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Akustika - Določanje izpostavljenosti hrupu v delovnem okolju - Metodologija (ISO/DIS 9612:2023)

Acoustics - Determination of occupational noise exposure - Methodology (ISO/DIS 9612:2023)

Akustik - Bestimmung der Lärmexposition am Arbeitsplatz - Verfahren der Genauigkeitsklasse 2 (Ingenieurverfahren) (ISO/DIS 9612:2023)

Acoustique Détermination de l'exposition au bruit en milieu de travail - Méthodologie (ISO/DIS 9612:2023)

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13.140	Vpliv hrupa na ljudi	Noise with respect to human beings

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Acoustics — Determination of occupational noise exposure — Methodology

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ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Email: copyright@iso.org
Website: www.iso.org

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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.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

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

This second edition cancels and replaces the first edition (ISO 9612:2009), which has been technically revised.

The main changes compared to the previous edition are as follows:

— A reshaping of the guidance on measurement of $L_{p,\mathrm{A,eq}T,m}$ for the task based strategy (9.3)

— A revision of the measurement plan for the job-based strategy (10.2)

— The addition of HEG sampling requirements for the full day measurement strategy(11.2),

— Some precisions and clarifications on the instrumentation section,

— Some additions to the test report section: number of peak events, $L_{\mathrm{EX,8h,95\ \%}}$ …

— The addition of clause 7 in Annex C, which gives the formulae to calculate the measurement uncertainty when multiple nominal days are used. Clause 8 is also introduced to clarify uncertainty of peak measurements,

— The introduction of a new Annex G: *Example calculation of daily noise exposure level for flexible workers.*

— A full revision of the Excel calculation file attached to the standard

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

This document provides a stepwise approach to the determination of occupational noise exposure from noise level measurements. The procedure contains the following major steps: work analysis, selection of measurement strategy, measurements, error handling and uncertainty evaluations, calculations, and presentation of results. This document specifies three different measurement strategies: task-based measurement; job-based measurement; and full-day measurement. This document gives guidance on selecting an appropriate measurement strategy for a particular work situation and purpose of investigation. This document also provides an informative spreadsheet to allow calculation of measurement results and uncertainties. ISO is not responsible for errors that may arise or occur with the use of this spreadsheet.

This document recognizes the use of hand-held sound level meters as well as personal sound exposure meters. The methods specified optimize the effort required for obtaining a given accuracy.

Acoustics — Determination of occupational noise exposure — Methodology

1 Scope

This document specifies a method for measuring workers' exposure to noise in a working environment and calculating the noise exposure level. This document deals with Aweighted levels but is applicable also to C-weighted levels. Three different strategies for measurement are specified. The method is useful where a determination of noise exposure to engineering grade is required, e.g. for detailed noise exposure studies or epidemiological studies of hearing damage or other adverse effects.

The measuring process requires observation and analysis of the noise exposure conditions so that the quality of the measurements can be controlled. This document provides methods for estimating the uncertainty of the results.

This document is not intended for assessment of masking of oral communication or assessment of infrasound, ultrasound and non-auditory effects of noise. It does not apply to the measurement of the noise exposure of the ear when hearing protectors are worn.

Results of the measurements performed in accordance with this document can provide useful information when defining priorities for noise control measures.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 1999:1990, *Acoustics — Estimation of noise-induced hearing loss*

ISO/IEC Guide 98-3, *Uncertainty of measurement — Part 3: Guide to the expression of uncertainty in measurement (GUM:1995)*

IEC 60942:2017, *Electroacoustics — Sound calibrators*

IEC 61252:2017, *Electroacoustics — Specifications for personal sound exposure meters*

IEC 61672-1:2013, *Electroacoustics — Sound level meters — Part 1: Specifications*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1
A-weighted time-averaged sound pressure level
$L_{p,\text{A},T}$
A-weighted equivalent continuous sound pressure level
$L_{p,\text{A,eq}T}$
ten times the logarithm to the base 10 of the ratio of the time average of the square of the A-weighted sound pressure, p_A, during a stated time interval of duration T (starting at t_1 and ending at t_2), to the square of a reference value, p_0, expressed in decibels

$$L_{p,\text{A},T} = L_{p,\text{A,eq},T} = 10\ \lg\left[\frac{\frac{1}{T}\int_{t_1}^{t_2} p_A^2(t)dt}{p_0^2}\right] \text{dB} \quad (1)$$

where the reference sound pressure, p_0, is 20 µPa

Note 1 to entry: Adapted from ISO/TR 25417:2007[9].

3.2
A-weighted noise exposure level normalized to an 8 h work day
daily noise exposure level
$L_{\text{EX,8h}}$
<occupational noise> level, in decibels, given by the formula:

$$L_{\text{EX,8h}} = L_{p,\text{A,eq}T_e} + 10\ \lg\left[\frac{T_e}{T_0}\right] \text{dB} \quad (2)$$

where

$L_{p,\text{A,eq}T_\text{e}}$	is the A-weighted equivalent continuous sound pressure level for T_e;
T_e	is the effective duration, in hours, of the working day;
T_0	is the reference duration, t_0 = 8 h.

Note 1 to entry: If the effective duration of the working day, T_e, is equal to 8 h, then $L_{\text{EX,8h}}$ equals $L_{p,\text{A,eq,8h}}$.

Note 2 to entry: If the average or normalized exposure over a number of days is expired, Formula (3) can be used

$$\bar{L}_{\text{EX,8h}} = 10\ \lg\left[\frac{1}{x}\sum_{x=1}^{X} 10^{0,1 \cdot L_{\text{EX,8h},x}}\right] \text{dB} \quad (3)$$

where $L_{\text{EX,8h},x}$ is the daily noise exposure level for day x.

The value of X is chosen according to the purpose of the averaging process. For example, X = 5 leads to a daily noise exposure level normalized to a nominal week of five 8 h working days.

Note 3 to entry: This definition differs from that given in ISO/TR 25417:2007[9].

3.3
nominal day
working day over which it is chosen to determine the noise exposure

Note 1 to entry: The nominal day is determined from the work analysis and depends on the purpose of the measurements. For example, it may be a typical day representing the work performed over several days or the day with the highest noise exposure. See also 7.3.

Note 2 to entry: The noise exposure level is normally calculated on a daily basis, but there may be circumstances where the use of weekly or longer noise exposure periods is considered appropriate.

Note 3 to entry: The nominal day can be a synthesized working day that may include fragments of different real working days of a week or of several consecutive weeks.

3.4
C-weighted peak sound pressure level
$L_{p,\mathrm{Cpeak}}$
ten times the logarithm to the base 10 of the ratio of the square of the C-weighted peak sound pressure, p,Cpeak , to the square of a reference value, p_0 , expressed in decibels

$$L_{p,\mathrm{Cpeak}} = 10 \lg \frac{p_{\mathrm{Cpeak}}^2}{p_0^2} \text{ dB} \tag{4}$$

where the reference sound pressure, p_0 is 20 µPa

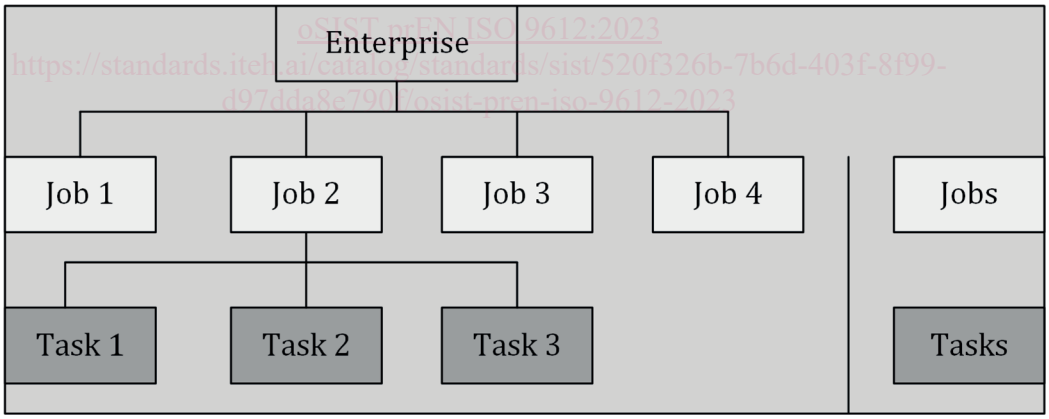
3.5
task
<occupational noise> distinct part of a worker´s occupational activity

Note 1 to entry: Figure 1 illustrates the hierarchy of jobs and tasks.

3.6
job
<occupational noise> overall occupational activity that is carried out by a worker, consisting of all the tasks performed by the worker during the entire working day or shift

Note 1 to entry: A worker often has a job title that describes his or her job, sometimes complemented with an additional description to ensure clear identification, e.g. "welder - process line A".

Note 2 to entry: Figure 1 illustrates the hierarchy of jobs and tasks.



Key

Job 1	scaffolders	Task 1	planning
Job 2	welders	Task 2	grinding
Job 3	painters	Task 3	welding
Job 4	store keepers		

Figure 1 — An example illustrating the hierarchy of jobs and tasks

4 Symbols

Symbol	Description	Unit
c_i	sensitivity coefficient related to each input quantity	

Symbol	Description	Unit
c_1	sensitivity coefficient associated with job noise level sampling	
$c_{1a,m}$	sensitivity coefficient associated with noise level sampling of task m	
$c_{1b,m}$	sensitivity coefficient associated with estimation of duration of task m	dB h^{-1}
c_2	sensitivity coefficient associated with measurement instrumentation	
c_3	sensitivity coefficient associated with microphone position	
i	task sample number	
I	the total number of task samples	
j	number of observations of task duration	
J	total number of observations of task duration	
k	coverage factor related to a confidence interval	
K_N	denominator as given in C.3.3, Note 2	
$L_{EX,8h}$	A-weighted noise exposure level normalized to a nominal 8 h working day	dB
$\bar{L}_{EX,8h}$	A-weighted noise exposure level normalized to a nominal 8 h working day averaged over a number of days	dB
$L_{EX,8h,95\,\%}$	A-weighted noise exposure level including its associated uncertainty - one sided 95 % confidence interval limit NOTE Statistically, assuming a normal distribution of the noise exposure, 95 % of the workers are exposed at or below this level	S
$L_{EX,8h,m}$	A-weighted noise exposure level of task m contributing to the daily noise exposure level	dB
$L^*_{p,A,eqT,m}$	estimate of the true A-weighted equivalent continuous sound pressure level for task m	dB
$L_{p,A,T} = L_{p,A,eqT}$	A-weighted equivalent continuous sound pressure level over a period T	dB
$L_{p,A,eqT,m}$	A-weighted equivalent continuous sound pressure level for task m	dB
$\bar{L}_{p,A,eqT,m}$	arithmetic average of a number of samples of the A-weighted equivalent continuous sound pressure levels for task m	dB
$L_{p,A,eqT,n}$	A-weighted equivalent continuous sound pressure level of job sample n	dB
$L_{p,A,eqTe}$	A-weighted equivalent continuous sound pressure level for the effective duration of the working day	dB
$L_{p,Cpeak}$	C-weighted peak sound pressure level	dB
m	task number	
M	total number of tasks	
n	job sample numbers	
N	total number of job samples	
n_G	number of workers in a homogenous exposure group	
p_0	reference value; $p_0 = 2 \times 10^{-5}$ Pa	Pa
p_A	A-weighted sound pressure	Pa
pCpeak	C-weighted peak sound pressure	Pa
Q_2	correction for measurement instrumentation	dB
Q_3	correction for microphone position	dB
T	time period over which an average is taken	h
T_0	reference duration; $T_0 = 8$ h	h
T_e	effective duration of the working day	h
T_m	duration of task m	h

Symbol	Description	Unit
$T_{m,j}$	duration of sample j of task m	h
T_n	duration of job sample n	h
U	expanded uncertainty	dB
u	combined standard uncertainty	dB
u_i	standard uncertainty of each input quantity	dB
u_1	standard uncertainty of the energy average of a number of measurements of A-weighted equivalent continuous sound pressure level	dB
u_1^*	estimated standard uncertainty of a number of measurements of A-weighted equivalent continuous sound pressure level	dB
$u_{1a,m}$	standard uncertainty due to noise level sampling of task m	dB
$u_{1b,m}$	standard uncertainty due to the estimation of duration of task m	h
u_2	standard uncertainty due to the instrumentation	dB
$u_{2,m}$	standard uncertainty due to the instrumentation in the task method	dB
u_3	standard uncertainty due to microphone position	dB
$\overline{U}$	expanded uncertainty for multiple nominal day	dB
x	day number	
X	total number of days	

5 Instrumentation

5.1 Sound level meters and personal sound exposure meters

Measurements can be made by using either integrating-averaging sound level meters or personal sound exposure meters.

Sound level meters, including the microphone and associated cables, shall meet the requirements for IEC 61672-1:2013, class 1 or class 2 instrumentation. Class 1 instrumentation is preferred and should be used when measuring at very low temperatures or when the noise is dominated by high frequencies (see also NOTES 3 and 5).

Personal sound exposure meters, including the microphone and cable, shall meet the requirements specified in IEC 61252:2017. Personal sound exposure meters also fulfilling the requirements of IEC 61672-1:2013, class 1, are recommended when measuring at very low temperatures or when the noise is dominated by high frequencies (see also NOTES 3 and 5).

NOTE 1 Personal sound exposure meter is often referred to as "noise dose meter" or "noise dosimeter" (North America).

NOTE 2 For IEC 61672-1:2013, class 1 instruments, the specified tolerance limits are applied for the temperature range from -10 °C to +50 °C. For instrumentation in accordance with IEC 61672-1:2013, class 2, and for personal sound exposure meters in accordance with IEC 61252:2017, the influence of variations in the air temperature on the measured signal level is specified over the range from 0 °C to +40 °C. In order to maintain accuracy when performing measurements outside this temperature range, it can be necessary to use an instrument for which the manufacturer specifies compliance for a wider temperature range. Alternatively, a sound level meter in accordance with IEC 61672-1:2013, class 1, can be selected. In cold conditions, the measuring instrument can be kept warm, e.g. under clothing, such that only the microphone is exposed to low temperatures.

NOTE 3 The choice of the instrumentation influences the uncertainty of the measurements.

NOTE 4 For personal sound exposure meters, IEC 61252 allows wide tolerances in the frequency characteristics above 4 000 Hz, which can lead to incorrect measurement of high frequency sound such as that from air nozzles. In order to reduce the uncertainty when measuring noise dominated by high frequencies, it can be necessary to use a measuring instrument for which the manufacturer specifies high frequency characteristics within a narrower tolerance range. Alternatively, a sound level meter specified in accordance with IEC 61672-1:2013, class 1 or 2, can be selected in the following way: Due to the tolerances defined in IEC 61672-1:2013, class 2 sound level meters can be appropriate for measurements up to 8 kHz. Measurements up to 16 kHz can only be performed by using a sound level meter meeting the requirements of class 1. Assessment of airborne sound beyond 16 kHz can produce unreliable results even when using class 1 sound level meters (see also scope of the standard).

Personal sound exposure meters can have a cut-off level at around 70 dB. This may influence the value of the measured noise exposure, but only at low exposure levels.

5.2 Calibrator

For class 1 sound level meters, the sound calibrator shall conform to class 1 specifications of IEC 60942. For class 2 sound level meters, the sound calibrator shall conform to either class 1 or class 2 specifications of IEC 60942.

5.3 Periodic verification

The calibration of the sound calibrator and the compliance of the instrumentation system with the requirements of IEC 61672-1, IEC 61252 and other relevant standards shall be verified at intervals in a laboratory making calibrations traceable to appropriate standards.

Unless national regulations dictate otherwise, it is recommended that the sound calibrator and the compliance of the instrumentation system with the requirements of IEC 61672-1 be verified at intervals not exceeding 2 years.

The date for the last periodic verification and the name of the laboratory that performed it shall be recorded and given in the measurement report.

6 Methodology – Chronological steps

6.1 Step 1: Work analysis

The work analysis shall provide sufficient information about the work and the workers under consideration so that an appropriate measurement strategy can be selected and measurements can be planned. Work analysis shall be carried out in accordance with Clause 7.

6.2 Step 2: Selection of the measurement strategy

A measurement strategy shall be selected from task-based measurement, job-based measurement and full-day measurement as specified in Clause 8. More than one measurement strategy may be used, if relevant (see Clause B.6).

6.3 Step 3: Measurements

The basic measurement quantity shall be $L_{p,\mathrm{A,eq}T}$. In addition, $L_{p,\mathrm{Cpeak}}$ shall be measured, if relevant.

The measurements shall follow the chosen strategy as specified in one of Clauses 9, 10 or 11 and comply with the requirements of Clause 12.

6.4 Step 4: Error handling and uncertainties

Sources of errors and uncertainties that may influence the result shall be evaluated in accordance with Clauses 13 and 14.

6.5 Step 5: Calculation and presentation of results and uncertainty

Calculate $L_{EX,8h}$ as specified for the selected strategy (see Clauses 9, 10, and 11) and the uncertainty as specified in Annex C. The results and uncertainties can be calculated by using the spreadsheet in https://standards.iso.org/iso/9612/ed-3/en.

The results shall be presented as specified in Clause 15. Annexes D, E, and F provide practical examples for the task-based, job-based, and full-day measurements, respectively.

7 Work analysis

7.1 Introduction

Work analysis is required in all situations. It shall provide the information necessary to:

a) describe the activities of the enterprise and the jobs of the workers under consideration;

b) define homogeneous noise exposure groups (see 7.2), if relevant;

c) determine a nominal day or days for each worker or group;

d) identify tasks which make up the jobs, if relevant;

e) identify possible significant noise events;

f) choose the measurement strategy;

g) establish the measurement plan.

The work shall be analysed with emphasis put on production, process, organization, workers and activities.

The measurements may be performed by using the task-based, job-based or full-day strategy. Whichever strategy is used, it is essential to identify all events which are significant with regard to noise exposure and to make sure that the measurement plan takes them into account. See Annex A for an example of a checklist.

NOTE The order in which the items above are performed can depend on the complexity of the situation on site. The items are strongly connected, and the process can therefore be iterative in complex situations, i.e. increased knowledge about one of the items can result in a new description or redefinition of others.

7.2 Defining homogeneous noise exposure groups (HEG)

Measurement efforts can be reduced by defining homogeneous noise exposure groups. These are groups of workers that are performing the same job and are expected to have similar noise exposures during the working day. If used, the homogeneous noise exposure group shall be clearly identified and can consist of one or more workers.

NOTE The term "similar exposure group" is sometimes used instead of "homogenous exposure group".

Homogeneous noise exposure groups can be defined in a number of ways. For example, it may be possible to define such groups according to job title, function, work area or profession. Alternatively, the groups can be defined by analysing the work according to production, process or work activity criteria.

In whichever way the groups are defined, they should be verified in consultation with the workers and supervisor, and ultimately by evaluating the measurement results, see 10.4.