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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

Reference number
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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.*

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

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

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
$L_{p\mathrm{eq}T}$
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:

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

NOTE 2 $L_{p\mathrm{eq}T}$ 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 $L_{p\,\mathrm{A\,eq}T}$, usually abbreviated to $L_{p\mathrm{A}}$.

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
$L_{p\mathrm{C,peak}}$
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
$L_{p,1\mathrm{s}}$
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:

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

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 ($K_{1\mathrm{A}}$, $K_{2\mathrm{A}}$, $K_{3\mathrm{A}}$), 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''_{pA} 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