INTERNATIONAL STANDARD

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Acoustics — Noise emitted by machinery and equipment — Measurement of emission sound pressure levels at a work station and at other specified positions — Engineering method in an essentially free field over a reflecting plane

Acoustique — Bruit émis par les machines et équipements — Mesurage des niveaux de pression acoustique d'émission au poste de travail et en d'autres positions spécifiées — Méthode d'expertise dans des conditions approchant celles du champ libre sur plan réfléchissant

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Foreword

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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.

International Standard ISO 11201 was prepared by Technical Committee ISO/TC 43, *Acoustics*, Subcommittee SC 1, *Noise*.

Annexes A, B and C of this International Standard are for information only.

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Introduction

0.1 This International Standard specifies a method for measuring the emission sound pressure levels at a work station and at other specified positions, in the vicinity of a machine or piece of equipment, in an essentially free field over a reflecting plane. In general, these sound pressure levels will be equal to or lower than those that would occur when the machinery or equipment is operating in its normal surroundings. This is because the sound pressure levels are determined by excluding the effects of background noise, as well as the effects of reflections other than those from the reflecting plane on which the machine under test is placed.

0.2 This International Standard is one of a series (ISO 11200 to ISO 11204) which specifies various methods for determining the noise emissions of a piece of machinery or equipment, or a sub-assembly of such equipment (machine under test). ISO 11200 gives guidance on the choice of the method to be used to determine the emission sound pressure levels of machinery and equipment. It also gives details of International Standards giving methods for the determination of sound power levels.

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Acoustics — Noise emitted by machinery and equipment — Measurement of emission sound pressure levels at a work station and at other specified positions — Engineering method in an essentially free field over a reflecting plane

1 Scope

1.1 General

This International Standard specifies a method for measuring the emission sound pressure levels of machinery and equipment, at a work station and at other specified positions nearby, in an essentially free field over a reflecting plane. A work station is occupied by 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 a work station, or in the vicinity of an unattended machine. As some of these positions may be occupied occasionally or regularly, they are sometimes referred to as bystander positions.

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

NOTE 1 The contents of this and related International Standards are summarized in table 1 of ISO 11200:1995.

This International Standard specifies requirements for the engineering grade of accuracy on the test environment and instrumentation. Corrections are applied for background noise, but not for the acoustic environment. 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. The purpose of the measurements is to permit comparison of the performance of different units of a given family of machinery or equipment, under defined environmental conditions and standardized mounting and operating conditions. The data obtained may also be used for the declaration and verification of emission sound pressure levels as specified in ISO 4871.

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 International Standard 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 reverberation and the contributions of other machines. A method of calculating the sound pressure levels in the vicinity of a machine operating alone in a workroom is given in ISO 11690-3. Commonly observed differences are 1 dB to 5 dB, but in extreme cases the difference may be even greater.

1.2 Types of noise and noise sources

The method specified in this International Standard is applicable to all types of machinery, both moving and stationary, for indoor or outdoor use.

The method is applicable to machines of all sizes, and to all types of noise as defined in ISO 2204 and ISO 12001.

1.3 Test environment

The type of test environment influences the accuracy of the determination of emission sound pressure levels. An essentially free field over a reflecting plane (indoors or outdoors) is required.

1.4 Specified positions

This International Standard is applicable to work stations and other specified positions where emission sound pressure levels are to be measured.

Examples of appropriate positions where measurements may be made include the following:

a) work station located in the vicinity of the machine under test; this is the case for many industrial machines and domestic appliances;

b) work station within a cab which is an integral part of the machine under test; this is the case for many industrial trucks and earth-moving machines;

c) work station within a partial or total enclosure (or behind a screen) supplied by the manufacturer as an integral part of the machinery or equipment;

d) work station partially or totally enclosed by the machine under test; this situation may be encountered with some large industrial machines;

e) bystander positions occupied by individuals not responsible for the operation of the machine under test, but who may be in its immediate vicinity, either occasionally or continuously;

f) other specified positions, not necessarily work stations or bystander positions.

The work station may also lie on a specified path along which an operator moves (see 11.4).

1.5 Measurement uncertainty

While it is not possible to give universal values for the standard deviation of reproducibility of emission sound pressure levels at work stations, guidance is given in clause 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 2204:1979, *Acoustics — Guide to International Standards on the measurement of airborne acoustical noise and evaluation of its effects on human beings.*

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 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 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.*

ISO 12001:—[1], *Acoustics — Noise emitted by machinery and equipment — Rules for the drafting and presentation of a noise test code.*

IEC 651:1979, *Sound level meters.*

IEC 804:1985, *Integrating-averaging sound level meters.*

IEC 942:1988, *Sound calibrators.*

IEC 1260:—[2], *Electroacoustics — Octave-band and fractional-octave-band filters.*

3 Definitions

For the purposes of this International Standard, the following definitions apply. More detailed definitions may be found in noise test codes for specific types of machinery and equipment.

3.1 emission: Airborne sound radiated by a well-defined noise source (e.g. the machine under test).

NOTE 3 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

1) To be published.

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

work station and/or at other specified positions (if any) in the vicinity of the source.

3.2 emission sound pressure, p: The 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, 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. It 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 651. It is expressed in decibels. The reference sound pressure is 20 μPa.

NOTE 4 Examples include:

— maximum A-weighted emission sound pressure level with time-weighting F: L_{pAFmax};

— C-weighted peak emission sound pressure level: $L_{pC,peak}$.

The emission sound pressure level shall be determined at a specified position in accordance with either a test code for a specific family of machines or, if no test code exists, a method that complies with the ISO 11200 series.

3.3.1 time-averaged emission sound pressure level, L_{peqT}: 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.

It is expressed in decibels and is given by the following equation:

$$L_{peqT} = 10 \lg \frac{1}{T} \int_0^T \frac{p^2(t)}{p_0^2} \, dt \ \text{dB} \qquad \ldots (1)$$

A-weighted time-averaged emission sound pressure levels are denoted by L_{pAeqT}, which is usually abbreviated to L_{pA}. L_{pAeqT} shall be measured with an instrument which complies with the requirements of IEC 804.

NOTES

5 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.

6 Equation (1) is identical to that for the familiar ISO environmental noise descriptor "equivalent continuous sound pressure level" defined in ISO 1996-1. 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 peak emission sound pressure level, $L_{p,peak}$: Highest instantaneous value of the emission sound pressure level determined over an operational cycle. It is expressed in decibels.

3.3.3 single-event emission sound pressure level, $L_{p,1s}$: Time-integrated emission 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 equation:

$$L_{p,1s} = 10 \lg \frac{1}{T_0} \int_0^T \frac{p^2(t)}{p_0^2} \, dt \ \text{dB} \qquad \ldots (2)$$

$$= L_{peqT} + 10 \lg \frac{T}{T_0} \ \text{dB}$$

NOTE 7 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 impulsive noise index (impulsiveness): Quantity by means of which the noise emitted by a source can be characterized as "impulsive". (See annex A.) It is expressed in decibels.

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. 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 ma-

chine, as described in the relevant noise test code, if any exists.

NOTE 8 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 dishwasher when washing or rinsing or drying).

3.10 operational cycle: Specific sequence of operational periods occurring while the machine under test performs a complete work cycle. 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 dishwasher when washing *and* rinsing *and* drying).

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: The noise from all sources other than the machine under test.

NOTE 9 Background noise may include contributions from airborne sound, structure-borne vibration, and electrical noise in instrumentation.

3.14 background noise level: The sound pressure level measured when the machine under test is not operating. It is expressed in decibels.

3.15 background noise correction, K_1: A correction term to account for the influence of background noise on the emission sound pressure level at the specified positions of the machine under test. K_1 is frequency dependent and is expressed in decibels. The correction in the case of A-weighting, K_{1A}, is to be determined from A-weighted measured values.

3.16 environmental indicator, K_2: A 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. In the case of A-weighting, it is denoted K_{2A} (see the ISO 3740 series).

4 Measurement uncertainty

A single value of an emission sound pressure level of a noise source determined in accordance with the method specified in this International Standard is likely to differ from the true value at a fixed position by an amount within the range of the measurement uncertainty. The uncertainty in measurements of emission sound pressure levels arises from several factors which affect the results, some associated with environmental conditions in the measurement room and others with experimental techniques.

The measurement uncertainty depends on the standard deviation of reproducibility and on the degree of confidence that is desired. Extensive measurement data are necessary in order to establish standard deviations of reproducibility of emission sound pressure levels at individual positions and, in any case, these standard deviations are likely to vary considerably between the many different types of machinery and equipment to which this International Standard is applicable. It is therefore not possible to provide information which is universally applicable, and reference can only be made to noise test codes for relevant data on individual types of noise source.

The engineering method described in this International Standard yields a higher degree of accuracy than the survey method described in ISO 11202 because the measurements are carried out under controlled environmental conditions.

For this engineering method, a value of the standard deviation of reproducibility equal to or less than 2,5 dB (excluding variations in operating and mounting conditions) is expected for the A-weighted emission sound pressure level of a source which emits noise with a relatively "flat" spectrum in the frequency range 100 Hz to 10 000 Hz.

The given value for the standard deviation of reproducibility is a maximum value but, for a well-defined family of machines, it may be smaller. For example, for one family of woodworking machines, it has been shown that the standard deviation of reproducibility is equal to 1,0 dB.

NOTE 10 If the machine under test is highly directional or its spectrum has tonal components, the measurement uncertainty may be larger. The risk of this being the case can be reduced by keeping the environmental indicator (see 6.2) less than 0,5 dB.

5 Instrumentation

The instrumentation system, including the microphone and cable, shall meet the requirements for a

class 1 instrument specified in IEC 651 or, in the case of integrating-averaging sound level meters, in IEC 804.

For measurements in octave or one-third-octave bands, the filters shall meet the requirements of IEC 1260.

Before and after each series of measurements, a sound calibrator with an accuracy of ± 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 with the requirements of IEC 942 shall be verified once a year. The compliance of the instrumentation system with the requirements of IEC 651 (or, in the case of integrating-averaging systems, with the requirements of IEC 804) shall be verified at least every 2 years.

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

6 Test environment

6.1 Specified positions in free space in the vicinity of the machine under test

Test environments that are suitable for measurements in accordance with this International Standard are a flat outdoor area or an indoor space that provides an essentially free field over a reflecting plane.

A laboratory hemi-anechoic room (see ISO 3745) or a flat outdoor area paved with sealed asphalt or concrete that meets the requirements given in 6.4 and 6.5 will be satisfactory for the purposes of measurements given in this International Standard. Other test environments meeting the requirements given in 6.2, 6.4 and 6.5 may also be used. No environmental corrections are permitted.

6.2 Criterion for the adequacy of the test environment

Ideally, the test environment should be free of reflecting objects other than a reflecting plane so that the machine under test radiates into a free field over a reflecting plane. Annex A of ISO 3744:1994 describes procedures for determining the magnitude of the environmental indicator, K_2, to account for the deviations of the test environment from the ideal condition. For this International Standard, the environmental indicator, K_{2A}, for a measurement surface enveloping the measurement positions, shall not exceed 2 dB.

NOTE 11 If it is necessary to make measurements in spaces in which K_{2A} exceeds 2 dB, then ISO 11202 or ISO 11204 may be applicable.

6.3 Enclosed work station positions

When the operator is located in an enclosed cab or in an enclosure remote from the machine under test, the cab or enclosure is regarded as an integral part of the machine under test and, consequently, sound reflections inside the cab or enclosure are considered contributions to the emission sound pressure level. No environmental corrections are permitted.

During noise emission measurements, doors and windows of the cabin or enclosure shall be open or closed as defined in the noise test code for the machinery or equipment being measured.

If the work station or bystander's position of the machine is located inside a cab or a cabin, an additional "conventional" work station or bystander's position outside the cab or cabin (e.g. for maintenance) in the vicinity of machine under test shall be specified in the noise test code.

6.4 Criterion for background noise

At the microphone position(s), the background noise (including wind noise at the microphone) measured as a weighted sound pressure level or in each of the frequency bands of interest shall be at least 6 dB (and preferably more than 15 dB) below the level due to the machine under test. Corrections for background noise in decibels are given by the following equation:

$$K_1 = -10 \lg \left(1 - 10^{-0,1\Delta L}\right) \text{ dB} \qquad \ldots (3)$$

where ΔL is the difference between the sound pressure levels measured, at a specified position, with the machine under test in operation and turned off, respectively.

For the purposes of this International Standard, if $\Delta L > 15$ dB, assume $K_1 = 0$; if $\Delta L < 6$ dB (i.e. $K_{1A} > 1,3$ dB), the measurement is invalid according to this International Standard.

K_1 shall be determined for each microphone position.

6.5 Ambient conditions during measurements

Ambient conditions may have an adverse effect on the microphone used for the measurements. Such conditions (e.g. strong electric or magnetic fields, wind, high or low temperatures, or impingement of air discharge from the machine under test) shall be avoided by proper selection or positioning of the microphone.

7 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 under test are

— the A-weighted sound pressure level, L'_{pA} (the prime indicates measured values);

— the C-weighted peak sound pressure level, $L_{pC,peak}$.

NOTES

12 Sound pressure levels using other frequency weightings or in octave or one-third-octave frequency bands, as well as other entities relating to the time-history of the noise emission (impulsiveness, sound pressure level as a function of time, etc.) may also be measured, as required for the design of low-noise machines.

13 For some applications, it may not be necessary to measure the value of the C-weighted peak sound pressure level. (See clause 5, note 4 of ISO 4871:—.)

8 Quantities to be determined

In order to obtain emission sound pressure levels at a specified position, *only* background noise corrections K_1 shall be applied to measured sound pressure levels, except peak sound pressure levels, $L_{pC,peak}$, for which no corrections are permitted.

Corrections K_1 to be considered are those relevant to the frequency weighting or frequency bands for which sound pressure levels have been measured. For frequency bands and A-weighting, respectively:

$$L_p = L'_p - K_1$$

$$L_{pA} = L'_{pA} - K_{1A} \quad \ldots (4)$$

where primes indicate measured values; no prime indicates emission values.

NOTE 14 If the machine under test produces isolated single-event sounds, the single-event emission sound pressure level at the specified position (see 3.3.3), $L_{p,1s}$, should be determined.

9 Installation and operation of machine under test

9.1 General

The manner in which the machine under test is installed and operated may have a significant influence on the emission sound pressure levels at the specified positions. 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 a noise test code, if any exists for the family of machinery or equipment to which the machine under test belongs, shall be followed. The same installation, mounting and operating conditions shall be used for the determination of emission sound pressure levels and sound power levels. The noise test code for the machinery concerned shall describe the installation, mounting and operating conditions in detail.

NOTE 15 The noise test code may make an exception to this requirement on identical installation, mounting and operating conditions for equipment that is used on tables. Such equipment may be mounted on the floor during sound power determinations.

Particularly for large machines, it is necessary to make a decision as to which components, sub-assemblies, auxiliary equipment, power sources, etc., belong to the machine under test.

9.2 Location of source

The machine under test shall be installed with respect to the reflecting plane in one or more locations as if it were being installed for normal usage. The machine under test shall be remote from any wall, ceiling or other reflecting object.

NOTE 16 Typical installation conditions for some machines involve two or more reflecting surfaces (e.g. an appliance installed against a wall), or free space (e.g. a hoist), or an opening in an otherwise reflecting plane (so that radiation may occur on both sides of the vertical plane). Detailed information on installation conditions should be based on the general requirements of this International Standard and on the relevant noise test code, if one exists.

9.3 Mounting of source

In many cases, the noise emission at the specified positions 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, that condition shall be used or simulated, if practicable.

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.

Many small machines, 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. Resilient mounting shall be interposed, if possible, between the machine to be tested and the supporting surfaces so that the transmission of vibration to the support and the reaction of the source are both minimized. In this case, the mounting base should be rigid (i.e. have a sufficiently high mechanical impedance) to prevent it from vibrating excessively and radiating sound. However, resilient mounts shall be used only if the machine under test is resiliently mounted in typical field installations.

NOTE 17 Coupling conditions (e.g. between prime movers and driven machines) may exert a considerable influence on the sound radiation of the machine under test.

9.3.1 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 machine under test requires a support for its operation, the support structure shall be small, considered to be a part of the machine under test, and as described in the relevant noise test code, if any exists.

9.3.2 Base-mounted and wall-mounted machinery and equipment

Such machinery and equipment shall be placed on a reflecting (acoustically hard) plane (floor or wall). Base-mounted machinery or equipment intended exclusively for mounting in front of a wall shall be installed on an acoustically hard surface in front of an acoustically hard wall. Table-top machinery or equipment shall be placed on a table or stand as required for operation according to the noise test code specific to the family of machinery or equipment to which the machine under test belongs. The table or stand shall be at least 1,5 m from any absorptive surface of the test room. Such machinery or equipment shall be placed at the centre of the top of the standard test table. A suitable design for a test table is shown in annex B.

9.4 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.

If practicable, all auxiliary equipment necessary for the operation of the machine under test that is not a part of it (see 9.1) shall be located outside the test environment. If this is impracticable, the auxiliary equipment shall be included in the test configuration and its operating conditions described in the test report.

9.5 Operation of the machine during test

During the noise measurements, the operating conditions specified in the relevant noise test code shall be used, if any exists for the particular family of machinery or equipment to which the machine under test belongs. If there is no test code, the machine under test shall, if possible, be operated 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 specified load and operating conditions;

b) machine under full load (if different from the first condition above);

c) machine under no load (idling);

d) machine under operating conditions corresponding to maximum sound generation representative of normal use;

e) machine with simulated load operating under carefully defined conditions;

f) machine under operating conditions with characteristic operational cycle.

Emission sound pressure levels at specified positions shall be determined for any desired set of operating conditions (i.e. temperature, humidity, device speed, 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 also depends on other operating parameters (e.g. type of material being processed or type of tool) then, out of the aggregate of possibilities, the ones to be defined shall be those which narrow down the variation possibilities as far as is practicable and which can be regarded as typical with regard to the noise emission.

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

If simulated operating conditions are used, they shall be chosen to give emission sound pressure levels at specified positions which are representative of normal usage of the machine under test.

In special cases, the results for several operating conditions can be combined by energy averaging, possibly with different time components taken into account, thereby yielding the result for the main operating condition so defined (see 10.1).

The operating conditions of the machine under test during noise measurements shall be fully described in the test report.

10 Measurements

10.1 Measurement time interval

10.1.1 General

The measurement time interval shall be chosen in such a way that the emission sound pressure level and, as required, the time characteristics of sound emission at specified positions can be determined for the specified operating conditions.

For a given source under test, the measurement time interval, T, may be composed of a number of sub-measurement time intervals, T_i, each of which corresponds to a specified operational period of the source. In this case, a single emission sound pressure level is usually desired. It is obtained by averaging the individual A-weighted emission sound pressure levels according to the following equation:

$$L_{pA} = 10 \lg \left[\frac{1}{T} \sum_{i=1}^{N} T_i 10^{0,1 L_{pA,T(i)}} \right] \text{ dB} \qquad \ldots (5)$$

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 or operational periods;

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

For machinery and equipment with a specified operational cycle, it is usually necessary to extend the measurement time interval to an integral number of consecutive operational cycles.

The measurement time interval shall correspond only to the operational periods for which the emission sound pressure level and, as required, the time characteristics of sound emission are desired.

Values of the measurement time interval, possible sub-measurement time intervals and number of operational cycles contained in the measurement time interval are usually to be found in the noise test code specific to the family of machinery or equipment to which the machine under test belongs, if any exists. In any case, these values shall be identical to those defined for determining the sound power level of the machine under test.

10.1.2 Steady noise

If the noise emission at a specified position is steady for the specified operating conditions (see ISO 2204 and ISO 12001), the measurement time interval shall be at least 15 s.

10.1.3 Non-steady noise

If the noise emission at a specified position is not steady for the specified operating conditions, the measurement time interval and operational periods of the machine under test shall be carefully defined and reported in the test results. They are normally specified in the relevant noise test code, if any exists.

10.1.4 Measurements in frequency bands

If measurements are to be made in octave or one-third-octave frequency bands, the minimum period of observation shall be 30 s for the frequency bands

centred on or below 160 Hz, and 15 s for the frequency bands centred on or above 200 Hz.

10.2 Measurement procedure

10.2.1 General

The emission sound pressure level(s) shall be measured over a typical period of operation of the machine under test (see 10.1). Readings of the emission sound pressure level(s) shall be taken at the specified positions.

Normally, an integrating-averaging sound level meter complying with IEC 804 shall be used to measure the emission sound pressure level (see clause 5). If it can be shown that the sound pressure level fluctuations measured with the time-weighting characteristic S are less than $\pm$ 1 dB, a conventional sound level meter complying with IEC 651 may be used. In this case, the sound pressure level is taken to be the average of the maximum and minimum levels during the period of observation, measured with the time-weighting characteristic S.

10.2.2 Repetition of measurements

In order to reduce the uncertainty of the determination of emission sound pressure levels at the specified positions, it may be necessary, for a specific type of machinery or equipment, to repeat the measurement a number of times as specified in the noise test code for the family of machines or equipment to which the machine under test belongs. The value (e.g. average or maximum) to be used after repeated measurements shall be that defined in the noise test code, if any exists. Repeating measurements involves the following procedure:

a) the machine under test is turned off and on again, if feasible;

b) the microphone is moved away and set again at the specified position;

c) the measurement is carried out again in the same environment, with the same instrumentation over the same measurement time interval and for the same mounting and operating conditions.

10.2.3 Procedure for impulsive noise

If the sound emission is impulsive (as described in annex A), particular care shall be taken when measuring the emission sound pressure level to ensure that the dynamic range of the instrumentation is sufficiently large, and that the sound level meter is equipped with an overload indicator.

For measurement of the time characteristics of impulsive sound emissions (e.g. peak values), additionally to the repetition procedure described in 10.2.2, the measurement time interval shall include at least 10 impulsive events, unless otherwise specified in the noise test code.

The final value retained is usually the average, unless the peak value is measured. In this case, the highest of the peak values is retained. If a more precise procedure is specified in the relevant noise test code, that procedure shall be used.

If the machine under test produces isolated single-event sounds, the single-event emission sound pressure level at the work station position (see 3.3.3), $L_{p,1s}$, shall be determined.

In order to determine whether or not the sound emission contains impulsive components, one of the procedures given in annex A may be followed.

11 Microphone positions

11.1 General

The measurement positions shall be chosen from the alternatives described in 11.2, 11.3, 11.4 or 11.5 .

The microphone shall be oriented in such a way that the angle of incidence of the sound coincides with the reference direction of the microphone as specified by the manufacturer to meet the requirements of IEC 651 or IEC 804, respectively. If practical, the emisson sound pressure level shall be measured with the machine under test unattended and with the microphone oriented towards the dominant sound source.

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 $\pm$ 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_{pA}, is observed.

NOTE 18 If the measured sound pressure level is strongly position dependent, it is recommended that the

space average be taken at several positions inside a small volume centred at the specified position.

Unless otherwise required in the relevant noise test code, if any exists, the operator position(s) shall be as described in 11.2 to 11.5.

11.2 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 test code 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 as in the noise test code specific to the family of machinery or equipment to which the machine under test belongs, if one exists. If there is no test code, 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.

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

If the operator is present, the requirements of 11.1 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 code, 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 found in the relevant noise test code, if any exists.

11.4 Microphone position(s) for an operator moving along a specified 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 equation (5).

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 code, 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 code specific to the family of machinery 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.

NOTE 19 If the specified path is on a rectangular measurement surface at a constant distance from the reference box, it is recommended that the method specified in ISO 11203 be applied.

11.5 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 noise test code.

Alternatively, if no noise test code exists, measurements shall be made at four or more microphone positions located 1 m away from each side of the reference box defined in ISO 3744 or ISO 3746 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 position where this value is measured shall be recorded.

NOTES

20 Instead of using discrete positions, it may be satisfactory to use the surface sound pressure level calculated from the sound power level in accordance with ISO 11203.

21 A noise test code may require that the average of the levels from the four or more positions is recorded as the emission sound pressure level of the machine under test, for example, as in ISO 7779.

12 Information to be recorded

The following information, when applicable, shall be compiled and recorded for all measurements made in accordance with this International Standard. Rounding of computed data values shall occur only after performing the final computational step before reporting.

12.1 Machine under test

Description of the machine, including its

— type,

— technical data,

— dimensions,

— manufacturer,

— machine serial number, and

— year of manufacture.

12.2 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.

12.3 Acoustic environment

Description of the test environment:

a) if indoors, description of physical treatment of walls, ceiling and floor; sketch showing the location of the machine under test and room contents; acoustical qualification of room in accordance with 6.2;

b) if outdoors, sketch showing the location of the machine under test with respect to surrounding terrain, including

1) physical description of test environment,

2) air temperature in degrees Celsius, barometric pressure in pascals, and relative humidity as a percentage,

3) wind speed, in metres per second.

12.4 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).

12.5 Location of specified positions

A precise quantitative description shall be recorded of all positions where emission sound pressure levels have been measured.

12.6 Noise data

a) All measured sound pressure level data.

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

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

d) A-weighted background noise levels and background noise correction, K_{1A}, at each specified position. If required, background noise levels and correction K_1 in frequency bands.

e) Place, date when the measurements were performed, and person responsible for the test.

13 Information to be reported

Only those recorded data (see clause 12) are to be reported which are required for the purposes of the measurements. If a standardized noise test code exists for the machinery or equipment under test, the code will specify the data that are to be reported.

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

The report shall include the date on which the emission 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 0,5 dB.