International Standard 6081

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Acoustics — Noise emitted by machinery and equipment — Guidelines for the preparation of test codes of engineering grade requiring noise measurements at the operator's or bystander's position

Acoustique — Bruit émis par les machines et matériels — Directives pour la rédaction des codes d'essais de la classe «expertise» comportant la mesure du bruit aux postes de conduite ou aux postes de l'assistant

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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.

Draft International Standards adopted by the technical committees are circulated to the member bodies for approval before their acceptance as International Standards by the ISO Council. They are approved in accordance with ISO procedures requiring at least 75 % approval by the member bodies voting.

International Standard ISO 6081 was prepared by Technical Committee ISO/TC 43, *Acoustics*.

Users should note that all International Standards undergo revision from time to time and that any reference made herein to any other International Standard implies its latest edition, unless otherwise stated.

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Acoustics — Noise emitted by machinery and equipment — Guidelines for the preparation of test codes of engineering grade requiring noise measurements at the operator's or bystander's position

0 Introduction

0.1 General

This International Standard provides guidelines for preparing test codes that specify methods for measuring the sound pressure levels at the operator's position(s) in close proximity to a specific machine or piece of equipment or in the operator's cab.

The sound pressure levels determined according to the procedures of such test codes are useful for comparing the noise emissions of different machines at the operator's position(s) under similar environmental conditions. Hence, this International Standard relates to the emissions of noise sources. It is not the intent of this International Standard to describe procedures for measuring the occupational noise exposures of workers (noise immission).

The sound pressure levels at the operator's position(s) which are obtained according to the procedures of test codes based on this International Standard represent the noise emission of the machine for operating conditions specified for this particular type of machine. In practice, these sound pressure levels are the lowest obtainable values because they are determined by excluding effects of reflections other than those from the reflecting plane on which the machine is placed.

This International Standard provides guidelines for the installation and operating conditions for the machinery and equipment undergoing evaluation. Specific test codes may specify installation and operating conditions more precisely.

It is not the intent of this International Standard to specify requirements or assign responsibilities for meeting any specific sound pressure level criteria at the operator's position(s).

0.2 Relationship to other standards and test codes

This International Standard provides general guidelines for preparing test codes requiring noise measurements at the operator's position and describing the instrumentation, test site characteristics (indoors and outdoors), microphone locations and installation and operating conditions of specific types of machinery and equipment.

This International Standard is to be used in conjunction with ISO 3740. International Standards or test codes based upon ISO 3740 are to be used for specifying mounting, operating and loading conditions of the source during its acoustical evaluation.

A specific noise test code for measurements at the operator's position(s) for a specific type of machine should be based on this International Standard. Preferably only one specific noise emission test code should be established based on the series ISO 3741 to ISO 3746 and ISO 6081 for the following purposes :

— determination of the sound power level;

— determination of the sound pressure level at the operator's or bystander's position(s).

Account should be taken of the fact that ISO 3741 to ISO 3746 and ISO 6081 describe methods for different grades (precision, engineering, survey) and different measurement environments.

If no specific test code exists for a particular type of machine, this International Standard may be used to provide guidelines for the measurements.

The methods described in this International Standard are not applicable to determinations of the total noise emissions of products; for this purpose, the sound power level of the machine should be determined in accordance with the appropriate International Standard in the series ISO 3741 to ISO 3746, or from appropriate test codes based upon those International Standards.

0.3 Measurement uncertainty

Measurements carried out in conformity with this International Standard should result in standard deviations which are equal to or less than those given in table 1.

Table 1 — Uncertainty in determining the equivalent continuous sound pressure level, L_{eq}

Octave band centre frequencies	One-third octave band centre frequencies	Standard deviation of mean value
Hz	Hz	dB
125	100 to 160	3,0
250 to 500	200 to 630	2,0
1 000 to 4 000	800 to 5 000	1,5
8 000	6 300 to 10 000	2,5

These standard deviations reflect the cumulative effects of all causes of measurement uncertainty, including variations from laboratory to laboratory, but excluding variations in the sound

pressure level from machine to machine and from test to test which may be caused, for example, by changes in the mounting or operating conditions of the machine.

For a source which emits noise with a relatively "flat" spectrum in the 100 to 10 000 Hz frequency range, the A-weighted equivalent continuous sound pressure level is determined with a standard deviation of approximately 2 dB.

1 Scope and field of application

This International Standard lays down the conditions of measurement of noise at the operator's position(s) and at other specified locations in the vicinity of different types of machinery and equipment used indoors and outdoors. It also applies to operator positions which are partially or totally enclosed by the machine or are within a cab which may be an integral part of the machine or remote from the machine. This International Standard is applicable to all sources, both moving and stationary, with the exception of transportation vehicles.

2 References

ISO 266, *Preferred frequencies for acoustical measurements.*

ISO 2204, *Acoustics — Guide to International Standards on the measurement of airborne acoustical noise and evaluation of its effects on human beings.*

ISO 3462, *Tractors and machinery for agriculture and forestry — Seat reference point — Method of determination.*

ISO 3740, *Acoustics — Determination of sound power levels of noise sources — Guidelines for the use of basic standards and for the preparation of noise test codes.*

ISO 3741, *Acoustics — Determination of sound power levels of noise sources — Precision methods for broad-band sources in reverberation rooms.*

ISO 3742, *Acoustics — Determination of sound power levels of noise sources — Precision methods for discrete-frequency and narrow-band sources in reverberation rooms.*

ISO 3743, *Acoustics — Determination of sound power levels of noise sources — Engineering methods for special reverberation test rooms.*

ISO 3744, *Acoustics — Determination of sound power levels of noise sources — Engineering methods for free-field conditions over a reflecting plane.*

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

ISO 3746, *Acoustics — Determination of sound power levels of noise sources — Survey method.*

ISO 5353, *Earth-moving machinery — Seat index point.*

IEC Publication 225, *Octave, half-octave, and third-octave band filters intended for the analysis of sound and vibrations.*

IEC Publication 651, *Sound level meters.*

IEC Publication 804, *Integrating-averaging sound level meters.*

3 Definitions

For the purposes of this International Standard, the following definitions apply.

3.1 sound pressure level, L_p, in decibels : Ten times the logarithm to the base 10 of the ratio of the square of the sound pressure to the square of the reference sound pressure.

The width of the frequency band used shall be indicated : for example, octave band sound pressure level, one-third octave band sound pressure level, etc. The reference sound pressure is 20 µPa.

3.2 A-weighted sound pressure level, L_{pA}, in decibels : The frequency-weighted value of the sound pressure level determined with a sound level meter set for the frequency weighting characteristic A. The reference sound pressure is 20 µPa.

NOTE — Any other frequency weighting, if used, should be defined in a similar manner, for example, L_{pC}.

3.3 AI-weighted sound pressure level, L_{pAI}, in decibels : The sound pressure level determined with a sound level meter set for the frequency-weighting characteristic A and the time-weighting characteristic I (impulse), as specified in IEC Publication 651.

3.4 equivalent continuous sound pressure level, L_{eq}, in decibels : Value of the sound pressure level of a continuous, steady sound that, within the measurement time interval, has the same mean square sound pressure as a sound under consideration the level of which varies with time. It is given by the formula

$$L_{eq} = 10 \lg \left[\frac{1}{t_2 - t_1} \int_{t_1}^{t_2} \frac{p^2(t)}{p_0^2} \, dt \right]$$

where

L_{eq} is the equivalent continuous sound pressure level, in decibels, determined over a time interval starting at t_1 and ending at t_2;

p_0 is the reference sound pressure (20 µPa);

$p(t)$ is the instantaneous sound pressure of the sound signal.

NOTE — The sound pressures are usually derived from the A-weighted levels. If so, it is recommended that the designation L_{Aeq} be used.

If other weightings or filters are used, this should be indicated.

3.5 operator : An individual whose work station is in the immediate vicinity of a machine or who is responsible for the remotely-controlled operation of a machine.

3.6 operator's position : The work station of the operator.

3.7 bystander : An individual who is not responsible for the operation of a machine but whose position may lie within the sound field produced by the machine either occasionally or continuously.

3.8 bystander's position : The typical location occupied by a bystander.

3.9 emission : The sound radiated by one, well-defined source; a descriptor may be incorporated in a product label and/or product specification; usually prescribed on a sound power level basis and, in addition, on a sound pressure level basis for an operator's position if such a position is defined.

NOTE — The emission contributes to the immission at the operator's ear position, where the immission is related to the noise exposure for defined operating conditions and observation times due to the emissions of all contributing noise sources, including reflections, contributions of background noise, etc.

3.10 operational period : An interval of time during which a specified process is accomplished by the machine (for example, for a dishwasher, washing, rinsing or drying).

3.11 operational cycle : A specific sequence of operational periods occurring repeatedly while the source is functioning.

3.12 measurement time interval : A portion of an operational period or operational cycle for which the equivalent continuous sound pressure level is determined.

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

4 Test environment

4.1 Test environment for measurement purposes

4.1.1 Operator positions in free space in the vicinity of the machine

A free field over a reflecting plane shall be used for the test environment and no environmental corrections are necessary or permitted for this engineering method. A free field over a reflecting plane can be assumed if the environmental correction as defined in ISO 3744 is smaller than 1 dB [when using a measurement surface on which the microphone position(s) at the operator's position(s) lie].

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

Usually, a laboratory semi-anechoic room (see ISO 3745) or a flat outdoor area paved with sealed asphalt or concrete that meets the requirements of 4.2 and 4.3 will be satisfactory for the purposes of measurements according to this International Standard.

4.1.2 Enclosed operator positions

When the operator is located in an enclosed cab or in an enclosure remote from the machine undergoing test, the cab or enclosure is regarded as an integral part of the machine and no environmental corrections are permitted.

4.2 Criterion for background noise

At the microphone position(s), the background noise (including wind noise at the microphone) measured as the A-weighted sound pressure level and in each frequency band of interest should be 10 dB below the level due to the machine being tested and shall be at least 6 dB below this level. Corrections for background noise are given in clause 9.

NOTE — Background noise which is less than 6 dB below the sound pressure level due to the machine under test is too high for the purposes of this International Standard. Under such circumstances, it is not possible to determine the sound pressure levels due to the machine at the operator's position(s) with sufficient accuracy to meet the requirements of this International Standard.

4.3 Ambient conditions

Environmental conditions (humidity, temperature, vibration, stray fields, etc.) shall be within the limits specified by the manufacturers of the measuring equipment and of the machine under test. The meteorological conditions (temperature, wind, precipitation, etc.) shall be such as not to influence the measurements within the limits of accuracy required.

5 Instrumentation

5.1 General

The instrumentation shall be designed to measure the level of the mean-square sound pressure, weighted and in octave or one-third-octave bands, and averaged over a specified observation time (see 8.2). The required time averaging may be accomplished in one of several ways :

a) By using an integrating-averaging sound level meter as specified in IEC Publication 804.

b) By integrating the squared signal over a fixed time interval. This integration may be performed by either digital or analogue means.

NOTE — This is the preferred method for noise containing significant impulsive components.

c) By "averaging" the squared signal using RC-smoothing with a given time constant. Such averaging provides only an approximation of the true time average, and it places restrictions on the "settling" time and observation time.

d) By numerically averaging the squared pressures corresponding to a number of measurements of sound pressure level, each measurement obtained using an integrating or averaging time that is considerably shorter than the measurement time interval, e.g. exponential time-averaging or performed by the time-weighting characteristics F or S.

Examples of suitable instrumentation systems are given in annex A.

5.2 Instrumentation system

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

A microphone with a diameter not greater than 13 mm shall be used for measurements.

NOTE — It is essential that care should be taken to isolate the microphone from vibrations or other influences (e.g. electromagnetic radiation) which could affect the measurements. If the microphone is moved during the measurements (e.g. if it is mounted on a moving operator), care shall be exercised to avoid introducing acoustical noise (e.g. noise due to the microphone rubbing against the operator's clothing) or electrical noise (e.g. due to a flexing cable) that could interfere with the measurements.

The use of other frequency weighting networks, in addition to A-weighting, is optional.

For measurements in frequency bands, an octave band or one-third octave band filter meeting the requirements of IEC Publication 225 shall be used. The centre frequencies of the frequency bands shall correspond to those of ISO 266.

6 Microphone positions

6.1 General

The specific noise test code for a particular type of machine shall specify whether the operator shall be present or absent during the acoustical measurements. If present, the operator(s) shall not wear abnormally sound absorptive clothing 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.

The noise test code for a particular type of machine shall clearly specify the microphone positions.

For machines that are not operator-attended and for bystanders, measurements may be made at one or more microphone positions located 1 m away from the reference rectangular surface defined in ISO 3744 or ISO 3746 and at a height of 1,5 m above the ground plane, if no other requirements are stated in a specific noise test code.

Unless otherwise required in a specific test code, the operator position(s) shall be as described in 6.2 to 6.4.

6.2 Microphone position(s) for seated operator

If an operator is not present, and if the seat is attached to the machine under test, the seat index point according to ISO 5353 or the seat reference point according to ISO 3462[1] shall be determined with the seat set at or as near as possible to the mid-point of its horizontal and vertical adjustment. Any seat suspension shall be depressed until the seat reaches the mid-point of its dynamic range. The microphone shall be located 0,69 ± 0,05 m above and 0,20 ± 0,02 m forward of the seat index point. If the seat index point is not defined, the microphone shall be located 0,80 ± 0,05 m above the middle of the seat plane.

If an operator is present, the adjustment of the seat should allow him to reach the controls comfortably. His height from the seat plane to the top of the head should be 0,91 ± 0,05 m and the microphone shall be located 0,20 ± 0,02 m to the side of the operator's head centre plane on a line with the eyes and on that side where the higher value of the A-weighted equivalent continuous sound pressure level, L_{Aeq}, is observed.

If an operator is not present and if the seat is not attached to the machine under test, the microphone positions shall be described in the specific noise test code for a particular type of machine.

6.3 Microphone position(s) for standing stationary operator

If no other location is specified for a standing operator, the microphone shall be located 1,500 ± 0,025 m above the reference point, i.e. the position on the ground plane on which the operator normally stands.

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 intersection of the straight line connecting the front of the toe of the operator's right foot and the back of the heel of the left foot with the straight line connecting the toe of the left foot and the heel of the right foot, when the operator is at his normal work station.

If the measurements are made with the operator absent, the microphone shall be located 1,500 ± 0,025 m directly above the reference point. If an operator is present, the microphone shall be located 0,20 ± 0,02 m to the side of the operator's head centre plane on a line with the eyes and on that side where the higher value of the A-weighted equivalent continuous sound pressure level, L_{Aeq}, is observed.

6.4 Microphone position(s) for operator moving along specified path

In those situations where an operator moves along a specified path in the vicinity of a particular type of machinery or equip-

1) The seat index point is located 0,097 m above and 0,130 m in front of the seat reference point.

ment, a sufficient number of microphone locations or a moving microphone shall be used to determine the sound pressure levels at the operator's position(s) or along his specified path.

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, the microphone positions shall be located 1,500 ± 0,025 m above the reference line.

Microphone positions shall be defined at all fixed operator positions and the specified path shall be given in the specific noise test code for a particular type of machine.

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.

6.5 Microphone orientation

The microphone shall be oriented horizontally forward so that the reference direction of incidence coincides with the direction in which the operator usually faces.

7 Installation and operating conditions

7.1 General

The specific noise test code for a particular type of machine shall specify the installation, loading and operating conditions for that type of machine or equipment. The installation and operation of a particular machine for the purposes described in this International Standard, or in special noise test codes based on this International Standard, shall be based on those conditions specified for the determination of the sound power level according to one of the International Standards in the series ISO 3741 to ISO 3746.

7.2 Auxiliary equipment

Ensure that any electrical conduits, piping or air ducts connected to the equipment do not radiate significant amounts of sound energy into the test environment. The test environment shall be cleared of all objects which might interfere with the measurements. All auxiliary equipment necessary for the operation of the device under test is usually treated as being part of the device under test and shall be located inside the test room; all additional equipment necessary only for the test should be located outside the test room.

7.3 Operation of source during tests

During the acoustical measurements, the source shall be operated in a specified manner typical of normal use. The governing condition of operation shall be that defined in a specific test code for the machine. If a specific test code does not exist, one or more of the following operating conditions may be appropriate :

a) device under normal load;

b) device under full load [if different from a)];

c) device under no load (idling);

d) device under operating condition corresponding to maximum sound generation;

e) device with simulated load operating under carefully defined conditions.

8 Measurement

8.1 Calibration and checking of measuring instruments

At least before each series of measurements, an acoustical calibrator with an accuracy of ± 0,5 dB shall be applied to the microphone to check the calibration of the entire measuring system, including cable, if any, at one or more frequencies over the frequency range of interest. At least one calibration frequency shall be in the range from 200 to 1 000 Hz. The calibrator shall be checked annually to verify that its output has not changed. In addition, an acoustical and an electrical calibration of the instrumentation system over the frequency range of interest shall be carried out at least every two years.

8.2 Measurement procedures

The equivalent continuous sound pressure level (A-weighted and in frequency bands) at each microphone position defined in this International Standard or in a specific test code for a particular type of machine shall be determined for each measurement time interval (see 8.3). If the sound pressure level varies over a range, particular care should be taken to ensure that the dynamic range of the instrumentation is sufficiently large, e.g. by using an integrating-averaging sound level meter which includes an overload indication.

8.2.1 Measurement with integrating systems

If true integration is used, then the integration time should be equal to the measurement time interval. If the measurement time interval is longer than the maximum integration time available on the instrument, sound pressure levels may be averaged on a mean-square basis to make the overall integration time equal to the measurement time interval.

8.2.2 Measurement with RC-smoothing (or with sound level meter)

Over a typical operational cycle of the source the sound pressure level can be

a) steady (see ISO 2204);

b) fluctuating (within a range of less than 5 dB using the time-weighting characteristic S);

c) fluctuating (within a range equal to or more than 5 dB using the time-weighting characteristic S).