INTERNATIONAL STANDARD

ISO 9612

First edition
1997-06-01

Acoustics — Guidelines for the measurement and assessment of exposure to noise in a working environment

Acoustique — Guide pour le mesurage et l'évaluation de l'exposition au bruit en milieu de travail

INTERNATIONAL ISO

Reference number
ISO 9612:1997(E)

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.

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 9612 was prepared by Technical Committee ISO/TC 43, *Acoustics*, Subcommittee SC 1, *Noise.*

Annexes A to E of this International Standard are for information only.

International Organization for Standardization
Case postale 56 • CH-1211 Genève 20 • Switzerland
Internet central@iso.ch
X.400 c=ch; a=400net; p=iso; o=isocs; s=central

Printed in Switzerland

Introduction

The uniform measurement, analysis and evaluation of noise at the workplace is important in order to assess the potential effects of noise on the health, well-being, safety and working efficiency of the worker. Although standards exist specifying the noise measurements at the operator positions and in the environment of specific equipment and other standards describing the effects of noise on specific human functions, the present International Standard provides general guidance for what type of measurements at which positions are required for evaluation of the noise with respect to its effects on the worker in order to monitor compliance with established documents and in order to indicate the need for reducing noise by abatement measures.

This page intentionally left blank

Acoustics — Guidelines for the measurement and assessment of exposure to noise in a working environment

1 Scope

This International Standard describes the determination of the acoustical quantities, especially the type and locations of sound pressure level measurements to be conducted, the time sampling and frequency analysis required and the special characteristics of the noise to be considered. The purpose is to allow an assessment of the noise in the working environment with respect to its various effects on the worker as a result of daily habitual exposure. This International Standard is intended to be used by appropriate authorities responsible for specifying and monitoring compliance with noise limits at the workplace and for deciding on the need for hearing conservation programmes and noise reduction measures. It does not by itself specify or recommend acceptable noise limits. The standard does not specify statistical sampling procedures to characterize the noise exposure of groups, although references to such procedures are included in the bibliography. The applications of the measurement results are described with respect to the effects of noise on hearing, interference with communication and other effects of noise. Special requirements for the description of infrasound and ultrasound exposure are included. Applications of the Standard to evaluate effects of the noise on health, working efficiency, well-being and the audibility of warning signals are summarized in Annex A. Annex B gives examples of equivalent continuous A-weighted sound pressure level calculations. Annex C discusses calculation of the rating level including tone and impulsive adjustment. Annex D specifies classes of accuracy for noise measurements. All the annexes are informative.

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 listed below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 266:1975, *Acoustics - Preferred frequencies for measurements*[1]

ISO 532:1975, *Acoustics - Method for calculating loudness level*

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

ISO 1999:1990, *Acoustics - Determination of occupational noise exposure and estimation of noise-induced hearing impairment*

ISO/TR 3352:1974, *Acoustics - Assessment of noise with respect to its effect on the intelligibility of speech*

ISO 3891:1978, *Acoustics - Procedure for describing aircraft noise heard on the ground*

ISO 4869-1:1990, *Acoustics - Hearing protectors - Part 1: Subjective method for the measurement of sound attenuation*

ISO 4869-2:1994, *Acoustics - Hearing protectors - Part 2: Estimation of effective A-weighted sound pressure levels when hearing protectors are worn*

ISO/TR 4870:1991, *Acoustics - The construction and calibration of speech intelligibility tests*

ISO 7196:1995, *Acoustics - Frequency weighting characteristic for infrasound measurements*

ISO 7731:1986, *Acoustics - Danger signals for work places - Auditory danger signals*

ISO 9921-1:1995, *Ergonomic assessment of speech communication - Part 1: Speech interference level and communication distances for persons with normal hearing capacity in direct communication (SIL method)*

IEC 651:1979, *Electroacoustics - Sound level meters*[1]
Amendment 1:1993

IEC 804:1985, *Electroacoustics - Integrating-averaging sound level meters*[1]
Amendment 1:1989. Amendment 2:1993

IEC 942:1988, *Electroacoustics - Sound calibrators*

IEC 1252:1993, *Electroacoustics - Specifications for personal sound exposure meters*

IEC 1260:1995, *Electroacoustics - Octave-band and fractional-octave-band filters*

3 Quantities and definitions

The following quantities are used in this International Standard. Instead of repeating the definitions of the quantities, reference is made to the relevant International Standards where the definitions are given.

[1] Under revision

Quantity	Symbol	Defined in
sound pressure level	L_p	ISO 1999
peak sound pressure level: level of the peak sound pressure	L_{peak}	IEC 651
A-weighted sound pressure level	L_{pA}	ISO 1999
C-weighted peak sound pressure level	L_{Cpeak}	IEC 651
equivalent continuous A-weighted sound pressure level over the duration T	$L_{Aeq,T}$	ISO 1999 ISO 9921-1 IEC 804
percentile level	$L_{AN,T}$	ISO 1996-1
octave-band sound pressure level		ISO 532
one-third-octave-band sound pressure level		ISO 532
time interval of 8 hours	T_0	
normalizing time interval: that time interval to which an equivalent continuous A-weighted sound pressure level is referred	T_N	
time interval of the daily duration of workers effective exposure to noise	T_e	
A-weighted sound exposure over duration T	$E_{A,T}$	ISO 1999
noise exposure level	$L_{EX,T}$	ISO 1999
noise-induced permanent threshold shift	NIPTS	ISO 1999
impulsive noise		ISO 12001
rating level	L_{Ar}	ISO 1996-1
speech interference level	SIL	ISO 9921-1 ISO/TR 3352
loudness level	L_N	ISO 226
perceived noise level	L_{PN}	ISO 3891

4 Measurements of noise in the working environment

4.1 General

This clause describes the procedure for measuring the sound pressure level at the work station. This procedure includes the use of instrumentation (4.2) and microphone location, measurement time interval and the determination of several noise quantities especially the equivalent continuous A-weighted sound pressure level (4.3.4), the normalized equivalent continuous A-weighted sound pressure level (4.3.5), the daily noise exposure (4.3.6) and rating level (4.3.10 and Annex C). A method to determine the equivalent continuous A-weighted sound pressure level and its uncertainty

by sampling technique is presented in Annex D.1. For the purpose of determining compliance with prescribed noise limits and assessment of the uncertainty of measurement (Annex D.2), for comparing the result to a limit (Annex D.3) and for contents of the measurement report (Annex D.4), guidance is provided in annexes.

4.2 Instrumentation

4.2.1 Sound level meter

Sound level meters shall comply at least with the requirements for a type 2 instrument given in IEC 651. Type 1 sound level meters are preferred.

Personal sound exposure meters shall comply with IEC 1252. To indicate if the instrument is being overloaded by the peak sound pressure, instruments incorporating an overload indication are preferred.

Integrating-averaging sound level meters shall comply at least with the requirements for a type 2 instrument given in IEC 804.

4.2.2 Octave and one-third octave-band filters

Octave and one-third octave band filters shall comply with the requirements given in IEC 1260. The nominal centre frequencies of the frequency bands shall correspond to those of ISO 266.

4.2.3 Auxiliary measuring devices

A level recorder used for registration of the level shall comply with the relevant clauses of IEC 651, e.g. the requirements on time weighting.

A statistical analyzer for the measurement of the percentile level shall comply with the time weighting F of IEC 651. The level intervals for the classification shall be chosen in relation to the overall range of noise levels but they shall not exceed 5 dB.

Tape recorders or other devices to store noise signals shall be such that the overall measuring equipment at least complies with the specifications for a type 2 instrument in IEC 651 and IEC 804.

Sound calibrators used for calibrating and checking the sound measuring equipment shall comply with class 2 specifications or better as given in IEC 942.

4.2.4 Calibration and checking

A recalibration for compliance with IEC 651, IEC 804 or IEC 1252 shall be performed regularly. It is recommended that the time intervals for the recalibration do not exceed three years.

A field check shall be made by the user at least before and after each series of measurements. Electrical check of amplifiers, recorders and indicators shall be made as well as an acoustic check of the whole system including the microphone (e.g., by applying a sound calibrator). The acoustical check should be made on site wherever possible. The precision of measurement should be determined (see Annex D).

4.3 Measurements

4.3.1 General

The preferred basic measurement quantities are the equivalent continuous A-weighted sound pressure level ($L_{Aeq,T}$) and the A-weighted sound exposure ($E_{A,T}$) during a stated time interval, T.

Depending on the type of noise and the type of effect to be evaluated, additional measurement quantities such as the maximum instantaneous sound pressure level unweigthed L_{peak}, A-weighted L_{Apeak}, C-weighted L_{Cpeak} or other quantities, may be measured.

In some cases, measurement of octave or one-third-octave-band levels of audible, infra - or ultrasound may be indicated. If communication capability is required speech interference level (SIL), signal to noise ratio (S/N) or other measures may be needed.

Depending on the purpose, the measurement may be made at fixed location(s) or on person(s) during work. For high accuracy the on-person method (microphone following the exposed person) may be preferred.

The exposure to noise at the working place comprises the noises produced there and the noises arriving from other sources in the environment.

If some time intervals are excluded from the measurement, e.g. for assessments with respect to some effects such as annoyance or well-being, this must be stated in the test report. Possible exclusions are time intervals with:

- sounds produced at the specific working place by the person at this place speaking to other persons;

- noises consisting of communication signals addressed to the specific working place (e.g. telephone, public address system).

The measurement shall provide quantitative description of the characteristic potential exposure to noise at the working place. Characteristic potential exposure to noise is given, if the number of occurrences, the type and origin of the noises at the working station are typical for the working place on a long-term basis. To support this statement, suitable information may be collected or a sufficient number of independent measurements (samples) be performed.

If the exposure to noise is determined for a well-defined working location, the measurement is performed at this specific location. If the person occupies more than one working place, the equivalent continuous A-weighted sound pressure level or the A-weighted sound exposure may be determined either separately for the different working locations or for the person occupying these working locations, each for one period of time allowing determination of this person's cumulative exposure during the workshift.

4.3.2 Microphone locations and measurement positions

Preferably the microphone location shall be the position of the head of the person occupying the working place under consideration without the person present.

In other cases, when the person has to be in this working place, the microphone should be located, when practicable, approximately 0,10 m from the entrance of the external canal of the ear receiving the higher value of the equivalent continuous A-weighted sound pressure level. The microphone of sound exposure meters and sound level meters worn on a person shall be mounted on the helmet or on the shoulder or collar at a distance approximately between 0,1 m to 0,3 m from the entrance of the external canal of the ear.

NOTES

1 To support the microphone, a helmet or frame may be used.

2 A shoulder location should be used for the microphone, when convenient.

If the measuring instrument or parts of it are worn on the worker, care shall be taken not to disturb the performance of the person and especially not to introduce safety risks. Similarly, care should be taken to avoid misuse of the instrument during measurements.

If the head position at a working location is not well defined or otherwise stated by the appropriate authorities, the following microphone heights shall be used (see ISO 11201):

for standing persons	1,55 m ± 0,075 m above the ground on which the person is standing;
for seated persons	0,91 m ± 0,05 m above the middle of the seat plane with the seat set at or as near as possible to the midpoint of its horizontal and vertical adjustment.

For measurement positions at a specific location the reference direction of the microphone shall be in accordance with the manufacturer's instruction. (If possible, the microphone should point in the direction of sight of the person occupying this working place).

If the worker's locations are very close to the noise sources, the microphone location and direction shall be precisely stated in the test report.

NOTES

3 Near the sound source even small changes of the microphone location may result in variations of the sound pressure level. If tones are clearly audible at the working place (see Annex B), standing sound waves may occur. To determine the local variations of the sound pressure level, the microphone should be moved over a range of 0,10 m to 0,50 m. The variations of the sound level observed during the movement of the microphone are treated as time varying levels and averaged accordingly.

4 If the microphone must be located very close to a person's body, appropriate (sometimes elaborative) adjustments must be made by comparing results obtained with and without the person present. This applies particularly for noises with strong components at high frequencies and for small sources at a short distance. Normally values measured with the person present are higher than those without a person present.

5 Care must be taken when using a personal sound level meter with the microphone not located near the ear.

6 Special measurement procedures are required for the measurement of noise exposure under earphones (e.g. for secretaries, telephonists, pilots, aircontrollers) or under helmets (e.g. flying and motorcycle helmets); these methods are not described in this International Standard.

To reduce the measurement time in areas with a large number of working places the following procedure may be used:

Zones of working places with equal exposure to sound are defined and the measurement is performed at a sample of typical working places. The average of the measurement results at these

locations is taken as representative for all working places of that zone. Such a grouping is only permissible if the levels $L_{Aeq,T}$ determined at different places differ by not more than 5 dB. In addition, compliance with noise limits shall be checked at all working places in case of doubt. For some work areas, it may be more appropriate to define zones in terms of equal levels, $L_{Aeq,T}$.

Working places with equal noise exposure may be:

- working places with workers with equal activity;

- working places where the noise exposure is essentially determined by noise sources at a large distance from the working places (e.g. more than 5 m to 20 m in factory halls).

NOTE 7 - At a distance from the noise source (about 5 m to 20 m) the level decreases by about 2 dB to 4 dB per doubling of the distance from the sound source in normal factory halls with low sound absorption.

In factory halls with high sound absorption the level decrease per doubling of the distance may amount to about 4 dB to 6 dB.

4.3.3 Measurement time

4.3.3.1 The normalizing/reference time interval, T_N, is that time interval representing the duration of one workshift (conventionally 8 hours (T_o)), over which a continuous A-weighted sound pressure level is determined.

The measurement time interval, T, is that time interval over which the squared A-weighted sound pressure is integrated and averaged.

NOTE 8 - The time and day of the measurement and the duration of measurement should be reported.

The measurement time intervals shall be chosen so that all significant variations of noise levels at the working place are measured and included. Further, the choice of the measurement time intervals shall be such that the measurement result is consistent with repetition.

During the measurement time interval, sound which is characteristic of the specific working place must exist (see 4.3.1). Two procedures may be used to acquire the characteristic noise exposure:

$T = T_N$: If the measurement time interval is extended over the normalizing/reference time interval, the total exposure to noise of the workshift to be rated may be determined directly.

$T < T_N$: If a measurement time interval is less than the normalizing/reference time interval, the characteristic noise exposure being measured may be selected by experience.

4.3.3.2 If the measurement is extended over a shorter time interval only ($T < T_N$), the measurement time interval or the sample must be chosen such that the noise exposure is determined which is characteristic of the working place and is representative for the normalizing time interval. It may be possible by questionnaire/collection of information regarding the typical noise sources (e.g. working processes, machines, activities at the working place and in its environment) to determine their time fraction of the workshift and contributed average level for each part time interval (see Annex B).

The measurement time interval depends on the type of noise exposure. It may be subdivided into part time intervals within which the exposure to noise is of the same type, e.g. corresponding to the different activities at the working place or in its environment.

The selected measurement duration shall depend on fluctuations of the noise. It shall be sufficiently long for the resulting noise exposure level to be representative of the activities performed by the employee. The duration shall be either the entire length of an activity, a portion thereof, or several repetitions of the activity, as required to stabilize the readings of the sound exposure level or the equivalent continuous A-weighted sound pressure level within 0,5 dB.

The minimum duration shall be 15 s. If the noise shows a pronounced periodicity, the minimum duration should be at least one cycle; otherwise a multiple of complete cycles shall be used.

The sampling procedure may be extended to several workshifts and averaged (see Annex D).

4.3.4 Determination of equivalent continuous A-weighted sound pressure level

The preferred method of measurement is to use an integrating-averaging sound level meter to measure the equivalent continuous A-weighted sound pressure level, $L_{Aeq,T}$, during the stated time interval.

If a sound level meter is used, and if the noise is such that the fluctuations in level are small (see the note), the arithmetic average of the indicated reading of the meter (or recorder) is approximately equal to the equivalent continuous A-weighted sound pressure level.

NOTE 9 - The noise may be deemed to have small fluctuations if the total meter excursion lies within a range of 5 dB with time weighting S.

If the measurement time interval T is subdivided into smaller intervals T_i, the equivalent continuous A-weighted sound pressure level is calculated by using the formula:

$$L_{Aeq,T} = 10 \lg \left(\frac{1}{T} \sum_{i=1}^{m} T_i \cdot 10^{L_{Aeq,Ti}/10} \right) \quad \text{dB}$$

where:

$L_{Aeq,Ti}$ is the equivalent continuous A-weighted sound pressure level occurring over the time interval T_i;

T is equal to $\sum_{i=1}^{m} T_i$;

m is the total number of sub-intervals of time.

4.3.5 Normalization of equivalent continuous A-weighted sound pressure level to a nominal 8 h working day

In order to compare noise exposures from workdays of different durations it is desirable, for many purposes, to normalize daily occupational noise exposure of shorter or longer duration, T_e, to a nominal 8 hour work day. In this International Standard, the time interval over the 8 hour period is called T_0. The normalized daily noise exposure level is obtained by using the formula: