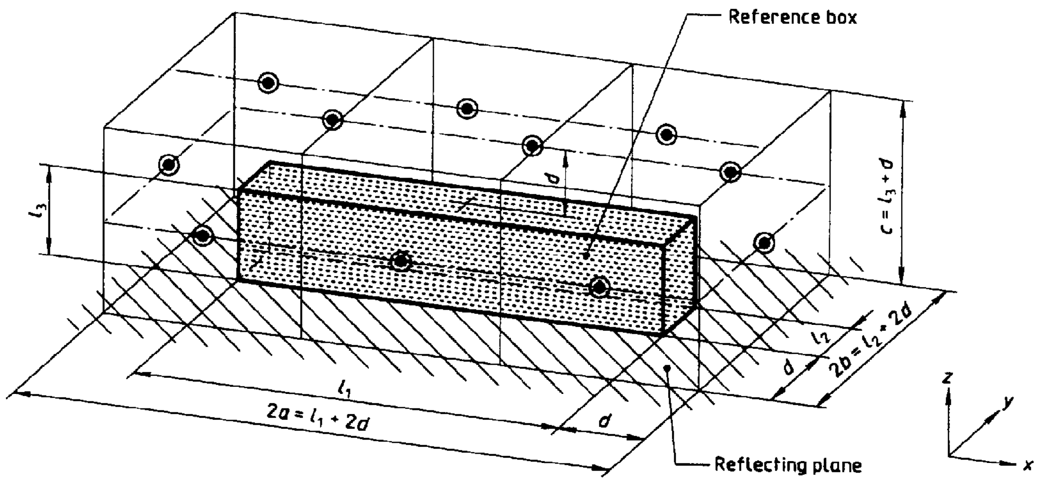


Figure C.4 — Example of a measurement surface and microphone positions for a long machine
($4d < l_1 \leqslant 7d$, $l_2 \leqslant d$, $l_3 \leqslant 2d$)

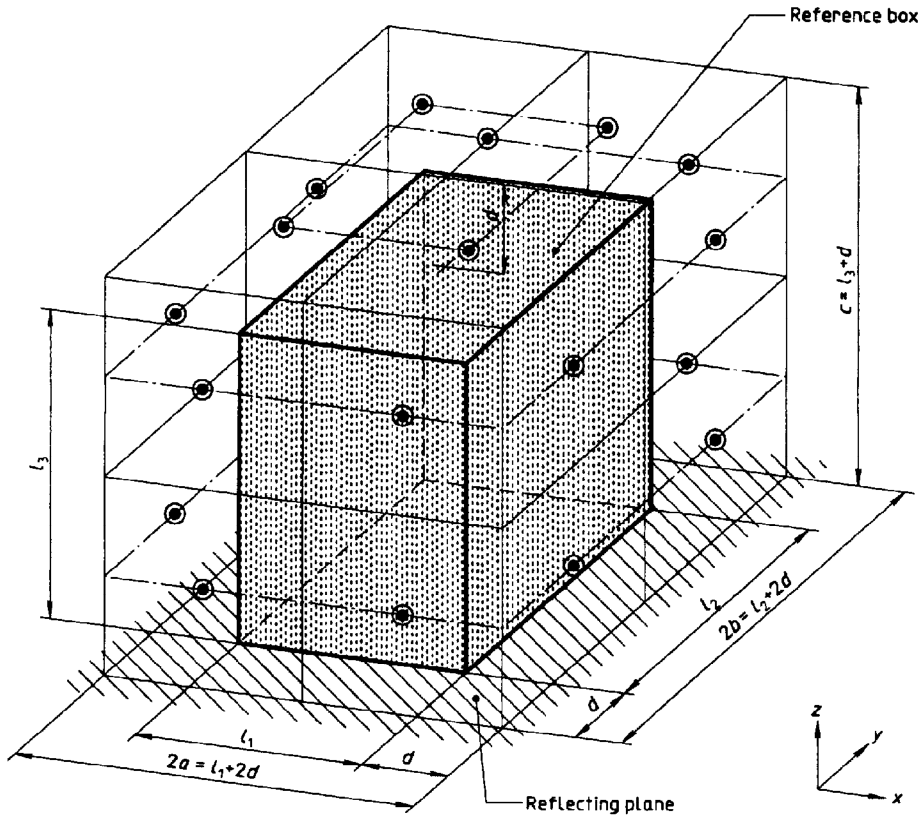


Figure C.5 — Example of a measurement surface and microphone positions for a medium-sized machine
($d < l_1 \leqslant 4d$, $d < l_2 \leqslant 4d$, $2d < l_3 \leqslant 5d$)

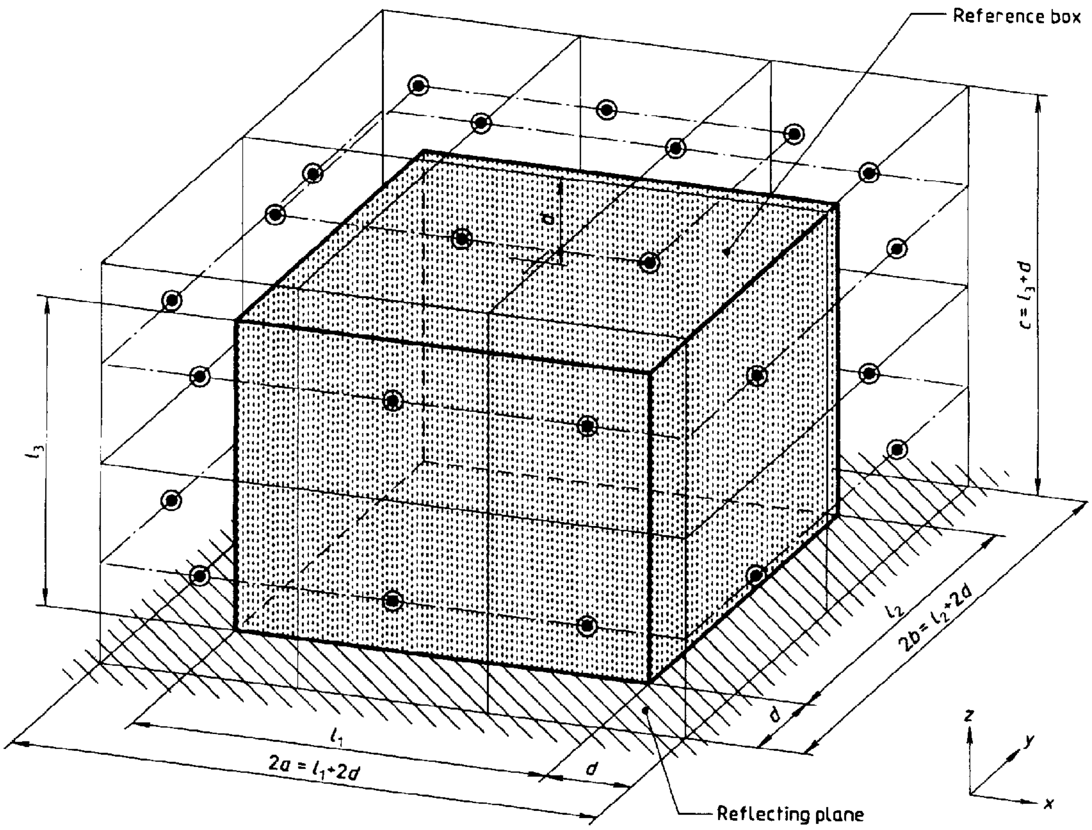


Figure C.6 — Example of a measurement surface and microphone positions for a large machine
($4d < l_1 \leqslant 7d$, $d < l_2 \leqslant 4d$, $2d < l_3 \leqslant 5d$)

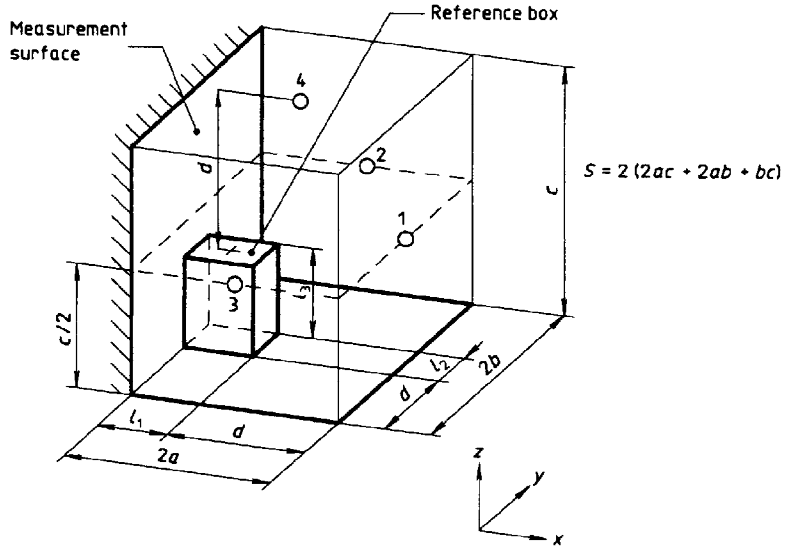


Figure C.7 — Measurement surface (parallelepiped) with four microphone positions for floor-standing appliances placed against a wall

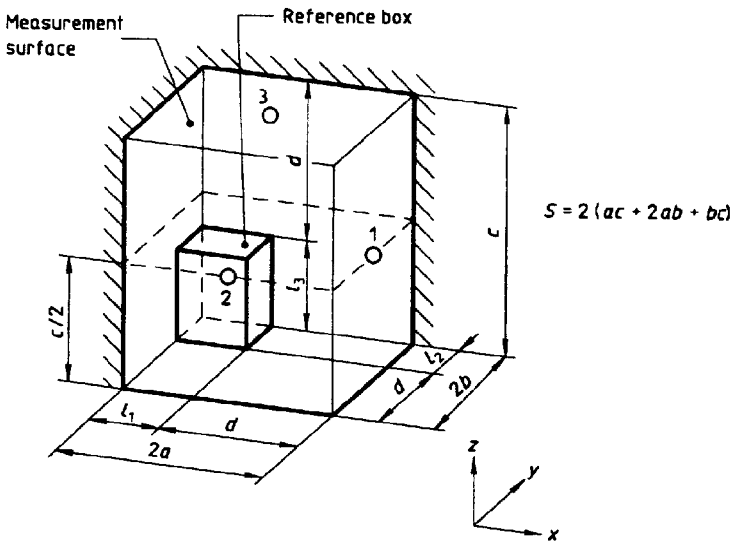


Figure C.8 — Measurement surface (parallelepiped) with three microphone positions for floor-standing appliances placed against two walls

Annex D
(informative)

Guidelines for the detection of impulsive noise

In some cases, comparison of the time-averaged A-weighted sound pressure level determined with the time characteristics I, L_{pAIeq}, with the corresponding value of L_{pAeq} for the same operational cycle, may be helpful in deciding whether or not the noise contains significant impulsive components. For this purpose, the comparison is made at one or more microphone positions, and at least five operational cycles at each position are observed. The difference $(L_{pAIeq} - L_{pAeq})$ is the impulsive noise index (impulsiveness).

NOTE 30 If the mean value of the impulsive noise index is equal to or greater than 3 dB, the noise is considered to be impulsive.

For an isolated single event, or for a sequence of consecutive events with intervals of 1 s or more between the events, the difference between the maximum values of L_{pAI} and L_{pAS} may be used as a descriptor of the single event. The difference $(L_{pAImax} - L_{pASmax})$ is the single-event impulsive noise index, which may be used for describing a single-event impulsive noise. For consecutive single events the arithmetic average of the maximum values o L_{pAI} for the individual events and the average maximum of L_{pAS} over all the events are used.

Annex E
(informative)

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[4] ISO 3743-1:1994, *Acoustics — Determination of sound power levels of noise sources — Engineering methods for small, movable sources in reverberant fields — Part 1: Comparison method for hard-walled test rooms.*

[5] ISO 3743-2:1994, *Acoustics — Determination of sound power levels of noise sources using sound pressure — Engineering methods for small, movable sources in reverberant fields — Part 2: Methods for special reverberation test rooms.*

[6] ISO 7574-2:1985, *Acoustics — Statistical methods for determining and verifying stated noise emission values of machinery and equipment — Part 2: Methods for stated values for individual machines.*

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[11] ISO 12001:—[2], *Acoustics — Noise emitted by machinery and equipment — Rules for the drafting and presentation of a noise test code.*

[12] IEC 1260:—[3], *Electroacoustics — Octave-band and fractional-octave-band filters.*

2) To be published.

3) To be published. (Revision of IEC 225:1966)

List of references

See national foreword.

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