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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 — Survey method *in situ*

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 de contrôle in situ

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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 11202 was prepared by Technical Committee ISO/TC 43, *Acoustics*, Subcommittee SC 1, *Noise*.

Annex A forms an integral part of this International Standard. Annexes B, C and D 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. The method specified in this International Standard follows the method specified in ISO 11201 (engineering method), except for the following:

a) measurements are permitted *in situ*; and

b) a simplified method is specified for determining a local environmental correction which yields results approximating those obtained in a free field over a reflecting plane. This correction is used to derive the emission sound pressure levels at specified positions, including work stations. The results are limited to the survey grade of accuracy.

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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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 a semi-reverberant field. Emission sound pressure level are measured as A-weighted and, if required, C-weighted peak.

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

A method is given for determining a local environment correction (subject to a specified limiting maximum value) to be applied to the measured sound pressure levels in order to exclude at least part of the effects of reflections from reflecting surfaces other than the plane on which the machinery or equipment is placed. This correction is based on the equivalent sound absorption area of the test room.

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 an attended or unattended machine. Such positions are sometimes referred to as bystander positions.

This International Standard specifies requirements for the survey grade of accuracy on the test environment and instrumentation. 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 method is applicable to an indoor or outdoor environment with one or more reflecting planes present, meeting specified requirements.

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 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.*

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 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

1) To be published.

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:

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

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:

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

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

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 C.) 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 machine, 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).

3.17 local environmental correction, K_3: A 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. 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}.

3.18 typical distance, a: Distance from the specified position to the closest major sound source of the machine under test. If the major sound sources of the machine are ill-defined, then a is chosen as the distance from the specified position to the nearest part of the machine under test.

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 survey method described in this International Standard yields a lower degree of accuracy than the engineering method described in ISO 11201 because the measurements are carried out under environmental conditions that are less well controlled.

NOTE 10 The method for determination of the local environmental correction, K_3, which is described in this International Standard, nominally underestimates the magnitude of K_3 and the value of K_3 to be applied is limited to 2,5 dB. Therefore, the emission sound pressure levels obtained by this method will often be higher than the emission sound pressure levels obtained in accordance with ISO 11201.

Detailed information on the precision of this method cannot be given as the magnitude of the local environmental correction is limited to 2,5 dB. However, a value of the standard deviation of reproducibility equal to or less than 5 dB (excluding variations in operating and mounting conditions) is expected for a source which emits noise with a relatively "flat" spectrum in the frequency range 100 Hz to 10 000 Hz, provided the tests are performed in similar acoustic environments. The given value for the stan-

dard deviation of reproducibility is a maximum value, but for a well-defined family of machines, it may be smaller.

NOTE 11 ISO 11204 gives another more accurate method to determine K_{3A}. Requirements on K_{3A} depend on the method used to determine L_{pA}.

5 Instrumentation

The instrumentation system, including the microphone and cable, shall meet the requirements for a class 1 or class 2 instrument specified in IEC 651 or, in the case of integrating-averaging sound level meters, in IEC 804.

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 General

Any environment which meets the qualification requirements of 6.2 and which is adequately isolated from background noise in accordance with the requirements of 6.4 is suitable for measurements in accordance with this International Standard.

6.2 Criterion for the adequacy of the test environment

Annex A of ISO 3746:1995 describes procedures for determining the magnitude of the environmental indicator K_{2A}, to account for deviations of the test environment from ideal, free-field conditions. For this International Standard, the environmental indicator, K_{2A}, shall not exceed 7 dB.

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.

NOTE 12 If the instrumentation system meets the requirements for a class 1 instrument as specified in IEC 651 and IEC 804, the measurements will comply with the requirements of ISO 11201, provided that the background noise requirements of that standard are met.

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 the 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 3 dB (and preferably more than 10 dB) below the level due to the machine under test. Corrections for background noise in decibels are given by the following equation:

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

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 $\Delta L > 10$ dB, assume $K_1 = 0$; if $\Delta L < 3$ dB (i.e. $K_{1A} > 3$ 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.

6.6 Local environmental correction

Annex A describes a procedure for determining the magnitude of the local environmental correction K_3, to account for the influence of reflected sound on the emission sound pressure level at the specified position(s).

The method given in annex A requires information about the acoustical properties of the test room. It normally underestimates the magnitude of K_3. The local environmental correction K_{3A}, in the case of A-weighting, to be applied to the measured data shall not exceed 2,5 dB.

NOTE 13 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.

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, $L_{pC,peak}$.

NOTE 14 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, *both* background noise corrections K_1 and local environmental corrections K_3 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 and K_3 to be considered are those relevant to the frequency weighting for which emission sound pressure levels have been measured. For A-weighting:

$$L_{pA} = L'_{pA} - K_{1A} - K_{3A} \quad \ldots (4)$$

where the prime indicates measured values; no prime indicates emission values.

For a specified position inside an enclosure, as defined in 6.3, no environmental corrections are permitted.

NOTE 15 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 and operating conditions of the machine under test 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 16 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 17 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 18 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.).