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Test code for machine tools —

Part 5: **Determination of the noise emission**

Code d'essai des machines-outils —

Partie 5: Détermination de l'émission sonore

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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 3.

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 part of ISO 230 may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

International Standard ISO 230-5 was prepared by Technical Committee ISO/TC 39, *Machine tools*, Subcommittee SC 6, *Noise of machine tools.*

ISO 230 consists of the following parts, under the general title *Test code for machine tools*:

— *Part 1: Geometric accuracy of machines operating under no-load or finishing conditions*

— *Part 2: Determination of accuracy and repeatability of positioning numerically controlled axes*

— *Part 3: Determination of thermal effects*

— *Part 4: Circular tests for numerically controlled machine tools*

— *Part 5: Determination of the noise emission*

— *Part 6: Diagonal displacement test*

Annexes A and B form a normative part of ISO 230. Annexes C, D and E are for information only.

Test code for machine tools —

Part 5: Determination of the noise emission

1 Scope

1.1 General

This part of ISO 230 specifies methods for testing the noise of stationary floor-mounted machine tools and related auxiliary equipment directly on the shop floor. The purpose of the measurements is to obtain noise-emission data for machine tools.

The data obtained may be used for the purpose of declaration and verification of airborne noise emission from machine tools as specified in ISO 4871, and also for the comparison of the performance of different units of a given family of machine tools or equipment, under defined environmental conditions and standardized mounting and operating conditions.

For the purposes of this part of ISO 230, “auxiliary equipment” means hydraulic power packs, chip conveyors, coolant-oil mist extractors, heat exchangers, refrigerators, etc. Noise emitted by centrally operated auxiliary equipment, connected to several machine tools, shall be considered as background noise.

General instructions are given for the installation and operation of the machine under test and for the choice of microphone positions for the work station and for other specified positions. More detailed instructions can be found in specific noise-test standards for individual types of machine tools.

Clause 11 specifies a method for measuring the emission sound pressure levels at work stations and at other specified positions in the vicinity of a machine tool. This method follows the methods specified in ISO 11202 and ISO 11204.

Clause 12 specifies a method for measuring the sound pressure levels on a measurement surface enveloping the machine tool and for calculating the sound power level produced by the machine tool. This method follows the methods specified in ISO 3744 and ISO 3746.

The determination of the sound power level on the basis of the intensity method (ISO 9614 and ISO 9614-2) is not dealt with in this part of ISO 230.

1.2 Types of noise and noise sources

The methods specified in this part of ISO 230 are suitable for all types of noise emitted by machine tools.

This part of ISO 230 is applicable to machine tools of any type and size, including devices, components and sub-assemblies.

NOTE Measurements according to this part of ISO 230 may be impracticable for very tall or very long machine tools, such as transfer lines.

1.3 Test environment

The test environment that is applicable for measurements made in accordance with this part of ISO 230 is generally located indoors, with one or more reflecting planes present, meeting specified requirements, as described in clauses 11 and 12, respectively in 11.4.2 and in clause 12.3.2.

1.4 Accuracy grades

Individual values of emission sound pressure levels at a fixed position and of the sound power level of a machine tool determined in accordance with the procedures given in this part of ISO 230 are likely to differ from the true values by an amount within the range of the respective measurement uncertainties. The uncertainties in measurements of emission sound pressure levels and in determinations of the sound power level arise from several factors which affect the results, some associated with environmental conditions at the test site and others with experimental techniques. This part of ISO 230 deals with methods to determine the emission sound pressure levels and the emission sound power level, where the results meet grade 2 accuracy (engineering method) and grade 3 accuracy (survey method). Because of its higher accuracy, grade 2 should be achieved whenever possible. Specific information on measurement uncertainties is given in clause 7.

Although grade 2 accuracy (engineering) is preferred, grade 3 accuracy (survey) is acceptable for noise declaration and most other purposes. In this part of ISO 230, only the determination of grade 3 is described completely. For grade 2, ISO 3744 and ISO 11204 shall also be used.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of ISO 230. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this part of ISO 230 are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC 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 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*.

ISO 4871:1996, *Acoustics — Declaration and verification of noise-emission values of machinery and equipment*.

ISO 6926:1999, *Acoustics —Requirements for the performance and calibration of reference sound sources used for the determination of sound power levels.*

ISO 7960:1995, *Airborne noise emitted by machine tools — Operating conditions for woodworking machines.*

ISO 8500: —[1], *Airborne noise emitted by machine tools — Operating conditions for mechanical presses up to 2 500 kN.*

ISO 8525:— [1], *Airborne noise of machine tools — Operating conditions for metal cutting machine tools.*

ISO 11200:1995, *Acoustics — Noise emitted by machinery and equipment — Guidelines for the use of basic standards for the determination of emission sound pressure levels at a work station and at other specified positions.*

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1) To be published.

ISO 11202:1995, *Acoustics — Noise emitted by machinery and equipment — Measurement of emission sound pressure levels at a work station and at other specified positions — Survey method* in situ*.*

ISO 11204:1995, *Acoustics — Noise emitted by machinery and equipment — Measurement of emission sound pressure levels at a work station and at other specified positions — Method requiring environmental corrections.*

IEC 60651:1979, *Sound level meters,* and Amendment 1:1993.

IEC 60804:1985, *Integrating-averaging sound level meters,* and Amendment 1:1989 and Amendment 2:1993.

IEC 60942:1997, *Electroacoustics — Sound calibrators*.

3 Terms and definitions

For the purposes of this part of ISO 230, the following terms and definitions apply.

NOTE 1 In the following definitions and in the formulae throughout this part of ISO 230, the use of a prime (L'_p, etc.) indicates measured values without any correction.

NOTE 2 More detailed definitions may be found in noise-test conditions for specific types of machine tools and related equipment.

3.1
emission
airborne sound radiated by a well-defined noise source (e.g. the machine under test) under specified operating and mounting conditions

NOTE Noise-emission descriptors may be incorporated in a product label and/or product specification. The basic noise-emission descriptors are the sound power level of the source itself and the emission sound pressure levels at a work station and/or at other specified positions (if any) in the vicinity of the source.

3.2
emission sound pressure
p
sound pressure, at a specified position near a noise source, when the source is in operation under specified operating and mounting conditions on a reflecting plane surface (i.e. the floor), excluding the effects of background noise as well as the effects of reflections other than those from the plane or planes permitted for the purpose of the test

NOTE The emission sound pressure is expressed in pascals.

3.3
emission sound pressure level
L_p

ten times the logarithm to the base 10 of the ratio of the square of the emission sound pressure, $p^2(t)$, to the square of the reference sound pressure, p_0^2, measured with a particular time weighting and a particular frequency weighting, selected from those defined in IEC 60651

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

NOTE The emission sound pressure level is determined at a specified position and is expressed in decibels. The reference sound pressure is 20 µPa.

3.3.1
time-averaged emission sound pressure level

$L_{p\text{eq}T}$

emission 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

NOTE 1 The time-averaged emission sound pressure level is expressed in decibels and is given by the following equation:

$$L_{p\text{eq}T} = 10\lg\left[\frac{1}{T}\int_0^T \frac{p^2(t)}{p_0^2}\,\mathrm{d}t\right]\ \text{dB} = 10\lg\left[\frac{1}{T}\int_0^T 10^{0,1L_p(t)}\,\mathrm{d}t\right]\ \text{dB} \qquad (2)$$

NOTE 2 $L_{p\text{eq}T}$ shall be measured with an instrument which complies with the requirements of IEC 60804.

NOTE 3 The A-weighted time-averaged emission sound pressure levels are noted by $L_{p\text{A}\,\text{eq}T}$, usually abbreviated to $L_{p\text{A}}$.

NOTE 4 In general, the subscripts eq and T are omitted since time-averaged emission sound pressure levels are necessarily determined over a certain measurement time interval.

NOTE 5 Equation (2) is identical to that for the familiar ISO environmental noise descriptor "equivalent continuous sound pressure level" defined in ISO 1996-1 and ISO 1999. However, the emission quantity defined above is used to characterize the noise emitted by a machine under test and assumes that standardized measurement and operating conditions, as well as a controlled acoustical environment, are used for the measurements.

3.3.2
C-weighted peak emission sound pressure level

$L_{p\text{C,peak}}$

highest instantaneous value of the C-weighted emission sound pressure level determined over an operational cycle

NOTE The C-weighted peak emission sound pressure level is expressed in decibels

3.3.3
single-event emission sound pressure level

$L_{p,1\text{s}}$

time-integrated emission sound pressure level of an isolated single sound event of specified duration T (or specified measurement time interval T) normalized to T_0 = 1 s

NOTE 1 The single-event emission sound pressure level is expressed in decibels and is given by the following equation:

$$L_{p,1\text{s}} = 10\lg\left[\frac{1}{T_0}\int_0^T \frac{p^2(t)}{p_0^2}\,\mathrm{d}t\right]\text{dB} = L_{p\text{eq}T} + 10\lg\frac{T}{T_0}\ \text{dB} \qquad (3)$$

NOTE 2 The above equation is identical to that for the familiar ISO environmental noise descriptor "sound exposure level". However, the emission quantity defined above is used to characterize a noise source and assumes that a controlled environment is used for the measurements.

3.4
sound pressure level

L_p'

level which is measured at any position without any correction ($K_{1\text{A}}$, $K_{2\text{A}}$, $K_{3\text{A}}$), as indicated by the prime

3.5
free field over a reflecting plane
sound field in a homogeneous, isotropic medium in the half space above an infinite, rigid plane surface on which the machine under test is located

3.6
work station
operator's position
position in the vicinity of the machine under test which is intended for the operator

3.7
operator
individual whose work station is in the vicinity of a machine and who is performing a work task associated with that machine

3.8
specified position
position defined in relation to a machine, including, but not limited to, an operator's position

NOTE 1 The position can be a single, fixed point, or a combination of points along a path or on a surface located at a specified distance from the machine, as described in the relevant noise-test code, if any exists.

NOTE 2 Positions located in the vicinity of a work station, or in the vicinity of an unattended machine, may be identified as "bystander positions".

3.9
operational period
interval of time during which a specified process is accomplished by the machine under test (e.g. for a machining centre when drilling or changing tools or boring)

3.10
operational cycle
specific sequence of operational periods occurring while the machine under test performs a complete work cycle

NOTE Each operational period is associated with a specific process that may occur only once, or may be repeated, during the operational cycle (e.g. for a machining centre when drilling and changing tools and boring).

3.11
measurement time interval
portion or a multiple of an operational period or operational cycle for which the emission sound pressure level is determined or over which the maximum emission sound pressure level is searched for

3.12
time history
continuous recording of the emission sound pressure level, as a function of time, which is obtained during one or more operational periods of an operational cycle

3.13
background noise
noise from all sources other than the machine under test

NOTE 1 The background noise is measured as an A-weighted sound pressure level $L''_{p\mathrm{A}}$ and is expressed in decibels.

NOTE 2 The background noise may include contributions from airborne sound, structure-borne vibration, and electrical noise in instrumentation.

3.14
background noise correction
correction to the sound pressure level required when the difference ΔL_A between the A-weighted sound pressure level L'_{pA}, with the machine tool under test in operation, and the A-weighted sound pressure level L''_{pA} of the background noise at a specified position is lower than specified values (see 11.4.2.1, 11.4.2.2, 12.3.2.1 and 12.3.2.2)

3.15
environmental correction
K_2
correction term to account for the influence of reflected or absorbed sound on the surface sound pressure level

NOTE K_2 is frequency dependent and is expressed in decibels. The correction in the case of A-weighting is denoted K_{2A}.

3.16
local environmental correction
K_3
correction term to account for the influence of reflected sound on the emission sound pressure level at a specified position (e.g. a work station) for the machine under test

NOTE K_3 is dependent upon both frequency and position and is expressed in decibels. In the case of A-weighting, it is denoted K_{3A}.

3.17
reference box
hypothetical surface which is the smallest rectangular parallelepiped that just encloses the source and terminates on the reflecting plane or planes

3.18
measurement surface
hypothetical surface, of area S, enveloping the source on which the measurement points are located

NOTE The measurement surface terminates on one or more reflecting planes, i.e. the reflecting plane(s) are not included in the area of the measurement surface.

3.19
surface sound pressure level
$\overline{L_{pf}}$
energy-average of the time-averaged sound pressure levels at all the microphone positions on the measurement surface, with the background noise correction and the environmental correction K_2 applied

NOTE The surface sound pressure level is expressed in decibels.

3.20
sound power
W
rate per unit time at which airborne sound energy is radiated by a source

NOTE The sound power is expressed in watts.

3.21
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

NOTE 1 The sound power level is expressed in decibels. The reference sound power is 1 pW (10^{-12} W).

NOTE 2 The frequency weighting or the width of the frequency band used should be indicated.

NOTE 3 For example, the A-weighted sound power level is L_{WA}.

3.22
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

3.23
measurement distance
d
the distance from the reference box to a box-shaped measurement surface.

NOTE The measurement distance is expressed in metres.

4 Measuring equipment

4.1 General

The measuring equipment, including the microphone and cable, shall preferably meet the requirements for a type 1 instrument specified in IEC 60651 or, in the case of integrating-averaging sound level meters, the requirements for a type 1 instrument specified in IEC 60804.

If this is not possible, type 2 instruments may be used, leading the test results to meet grade 3 accuracy (survey method).

4.2 Calibration

Before and after each series of measurements, a sound calibrator with an accuracy of ± 0,3 dB (class 1 as specified in IEC 60942) 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 with the requirements of IEC 60942 shall be verified once a year. The compliance of the instrumentation system with the requirements of IEC 60651 (or, in the case of integrating-averaging systems, with the requirements of IEC 60804) shall be verified 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.

4.3 Adverse 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 machine under test, high or low temperature) 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.

5 Installation and operation of the machine under test

5.1 General

The manner in which the machine under test is installed and operated may have a significant influence on the noise emission. This clause specifies conditions that are intended to minimize variations in the noise emission due to the installation and operating conditions of the machine under test. Relevant instructions of noise-test standards for individual types of machine tools, if they exist for the family to which the machine under test belongs, shall be followed. The same installation and operating conditions of the machine under test shall be used for the determination of emission sound pressure levels, sound power levels, and for declaration purposes.

The specific noise-test standards to which reference is made in this subclause, and in further places in this part of ISO 230, are:

— ISO 7960 for woodworking machines;

— ISO 8500 for metal forming machines;

— ISO 8525 for metal cutting machines.

5.2 Machine location

Whenever possible, the machine under test shall be installed with respect to the reflecting plane as if it were being installed for normal usage. In the manufacturers' assembly shops, this is not always possible for machine tools such as large power presses, large boring machines, large press brakes, etc., which are often assembled in large pits or totally over the floor, at a different height from the reflecting plane, compared to the final installation in the user's workshop.

If the location of the machine within the test environment can be selected, sufficient space shall be allowed so that the measurement surface can envelop the machine under test in accordance with the requirements of 12.2.1.

5.3 Machine mounting

In many cases, the noise emission of the machine under test will depend upon the support or mounting conditions of the machine. Whenever a typical mounting condition exists for a machine tool, that condition shall be used or simulated, if feasible.

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

5.4 Auxiliary equipment

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

Whenever possible, the auxiliary equipment supplied with the machine shall be included in the reference box and its operating conditions described in the test report.

When the auxiliary equipment necessary for the operation of the machine under test is not supplied with the machine, it shall be located outside the test environment.

5.5 Operation of the machine during test

During the noise measurements, the operating conditions specified in the relevant noise-test standards shall be used, if they exist for the particular family of machine tools to which the machine under test belongs. If there are no specific noise-test standards, the machine under test shall be operated, if possible, in a manner which is typical of normal use. In such a case, one or more of the following operating conditions shall be selected:

a) machine under operating conditions with characteristic work cycle (e.g. special-purpose machine tools, transfer machines);

b) machine under specified operating conditions (under load, idling and/or specified cycle).

The noise emission of the machine may be determined for any desired set of operating conditions (i.e. loading, temperature, speeds, etc.). These test conditions shall be selected beforehand and shall be held constant during the test. The machine under test 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, these parameters shall be found in the noise-test standard for a specific family of machine tools, if they exist. If they do not exist, parameters shall be selected, as far as is practicable, that are typical of the operation and which give rise to the smallest variations.

For special purposes, it is appropriate to define one or more operating conditions in such a way that the noise emission of machine tools 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 found in the specific noise-test standards, if they exist.

Simulated operating conditions, such as those involving the use of hydraulic or electro-magnetic brakes, are not considered in this part of ISO 230.

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 machine tool under test during noise measurements shall be fully described in the test report.

6 Measurement procedure

Take readings of the A-weighted sound pressure level and C-weighted peak sound pressure level at each microphone position, as indicated in 11.2 and 12.2.2. The sound pressure level shall be observed over a typical period of operation of the machine.

Determine the following:

a) the A-weighted sound pressure levels $L'_{p\mathrm{A}}$ during operation of the machine under test;

b) the A-weighted sound pressure levels $L''_{p\mathrm{A}}$ produced by the background noise;

c) the C-weighted peak sound pressure level, $L_{p\mathrm{C,peak}}$, at the positions specified in 11.2 (for the purposes of clause 11 only).

The period of observation shall be at least 30 s, unless otherwise stated in the noise-test standard for the specific family of machine tools or equipment.

When isolated single-sound events need to be measured (e.g. power presses), determine the single-event sound pressure level $L_{p,1\mathrm{s}}$.

For noise that varies in time, it is important to specify carefully the period of observation, in order to achieve a stabilized time-averaged value, according to 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.

7 Measurement uncertainty

The measurement uncertainty (K) depends on the standard deviation of reproducibility (see annex A of ISO 4871:1996). For determining the sound power level in compliance with ISO 3744 and ISO 3746, and the emission sound pressure level at a work station in compliance with the series of International Standard of which ISO 11200 forms the introduction, maximum values of standard deviations of reproducibility are given (excluding variation in operating conditions) for the engineering (grade 2) and survey (grade 3) methods. However, the standard deviation of reproducibility is much smaller and varies considerably among the many different types of machine tools and equipment to which this part of ISO 230 is applicable.

Information about standard deviations of reproducibility and uncertainty (K) for the individual type of machine tool should be found in the specific relevant noise-test standards.

The method described in clauses 11 and 12 yields the grade 2 (engineering) and grade 3 (survey) accuracy depending on, for example, the environmental conditions, background noise, microphone array on the measurement surface. If no information exists in a specific noise-test standard, a proposal of uncertainty (K) is given in 10.2.

8 Information to be recorded

8.1 Test data

a) Place and date when the measurements were performed, and

b) person responsible for the test.

8.2 Machine under test

Description of the machine, including its

— type,

— technical data,

— dimensions,

— manufacturer,

— machine serial number, and

— year of manufacture.

8.3 Test conditions

a) Precise quantitative description of operating conditions and, if relevant, operational periods and cycle;

b) mounting conditions;

c) location of machine in the test environment;

d) if the machine under test has multiple noise sources, a description of the sources in operation during the measurements.

8.4 Acoustic environment

If the tests are carried out indoors:

a) description of physical treatment of walls, ceiling and floor;

b) sketch showing the location of the machine under test and room contents;

c) acoustical qualification of room in accordance with 11.4.3 and, if relevant, clause 12.3.3.

8.5 Instrumentation

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

b) method used for verifying the calibration of the measuring system; the date, place and result of calibration shall be recorded;

c) characteristics of windscreen (if any).

8.6 Noise data

8.6.1 For measurements of emission sound pressure levels:

a) all measured sound pressure level data;

b) location of microphone positions;

c) A-weighted emission sound pressure levels at specified positions and, as required, the same quantity with other frequency weightings and/or in other frequency bands;

d) C-weighted peak emission sound pressure levels at specified positions and, as required, other time characteristics of noise emission at work station(s);

e) A-weighted background noise levels at each specified position, and, if required, background noise levels in frequency bands;

f) A-weighted local environmental correction, $K_{3\mathrm{A}}$, at each of the specified positions.

8.6.2 For the determination of sound power levels:

a) A-weighted sound power level;

b) the linear dimensions and the area S of the measurement surface;

c) the measurement distance d, and the location of microphone positions;

d) the environmental correction $K_{2\mathrm{A}}$ and the method by which it was determined in accordance with one of the procedures of subclause 12.3.3;

e) A-weighted sound pressure levels $L'_{p\mathrm{A}i}$ and $L''_{p\mathrm{A}i}$ at each measuring point i;

f) the A-weighted surface sound pressure level $\overline{L_{p\mathrm{fA}}}$.

9 Information to be reported in the test report

Only those recorded data (see clause 7) that are required for the purposes of the measurements are to be reported. If standardized noise-test conditions exist for the machine tool or equipment under test, these test conditions will specify the data to be reported.

The report shall state whether or not the reported emission sound pressure levels at the specified positions and sound power levels have been obtained in full conformity with the requirements of this part of ISO 230.

The report shall include the date on which the sound pressure levels were measured and the name of the person responsible for the tests.

Emission sound pressure levels at the specified positions shall be reported to the nearest whole decibel (for grade 2 accuracy to the nearest 0,5 dB).

The A-weighted sound power level of the machine under test shall be reported to the nearest whole decibel (for grade 2 accuracy to the nearest 0,5 dB).

The environmental correction K_{2A} and the local environmental correction, K_{3A}, shall be reported.

As this part of ISO 230 includes two possible grades of accuracy, the test results shall always state explicitly the grade of accuracy achieved (engineering or survey).

10 Declaration and verification of noise-emission values

10.1 General

The declaration of the noise-emission values of machine tools and equipment, in technical literature and instruction manuals, is the responsibility solely of the manufacturer.

10.2 Declaration

For the declaration of the noise-emission values of machine tools and equipment measured according to this part of ISO 230, the declared dual-number noise-emission value is to be used, supplying to the reader the information both on the measured values and on the related uncertainty K (see clause 5 of ISO 4871:1996).

In applying this part of ISO 230, it is recommended that the following values of K be used for machine tools: 2,5 dB (grade 2) and 4 dB (grade 3), both for the emission sound pressure levels and the sound power level.

An example of a noise-emission declaration is given in annex E.

The guidelines for the noise declaration given in A.2.2 of ISO 4871:1996 shall be followed.

The manufacturer shall declare the following noise-emission quantities:

a) the A-weighted emission sound pressure level at the work station(s);

b) the A-weighted sound power level, if required;

c) the C-weighted peak emission sound pressure level at the work station(s), if required.

NOTE Additional noise-emission quantities may also be given in the declaration.

The declared noise-emission values shall be rounded to the nearest whole decibel.

10.3 Verification

The procedure for the verification given in 6.2 of ISO 4871:1996 shall be followed: the verification criterion is satisfied where the measured value

$$L_1 \leqslant (L + K)$$

where

L_1 is the measured value for the verification;

L may be any one of the three values stated in 10.2.

The verification shall be conducted by using the same mounting, installation and operating conditions as those used for the initial determination of noise-emission values.

11 Determination of the emission sound pressure levels at the work station(s) and at other specified positions

11.1 General

This part of ISO 230 specifies a method for measuring the emission sound pressure levels of machine tools and related auxiliary equipment at a work station and at other specified positions nearby.

It gives requirements for the test environment and for the local environmental correction (see 11.4.3) leading to results which may have the grade 2 accuracy (engineering method) or the grade 3 accuracy (survey method).

Emission sound pressure levels are measured as A-weighted, C-weighted peak, and, if required, in frequency bands.

NOTE 1 The contents of the International Standards related to this clause are summarized in Table 1 of ISO 11200:1995.

A work station is a specific position for the use of an operator. It may be located in open space in the room where the source operates, or in a cab fixed to the source, or in an enclosure remote from the source. One or more specified positions may be located in the vicinity of an attended or unattended machine. Such positions are sometimes referred to as bystander positions.

NOTE 2 At any given position in relation to a particular machine, and for given mounting and operating conditions, the emission sound pressure levels determined by the method of this part of ISO 230 will in general be lower than the directly measured sound pressure levels for the same machine in the typical workroom where it is used. This is due to the reflections and the contributions of other machines. For further information see ISO 11690-3.

11.2 Microphone positions

11.2.1 Introduction

The operator(s), if present, shall not wear clothing with abnormal sound-absorptive properties, or any hat or scarf (other than a protective helmet required for safety reasons, or a helmet or frame used to support a microphone) which might influence the sound measurements.

If an operator is present, the microphone shall be located 0,20 m ± 0,02 m to the side of the centre-plane of the operator's head, on a line with the eyes, with its axis parallel to the operator's line of vision, and on that side where the higher value of the A-weighted sound pressure level, $L_{p\mathrm{A}}$, is observed.

Unless otherwise required in the relevant noise-test standard for a specific type of machine tool, if any exists, the operator position(s) shall be as described in 11.2.2 to 11.2.5.

11.2.2 Microphone position(s) for a seated operator

If an operator is not present, and if the seat is attached to the machine under test, the microphone shall be located 0,80 m ± 0,05 m above the middle of the seat plane, unless a particular noise-test standard states otherwise.

If an operator is not present, and if the seat is not attached to the machine under test, the microphone positions shall be as described in the noise-test standard for the specific family standard of machine tools or equipment to which the machine under test belongs, if any exists. If there are no test standards, the microphone positions shall be described in the test report.

If an operator is present, the adjustment of the seat shall allow the operator to reach the controls comfortably. The distance from the seat plane to the top of the operator's head is assumed to be 0,91 m ± 0,05 m.

11.2.3 Microphone position(s) for a standing, stationary operator

If the operator is present, the requirements of 11.2.1 apply. If the measurements are made with the operator or bystander absent or if no other location is specified for a standing operator in the appropriate noise-test standard, the microphone location is defined relative to a reference point on the ground plane on which the operator normally stands. This reference point is the point on the floor directly below the centre of the operator's head. The microphone shall be located directly above the reference point at a specified height in the range 1,55 m ± 0,075 m. The specified height is usually to be found in the relevant noise-test standard, if any exists.

11.2.4 Microphone position(s) for an operator moving along a specific path

In those situations where an operator moves along a specified path in the vicinity of the machine under test, a sufficient number of microphone positions or a moving microphone shall be used to determine the sound pressure level along the specified path. This shall be done by using either continuous integration along the length of the path, or by making a sufficient number of measurements at discrete positions and defined intervals of time, and then applying the following equation:

$$L_{pA} = 10 \lg \left[\frac{1}{T} \sum_{i=1}^{N} T_i 10^{0,1 L_{pA,T(i)}} \right] \text{dB} \qquad (4)$$

where

T is the total measurement time interval;

$$T = \sum_{i=1}^{N} T_i$$

T_i are the sub-measurement time intervals;

N is the total number of sub-measurement time intervals;

$L_{pA,T(i)}$ is the A-weighted emission sound pressure level over a sub-measurement time interval T_i.

The reference line shall be defined as a line on the floor directly below the centre of the operator's head for a typical specified path. If no other height is specified for a moving operator in the appropriate noise-test standard, the microphone positions shall be located directly above the reference line at a specified height in the range 1,55 m ± 0,075 m.

Microphone positions shall be defined at all fixed operator positions and the specified path shall be as given in the noise-test standard for the specific family of machine tools or equipment to which the machine under test belongs, if any exists.

In the absence of such specified positions, at least four microphone positions shall be defined to sample adequately the sound field along the specified path.

11.2.5 Microphone positions for bystanders and for unattended machines

If no operator's position can be identified, a "conventional" work station (e.g. for maintenance, servicing or repair) or one or more bystander positions shall be defined and stated in the specific noise-test standard.

Alternatively, if no specific noise-test standard exists, measurements shall be made at four or more microphone positions located 1 m away from each side of the reference box defined in 3.17 at a height of 1,55 m ± 0,075 m above the ground plane. The value of the highest emission sound pressure level shall be recorded as the emission sound pressure level of the machine under test. The positions where this value is measured shall be recorded.

11.3 Quantities to be measured

The basic quantities to be measured at each specified position over the specified operational periods or operational cycle of the machine tool under test are L'_{pA}, L''_{pA}, $L_{pC,peak}$ as specified in clause 6 a), b) and c).

11.4 Quantities to be determined

11.4.1 General

In order to obtain emission sound pressure levels at a specified position, both background noise correction and local environmental correction K_3 shall be applied to measured sound pressure levels except peak sound pressure levels, $L_{pC,peak}$, for which no corrections are permitted.

11.4.2 Emission sound pressure level

11.4.2.1 If, in the specified position, the difference ΔL_A between the measured A-weighted sound pressure level L'_{pA}, with the machine tool under test in operation, and the A-weighted sound pressure level L''_{pA} of the background noise exceeds 10 dB (15 dB for grade 2 accuracy), then the emission sound pressure level in the specified position is

$$L_{pA} = L'_{pA} - K_{3A} \text{ dB} \tag{5}$$

11.4.2.2 If, in the specified position, ΔL_A is between 3 dB and 10 dB (15 dB for grade 2 accuracy), then the emission sound pressure level in the specified position is

$$L_{pA} = 10 \lg \left[10^{0,1 L'_{pA}} - 10^{0,1 L''_{pA}} \right] - K_{3A} \text{ dB} \tag{6}$$

This correction for background noise shall be applied for each specified position in which ΔL_A is between 3 dB and 10 dB (15 dB for grade 2 accuracy).

If ΔL_A exceeds 6 dB, the results meet grade 2 accuracy, otherwise they meet grade 3 accuracy.

11.4.2.3 If $\Delta L_A < 3$ dB, the measurement is invalid according to this clause.

11.4.3 Local environmental correction

This subclause describes the procedures for determining the magnitude of the local environmental correction K_{3A}, to account for the influence of reflected sound on the emission sound pressure level at the specified position(s).

The pre-condition for this is that the environmental correction, K_{2A} (see 12.3.3) shall not exceed 7 dB.

If the engineering method (grade 2) is intended to be used, the requirements of ISO 11204 shall be followed for determining K_{3A}.

Otherwise, a method is given hereunder, leading to a grade 3 accuracy (survey method), which normally underestimates the magnitude of K_{3A}. The local environmental correction K_{3A} to be applied to the measured data shall not exceed 2,5 dB.

If the calculated value of K_{3A} exceeds 2,5 dB, then 2,5 dB shall be used as the estimated local environmental correction.

Therefore, the emission sound pressure levels obtained by this method will often be higher than the emission sound pressure levels obtained by an engineering method (grade 2).

NOTE 1 If the limit value of 2,5 dB is exceeded, the accuracy of the result is reduced. The result may, however, be reported and may be useful for determining an upper boundary to the emission sound pressure level at the specified position.

According to this method, the local environmental correction, K_{3A}, for a specified position is given by the following equation:

$$K_{3A} = 10\lg\left[1+4\left(2\pi a^2/A\right)\right]\text{dB} \quad (7)$$

where

a is the distance, in metres, from the specified position to the closest major sound source of the machine under test;

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

In cases where the major sound source is not well defined, a shall be chosen to be the distance from the specified position to the closest part of the machine under test. In the case of an operator moving along a path, a shall be chosen as the shortest distance between any part of the path and the machine under test.

NOTE 2 The specific noise-test standards, if relevant, give guidance on determination of the values of a.

The value of the equivalent sound absorption area A is determined by one of the methods given in annex B.

12 Method for the determination of sound power levels emitted by a machine tool

12.1 Introduction

This part of ISO 230-5 specifies a method for measuring the sound pressure levels on a measurement surface enveloping the machine tool and/or related equipment in order to calculate the sound power level produced by the noise sources. It gives requirements for the test environment as well as techniques for obtaining the surface sound pressure level from which the sound power level of the machine tool is calculated, leading to results which may have the grade 2 accuracy (engineering method) or the grade 3 accuracy (survey method).

NOTE The contents of the International Standards related to this part of ISO 230 are summarized in Table 0.1 of ISO 3744:1994 and ISO 3746:1995.

12.2 Measurement surface and microphone positions

12.2.1 Selection of the measurement surface

To facilitate the location of the microphone positions on the measurement surface, a hypothetical reference box shall be defined (see 3.17). When defining the dimensions of this reference box, elements protruding from the source that are not significant radiators of sound energy may be disregarded. These protruding elements should be identified in the specific noise-test standards for different types of machine tools.

The location of the machine tool 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.

For the purposes of this part of ISO 230, the only type of measurement surface to be used is a rectangular parallelepiped of area S whose sides are parallel to those of the reference box and spaced out a measurement distance d from the box.

The recommended value of d is 1 m, but in special cases it may be reduced to 0,5 m. Different values of d should not be used for the purposes of this part of ISO 230.

Particularly for large machine tools, it is important that the specific noise-test standards specify which components, sub-assemblies, auxiliary equipment, power sources, etc. belong to the machine under test and are to be included in the reference box.

For machines exceeding the dimensions considered in annex A, individual standards on operating conditions should specify methods for determining the measurement surface.

The noise-test standard for a particular family of machines should give detailed information on the particular surface and microphone array that are selected, as the use of different microphone positions may yield differing estimates of the sound power level of a machine tool (see 12.2.2.4).

The construction of the reference box, the three dimensions of the measurement surface, as well as the measurement distance d, shall be described in the test report.

12.2.2 Microphone positions

The microphone positions lie on the measurement surface and are located as specified hereunder.

The accuracy grade depends also on the number of microphone positions (for grade 2 see ISO 3744 and for grade 3 see ISO 3746).

12.2.2.1 Horizontal location of the microphone positions

Each vertical plane of the measurement surface shall be subdivided in the horizontal direction so as to give the smallest possible number of rectangular partial areas with equal bases of maximum length equal to $3d$ (see Figure A.1). The horizontal locations of the microphone positions are in the middle of the bases of each partial area.

Horizontal dimensions of the reference box acceptable for this part of ISO 230 are up to 10 m.

This part of ISO 230 also applies to machines larger than 10 m, as long as the noise emitting part of the machine fits in the reference box as stated.

If the horizontal dimensions of the reference box exceed 10 m, the sound power level shall not be determined. In this case, the emission sound pressure level shall be determined for specified positions.

12.2.2.2 Vertical location of the microphone positions

For machine tools whose vertical dimension l_3 is less or equal to 3,5 m, only one height of the microphone positions is considered in this clause, and it is equal to 1,6 m from the reflecting plane (the workshop floor) (see Figures A.2 and A.4).

For tall machines only ($l_3 > 3{,}5$ m) in which a significant amount of noise is emitted from the top (e.g. some power presses) a second row of microphone positions at a different height h_2 may be considered (see Figures A.3, A.5 and A.6), where

$$h_2 = 3/4\,(l_3 + d) \qquad (8)$$

If the vertical dimension l_3 of the machine under test exceeds 3,5 m, but no significant noise is emitted from sources over 3 m from the floor, only one row of microphone positions is retained, at 1,6 m from the floor.

12.2.2.3 Overhead microphone positions

For the purposes of this part of ISO 230, the microphone positions on the upper plane of the measurement surface are omitted, for the following reasons:

— it is time consuming, difficult and unsafe to reach those positions on machine tools;

— the actual microphone positions are generally inaccurate compared to the theoretical locations calculated;

— except in particular cases, the overhead microphone positions do not provide any added value to the averaged surface sound pressure level determined from the measurements on the vertical sides of the measurement surface.

In those particular cases, by agreement between the interested parties, and taking into account the safety of persons and instrumentation, overhead measurements may be carried out on the array determined from the microphone positions on the vertical sides of the measurement surface, as shown in Figures A.2 to A.6.

12.2.2.4 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 calculated surface sound pressure levels do not deviate by more than 1 dB from those determined from measurements over the complete set of microphone positions. An example is when the radiation pattern is shown to be symmetrical.

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

12.3.1 General

The calculations described in this clause apply to the measured sound pressure levels quoted in clause 6 a) and b).

12.3.2 Calculation of the A-weighted surface sound pressure level

12.3.2.1 If, in all microphone positions, the difference ΔL_A between the measured A-weighted sound pressure levels L'_{pAi}, with the machine tool under test in operation, and the A-weighted sound pressure levels L''_{pAi} of the background noise exceeds 10 dB (15 dB for grade 2 accuracy), then calculate the A-weighted surface sound pressure level, i.e. $\overline{L_{pfA}}$, using the following equation:

$$\overline{L_{pfA}} = 10 \lg \left[\frac{1}{N} \sum_{i=1}^{N} 10^{0,1 L'_{pAi}} \right] - K_{2A} \text{ dB} \tag{9}$$

where

$\overline{L_{pfA}}$ is the A-weighted surface sound pressure level;

L'_{pAi} is the A-weighted sound pressure level measured at the *i* th microphone position, in decibels, with the machine tool under test in operation;

N is the number of microphone positions.

12.3.2.2 If, in some of the microphone positions, ΔL_A is between 3 dB and 10 dB (15 dB for grade 2 accuracy), then calculate the A-weighted surface sound pressure level, i.e. $\overline{L_{pfA}}$, using equation (10):

$$\overline{L_{pfA}} = 10 \lg \left[\frac{1}{N} \sum_{i=1}^{N} \left(10^{0,1 L'_{pAi}} - 10^{0,1 L''_{pAi}} \right) \right] - K_{2A} \text{ dB} \tag{10}$$

where L''_{pAi} is the A-weighted sound pressure level of the background noise measured at the *i* th microphone position, in decibels.

If ΔL_A exceeds 6 dB (A), the results meet grade 2 accuracy. Otherwise, they meet grade 3 accuracy.

12.3.2.3 If $\Delta L_A < 3$ dB, the measurement is invalid according to this clause.

12.3.3 Corrections for test environment

This subclause describes the procedures for determining the magnitude of the environmental correction K_{2A}, to account for the influence of reflected sound on the surface sound pressure level on the measurement surface.

Measurements in accordance with this clause achieve grade 2 accuracy if $K_{2A} \leqslant 2$ dB, and grade 3 accuracy if $K_{2A} \leqslant 7$ dB.

12.3.3.1 Test procedure using a reference sound source

The correction K_{2A} should preferably 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

$$K_{2A} = L^*_{WA} - L_{WAr} \tag{11}$$

where

L^*_{WA} is the environmentally uncorrected A-weighted sound power level of the reference sound source, determined in accordance with 12.2 and12.3 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 (= 10^{-12} W)], in decibels.

12.3.3.2 Other procedures

Although the procedure using a reference sound source is preferred, on machine tools it is not always possible to correctly place the reference sound source and to accurately determine L^*_{WA}. In this case, other procedures are to be used, as described hereunder.

The environmental correction K_{2A} in equation (12) accounts for the influence of undesired sound reflections from room boundaries and/or reflecting objects near the machine tool under test. The magnitude of this environmental correction K_{2A} depends principally on the ratio of the equivalent 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 clause, the environmental correction K_{2A} is given by

$$K_{2A} = 10 \lg\left[1 + 4\left(S/A\right)\right] \text{dB} \tag{12}$$

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.

The value of the equivalent sound absorption area A is determined by one of the methods given in annex B.

12.3.4 Calculation of the A-weighted sound power level

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

$$L_{WA} = \overline{L_{pfA}} + 10 \lg\left(S/S_0\right) \text{ dB} \tag{13}$$

where

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

S_0 = 1 m^2.

Annex A
(normative)

Microphone array on the measurement surface

Dimensions in metres

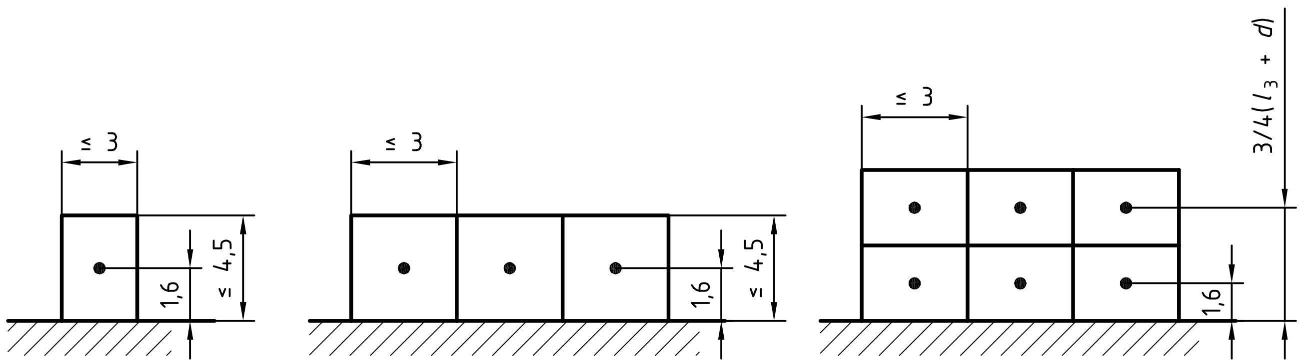
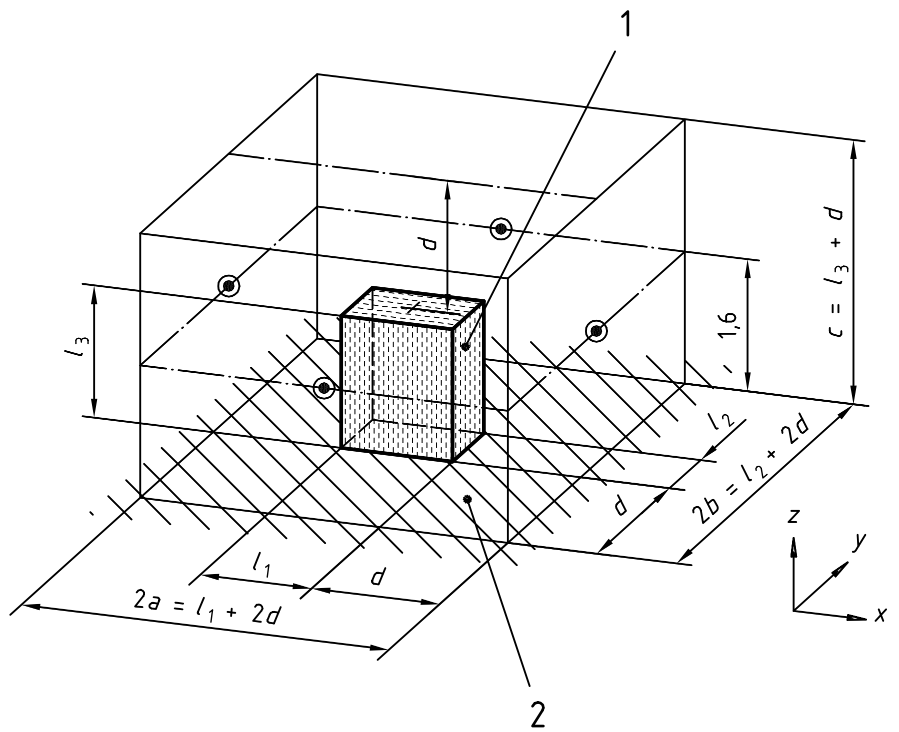


Figure A.1 — Procedure for fixing the specified microphone positions
in the general case of d = 1m (if d = 0,5 m, see ISO 3746)

Dimensions in metres



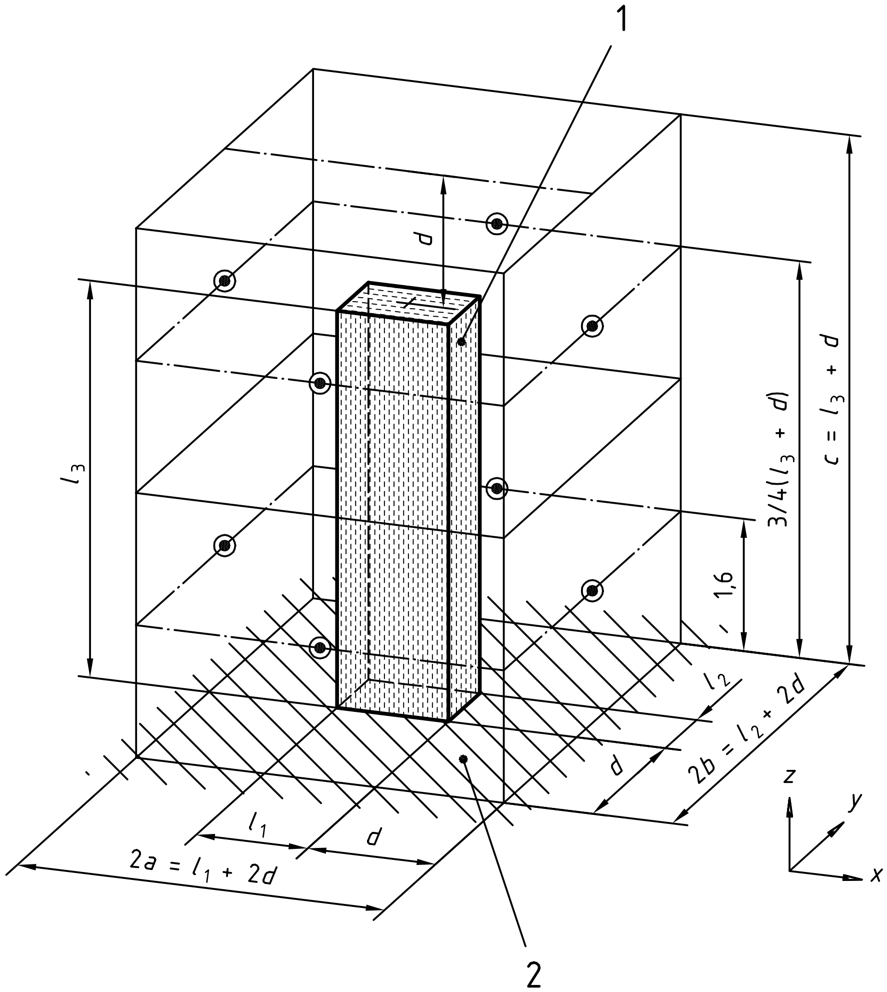
Key

1 Reference box

2 Reflecting plane

Figure A.2 — Example of a measurement surface and microphone positions for a small machine
($l_1 \leqslant 1$ m, $l_2 \leqslant 1$ m, $l_3 \leqslant 3{,}5$ m)

Dimensions in metres



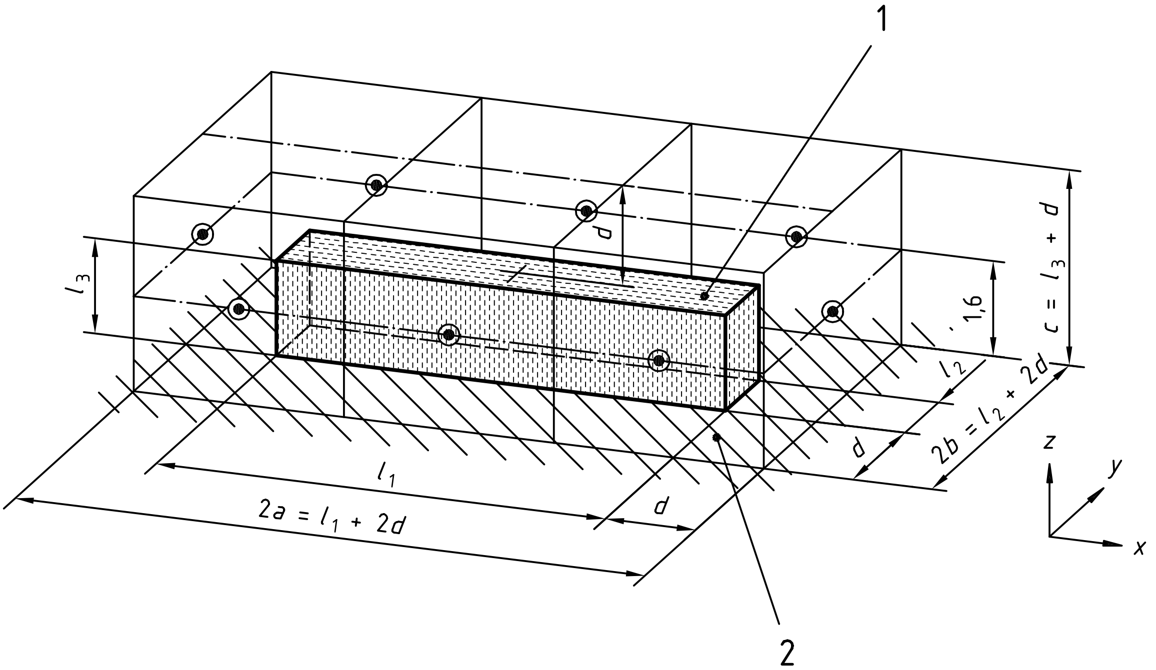
Key

1 Reference box

2 Reflecting plane

Figure A.3 — Example of a measurement surface and microphone positions for a tall machine with a small base area, ($l_1 \leqslant 1$ m, $l_2 \leqslant 1$ m, $l_3 > 3{,}5$ m)

Dimensions in metres



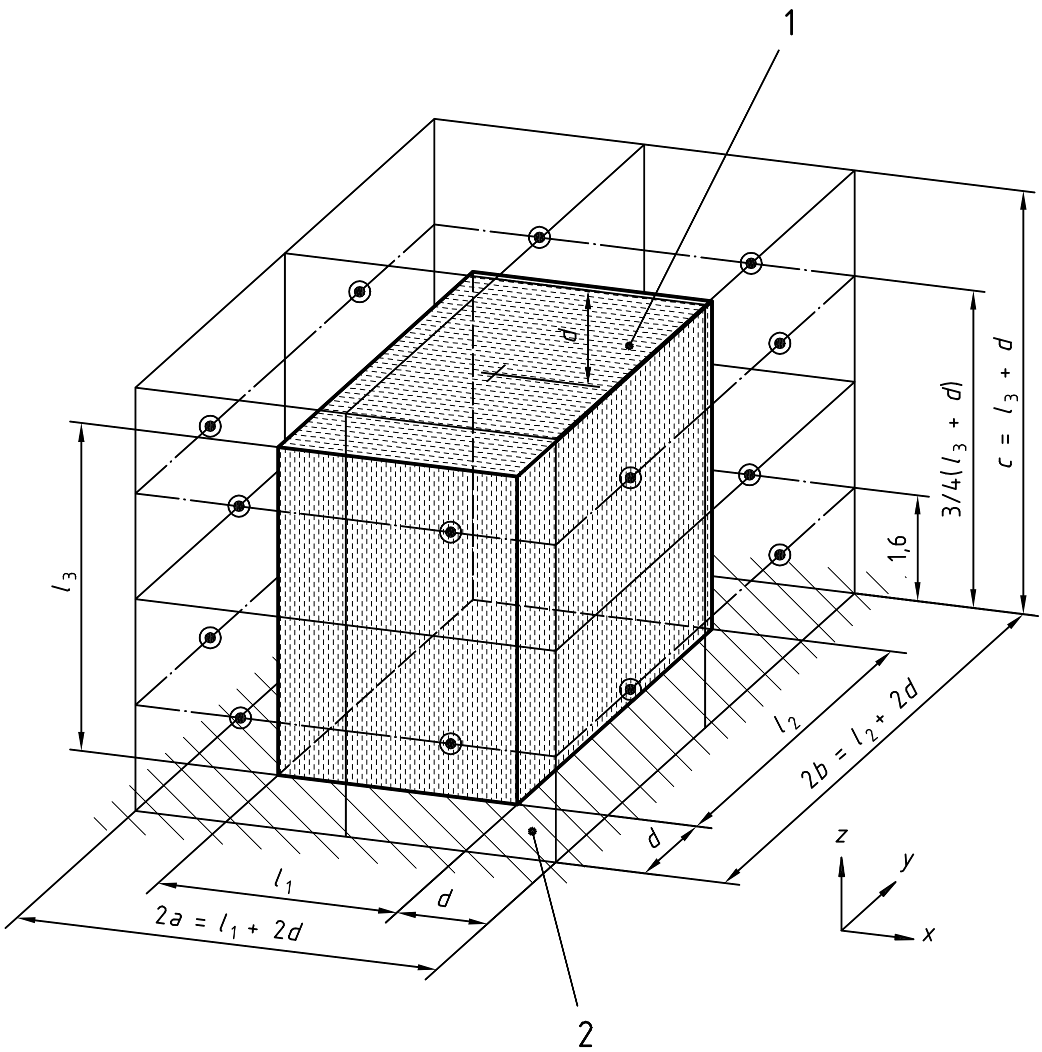
Key

1 Reference box

2 Reflecting plane

Figure A.4 — Example of a measurement surface and microphone positions for a long machine
(4 m < $l_1 \leqslant 7$ m, $l_2 \leqslant 1$ m, $l_3 \leqslant 3{,}5$ m)

Dimensions in metres



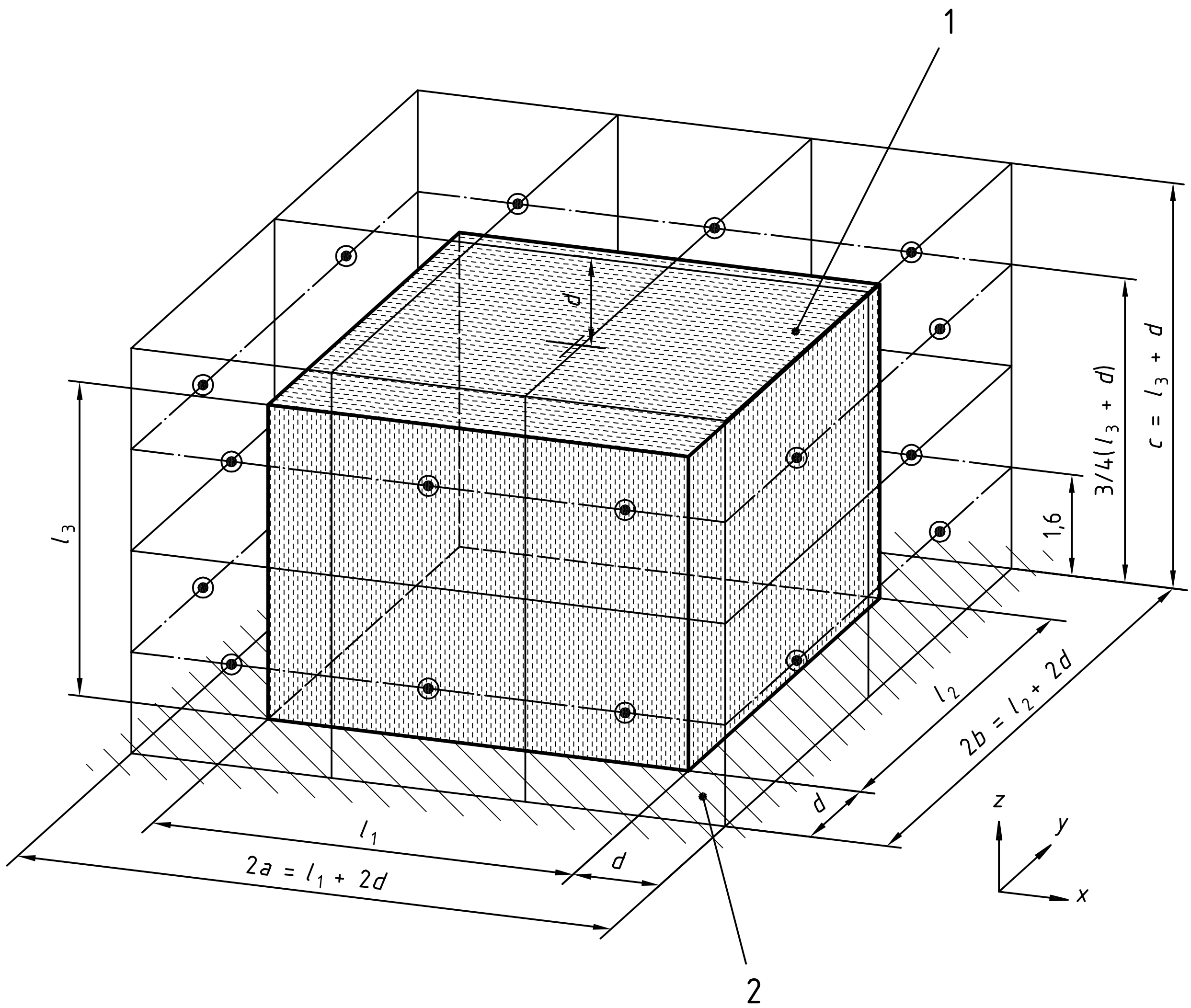
Key

1 Reference box

2 Reflecting plane

Figure A.5 — Example of a measurement surface and microphone positions for a medium-sized machine
($1\ \text{m} < l_1 \leqslant 4\ \text{m}$, $1\ \text{m} < l_2 \leqslant 4\ \text{m}$, $l_3 > 3{,}5\ \text{m}$)

Dimensions in metres



Key

1 Reference box

2 Reflecting plane

Figure A.6 — Example of a measurement surface and microphone positions for a large machine
($4\ m < l_1 \leqslant 7\ m$, $1\ m < l_2 \leqslant 4\ m$, $l_3 > 3,5\ m$)

Annex B
(normative)

Determination of the equivalent sound absorption area A

B.1 General

This annex provides two alternative methods for determining the equivalent sound absorption area A used for the local environmental correction K_{3A} [11.4.3, equation (7)] and the environmental correction K_{2A} [12.3.3.2, equation (12)].

B.1.1 Approximate method

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

$$A = \alpha \cdot S_V \quad \text{(B.1)}$$

where

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

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

Table B.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

B.1.2 Reverberation method

If it is required, determine the value of the a 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

$$A = 0{,}16\ (V/T) \qquad \text{(B.2)}$$

where

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

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

NOTE 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 1kHz.

B.2 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 part of ISO 230, 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

$$A/S \geqslant 1 \qquad \text{(B.3)}$$

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. 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 part of ISO 230.

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

NOTE In some special outdoor cases, the value of K_{2A} may be negative, but, for the purposes of this part of ISO 230, K_{2A} is then assumed to be zero.

Annex C
(informative)

Guidelines for the detection of impulsive noise

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

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

The C-weighted peak emission sound pressure level, $L_{p\mathrm{C,peak}}$ (as described in 3.3.2 and 11.3) may be used together with the time-averaged C-weighted sound pressure level, $L_{p\mathrm{Ceq}}$, for the same operational cycle. The difference ($L_{p\mathrm{C,peak}} - L_{p\mathrm{Ceq}}$) may be used as a descriptor of the impulsive content of the noise emitted by machine tools and equipment.

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 $L_{p\mathrm{AI}}$ and $L_{p\mathrm{AS}}$ may be used as a descriptor of the single event. The difference ($L_{p\mathrm{AImax}} - L_{p\mathrm{ASmax}}$) 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 of $L_{p\mathrm{AI}}$ for the individual events and the average maximum value of $L_{p\mathrm{AS}}$ over all the events are used.

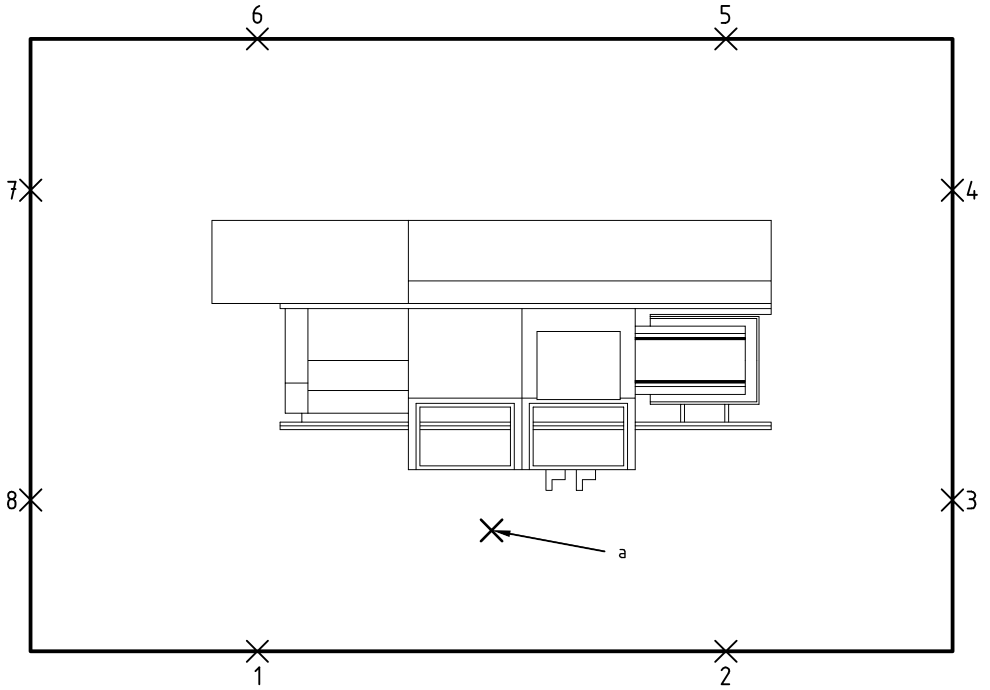
The C-weighted peak emission sound pressure level, $L_{p\mathrm{C,peak}}$, may be used together with the C-weighted maximum sound pressure level and the time characteristic S, $L_{p\mathrm{CSmax}}$. The difference ($L_{p\mathrm{C,peak}} - L_{p\mathrm{CSmax}}$) may be used as a descriptor of the single-event impulsive noise emitted by machine tools and equipment.

Annex D
(informative)

Example of information to be recorded
(see clause 8)

Machine under test		
Type	Horizontal hybrid lathe	
Technical data	Maximum permissible diameter 250 mm, distance between centres 1 000 mm	
Dimensions	l_1 = 2,96 m l_2 = 1,48 m l_3 = 1,83 m	
Manufacturer	Mm mm	
Machine serial number	12345	
Year of manufacture	1999	
Test conditions		
Description of operating conditions	a) Maximum spindle speed: 1 500 r/min b) Actual cylindrical turning: workpiece material: C 40 steel workpiece diameter: 80 mm cutting speed: 200 m/min depth of cut: 2 mm feedrate: 0,25 mm per revolution rotating speed: 800 r/min	
Mounting conditions	Resting on the floor	
Location of the machine	In the centre of the assembly room	
Description of noise sources	Main spindle motor and cutting tool	
Acoustic environment	Indoors, no physical treatment of walls	
Instrumentation		
Manufacturer, name, type, serial No.	Xxxx, Yyyy, Zzzz, nnnn	
Date, place and result of calibration	yyyy-mm-dd, in the same test room, by means of a sound-level calibrator: 0,2 dB	
Characteristics of the windscreen	No windscreen	
Noise data of emission sound pressure levels at the work station		
	Maximum spindle speed (1 500 r/min)	Cylindrical turning
A-weighted time-averaged emission sound pressure level	75,7	74,4
C-weighted peak emission sound pressure level	92	90
A-weighted background noise	< 60 dB	
K_{3A}	K_{3A} = 0,1 dB, determined by measuring the reverberation time	

Noise data of sound power levels			
		Maximum spindle speed (1 500 r/min)	Cylindrical turning
A-weighted sound power levels		90,5 dB = 1,11 mW	90,9 dB = 1,22 mW
Linear dimensions of the measurement surface		l_1 + 2 m = 4,96 m l_2 + 2 m = 3,48 m l_3 + 1 m = 2,83 m	
Area S of the measurement surface		≈ 65 m² ≈ 18,1 dB	
Measurement distance d		1 m	
K_{2A}		K_{2A} = 4,6 dB, determined using a reference sound source.	
A-weighted background noise		< 60 dB at each measuring point	
A-weighted sound pressure levels at each measuring point	1	77,5	77,0
	2	77,7	76,9
	3	77,2	78,6
	4	76,0	76,5
	5	75,9	77,4
	6	76,7	78,0
	7	75,6	76,5
	8	77,8	77,0
A-weighted surface sound pressure levels		72,3	72,7



a Operator's position

Annex E
(informative)

Example of noise-emission declarations for machine tools and equipment

An example of a dual-number declaration is given below, where typical values are shown, only for illustration.

Machine model number, operating conditions, and other identifying information: Type 990, Model 11-TC, 50 Hz, 230 V, rated load		
DECLARED DUAL-NUMBER NOISE-EMISSION VALUES **in accordance with ISO 4871**		
	Operating mode 1	**Operating mode 2**
Measured A-weighted sound power level, L_{WA} (ref.1pW), in decibels	91	91
Uncertainty, K_{WA}, in decibels	3	3
Measured A-weighted emission sound pressure level, L_{pA} (ref. 20 μPa) at the work station, in decibels	76	74
Uncertainty, K_{pA}, in decibels	3	3
Values determined according to the noise-test code given in ISO 230-5, using the basic standards ISO 3744 or 3746 and ISO 11202 or ISO 11204. The sum of a measured noise-emission value and its associated uncertainty represents an upper boundary of the range of values which is likely to occur in measurements.		

If there is no noise-test code or if the operating conditions are not in accordance with the test code indicated in this part of ISO 230 further information about the operating conditions should be given.

Bibliography

[1] ISO 1996-1:1982, *Acoustics — Description and measurement of environmental noise — Part 1: Basic quantities and procedures.*

[2] ISO 1999:1990, *Acoustics — Determination of occupational noise exposure and estimation of noise-induced hearing impairment.*

[3] ISO 9614-1:1993, *Acoustics — Determination of sound power levels of noise sources using sound intensity — Part 1: Measurement at discrete points.*

[4] ISO 9614-2:1996, *Acoustics — Determination of sound power levels of noise sources using sound intensity — Part 2: Measurement by scanning.*

[5] ISO/TR 11690-3:1997, *Acoustics — Recommended practice for the design of low-noise workplaces containing machinery — Part 3: Sound propagation and noise prediction in workrooms.*

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