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Ergonomics — Accessible design — Sound pressure levels of auditory signals for consumer products

Ergonomie — Conception accessible — Niveaux de pression acoustique des signaux auditifs pour produits de consommation courante

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ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.org
Web 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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. 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 document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 24501 was prepared by Technical Committee ISO/TC 159, *Ergonomics*, Subcommittee SC 5, *Ergonomics of the physical environment.*

Introduction

People conduct their daily lives surrounded by various consumer products. Consumer products, as defined in ISO 20282-1, include home electrical appliances, information and telecommunication products, gas-heating equipment, toys, sanitary equipment, and health-care products, many of which use auditory signals. These auditory signals can be indistinct because of the hearing loss which occurs with ageing or because of interfering sounds in the surroundings. Also, with age, our visual ability declines gradually. Auditory signals with an appropriate sound level can assist product users with auditory or visual impairment in using the product correctly and safely.

This International Standard specifies methods for determining an appropriate sound level range of auditory signals, so that all product users, including people with age-related hearing loss, can hear them properly against interfering sounds. This sound level range specification was determined, based on results of experiments in which people of all ages participated. Auditory signals whose sound pressure level is in that range are expected to be audible and comfortably loud for most users in the presence of interfering sounds.

This International Standard should be applied as appropriate to products, depending on the product type and its conditions of use. It does not apply to machines and equipment used for professional work.

This International Standard adopts the principles of accessible design given in ISO/IEC Guide 71 and amplified in ISO/TR 22411.

Ergonomics — Accessible design — Sound pressure levels of auditory signals for consumer products

1 Scope

This International Standard specifies methods for determining the sound pressure level range of auditory signals so that the users of consumer products, including people with age-related hearing loss, can hear the signal properly in the presence of interfering sounds.

Auditory signals, in this International Standard, refer to sounds with a fixed frequency (also called beep sounds) and do not include variable frequency sounds, melodic sounds, or voice guides.

This International Standard is applicable to auditory signals which are heard at an approximate maximum distance of 4 m from the product, as long as no physical barrier exists between the product and the user. It is not applicable to auditory signals heard through a head receiver or earphones, or to those heard with the ear located very near to the sound source because of the interference of the head with sound propagation.

This International Standard does not specify the sound pressure level of auditory signals regulated by other statutes, such as those for fire alarms, gas leakages and crime prevention, nor does it specify auditory signals particular to a communication tool such as telephones.

This International Standard does not specify auditory danger signals for public or work areas which are covered in ISO 7731, ISO 8201, and ISO 11429.

2 Normative references

The following referenced standards are indispensable for the application of this document. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 24500:2010, *Ergonomics — Accessible design — Auditory signals for consumer products*

IEC 60050-801, *International electrotechnical vocabulary — Chapter 801: Acoustics and electroacoustics*

IEC 61260, *Electroacoustics — Octave-band and fractional-octave-band filters*

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

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 24500 and IEC 60050-801 and the following apply.

3.1
product actuation sound
sound generated by actuation of the consumer product which incorporates the auditory signal to be designed

EXAMPLE A cooling-fan noise.

3.2
living environment sound
sound generated in the room where the consumer product which incorporates the auditory signal to be designed is used

NOTE This includes a sound generated by user behaviour (e.g. sound of water generated when washing dishes in a kitchen) or an actuation sound of some other product incorporating the auditory signal to be designed (e.g. actuation sound of a vacuum cleaner).

3.3
interfering sound
product actuation sound or living environment sound which is likely to have the greatest effect on audibility of the auditory signal to be designed

3.4
ambient noise
sound other than the sound to be measured as an auditory signal or as an interfering sound at the measurement location

EXAMPLE Outside traffic noise.

4 Symbols

For the purposes of this document, the following symbols apply.

$L_{S,A}$ A-weighted sound pressure level of an auditory signal, in decibels, measured using the method specified in Annex A.

$L_{N,A}$ A-weighted sound pressure level of interfering sound, in decibels, measured using the method specified in Annex B.

$L_{S,oct}$ level of the frequency band, in decibels, which has the maximum value among octave-band sound pressure levels of auditory signals, measured using the method specified in Annex A.

$L_{N,oct}$ octave-band sound pressure level, in decibels, of interfering sound at the same frequency band as $L_{S,oct}$, measured using the method specified in Annex B.

$L_{S,1/3oct}$ level of the frequency band, in decibels, which has the maximum value among one-third-octave-band sound pressure levels of auditory signals, measured using the method specified in Annex A.

$L_{N,1/3oct}$ one-third-octave-band sound pressure level, in decibels, of interfering sound at the same frequency band as $L_{S,1/3oct}$, measured using the method specified in Annex B.

5 Range of sound pressure levels of auditory signals

5.1 General

The range of sound pressure levels of auditory signals shall be determined following the procedure in 5.2 or 5.3, depending on whether the masking effect of interfering sound is taken into consideration or not.

When an auditory signal with a fixed sound level is used, the level shall be selected to fall in the range specified by application of the method. When the sound level is controllable by the user, the level shall be variable to cover the entire range.

NOTE It is important for designers to consider the implication of adjustable volume controls with respect to caution signals, if the adjustable range extends below the lower end specified by application of the method. An example of the record of measurement conditions and results is shown in Annex C. Some examples of measurement and range setting of the sound pressure level of auditory signals are shown in Annex D.

5.2 When not considering the masking effect of an interfering sound

5.2.1 General

For a case in which the masking effect of interfering sound can be ignored because its level is very low, only the users' hearing-ability change which occurs with ageing is considered for setting the range of the sound pressure level of the auditory signal.

The range of the sound pressure level shall be determined in accordance with either method using octave-band analysis or one-third-octave-band analysis, both of which are described in 5.2.2. For the methods for measuring the sound pressure level using octave-band analysis and one-third-octave-band analysis, see Annex A.

NOTE The method using one-third-octave-band analysis provides a more accurate range of sound pressure levels because the auditory signal is analysed more precisely with a narrower frequency bandwidth.

5.2.2 Method using octave-band analysis or one-third-octave-band analysis

The range of the sound pressure level of the auditory signal determined using octave-band analysis or one-third-octave-band analysis shall be as described below.

a) Lower end of $L_{S,oct}$ or $L_{S,1/3oct}$

The lower end of $L_{S,oct}$ or $L_{S,1/3oct}$ shall be determined as follows.

1) The lower end of $L_{S,oct}$ and $L_{S,1/3oct}$ shall be as given in Tables 1 and 2, respectively.

Table 1 — Lower end of $L_{S,oct}$

Centre frequency of band Hz	250	500	1 000	2 000	4 000 [b]
Sound pressure level dB	30 [a]	25	25	35	60

[a] The value of this frequency band is applied only to extremely quiet conditions.

[b] The fundamental frequency of the auditory signal should not be higher than 2 500 Hz (see ISO 24500). The values of those frequency bands are for auditory signals of specific products only (e.g. very small products in which only a tiny, high-frequency sound device can be implemented).

Table 2 — Lower end of $L_{S,1/3oct}$

Centre frequency of band Hz	250 to 315	400 to 1 250	1 600	2 000	2 500	3 150 [b]	4 000 [b]
Sound pressure level dB	30 [a]	25	30	35	40	50	60

[a] The value of this frequency band is applied only to extremely quiet conditions.

[b] The fundamental frequency of the auditory signal should not be higher than 2 500 Hz (see ISO 24500). The values of those frequency bands are for auditory signals of specific products only (e.g. very small products in which only a tiny, high-frequency sound device can be implemented).

2) Make the lower-end level higher than the value specified in 1) by 5 dB, to ensure signal perception in the case of reception and start signals, starting position signals, end signals (case of hearing at a position distant from the product), and strong caution signals with repeat counts of fewer than five times, in accordance with the classification of auditory signals specified in Clause 5 of ISO 24500:2010.

b) Upper end of $L_{S,oct}$ or $L_{S,1/3oct}$

The upper end of $L_{S,oct}$ or $L_{S,1/3oct}$ shall be determined as follows.

i) The upper end shall be 70 dB for auditory signals with a frequency of 2 500 Hz or lower.

ii) Make the upper-end level higher than the value specified in i) by 5 dB, to ensure signal perception in the case of end signals (case of hearing at a position distant from the product) and strong caution signals in accordance with the classification of auditory signals specified in Clause 5 of ISO 24500:2010.

5.3 When taking the masking effect of interfering sound into consideration

For a case in which the masking effect of assumed interfering sound in the environment for use of the product and the users' hearing-ability change with ageing are considered, the range of the sound pressure level of the auditory signal shall be determined so that any of the methods in 5.3.1 to 5.3.3 is met. For the procedures of octave-band analysis and one-third-octave-band analysis, see Annexes A and B.

The method in 5.3.1 provides a less accurate range of sound pressure levels than the methods in 5.3.2 and 5.3.3 and should be used only when the latter two are not available.

The method in 5.3.3 provides a more accurate range of sound pressure levels than the method in 5.3.2 does, because the auditory signal and interfering sound are analysed more precisely with a narrower frequency bandwidth.

5.3.1 Method using A-weighted sound pressure level measurement

The range of the sound pressure level of the auditory signal determined using A-weighted sound pressure level measurement shall be as described below.

a) Lower end of $L_{S,A}$

The lower end of $L_{S,A}$ shall be determined as follows.

1) The relative sound pressure level of the auditory signal to interfering sound ($L_{S,A} - L_{N,A}$) shall be –5 dB.

NOTE Only the energy of the interfering sound within the frequency band (called critical band) around the signal frequency affects the audibility of the signal. Therefore, the sound pressure level of the auditory signal can be lower than that of the interfering sound.

2) The lower end shall be made higher than the value specified in 1) by 5 dB, to ensure signal perception in the case of reception and start signals, starting position signals, end signals (case of hearing at a position distant from the product), and strong caution signals with repeat counts of fewer than five times in accordance with the classification of auditory signals specified in Clause 5 of ISO 24500:2010.

b) Upper end of $L_{S,A}$

The upper end of $L_{S,A}$ shall be determined as follows.

i) The relative sound pressure level of the auditory signal to interfering sound ($L_{S,A} - L_{N,A}$) shall be 15 dB.

ii) The maximum upper end shall be 75 dB when the upper end exceeds 75 dB as a result of the setting in i).

iii) Make the upper-end level higher than the values specified in i) and ii) by 5 dB, to ensure signal perception in the case of end signals (case of hearing at a position distant from the product) and strong caution signals in accordance with the classification of auditory signals specified in Clause 5 of ISO 24500:2010.

5.3.2 Method using octave-band analysis

The range of the sound pressure level of the auditory signal determined using octave-band analysis shall be as described below.

a) Lower end of $L_{S,oct}$

The lower end of $L_{S,oct}$ shall be determined as follows.

1) The relative sound pressure level of the auditory signal to interfering sound ($L_{S,oct} - L_{N,oct}$) shall be the value given in Table 3.

Table 3 — Lower end of relative sound pressure level ($L_{S,oct} - L_{N,oct}$) of auditory signal to interfering sound

Centre frequency Hz	250 to 1 000	2 000	4 000 [a]
Relative sound pressure level of auditory signal to interfering sound dB	5	0	5

[a] The fundamental frequency of the auditory signal should not be higher than 2 500 Hz (see ISO 24500). The value of this frequency band is for auditory signals of specific products only (e.g. very small products in which only a tiny, high-frequency sound device can be implemented).

2) As a result of the setting in 1), the lower end can be lower than the value given in Table 1. In that case, the value given in Table 1 shall be taken as the lower end.

3) Make the lower-end level higher than the value specified in 1) and 2) by 5 dB, to ensure signal perception in the case of reception and start signals, starting position signals, end signals (case of hearing at a position distant from the product) and strong caution signals with repeat counts of fewer than five times in accordance with the classification of auditory signals specified in Clause 5 of ISO 24500:2010.

b) Upper end of $L_{S,oct}$

The upper end of $L_{S,oct}$ shall be determined as follows.

i) The relative sound pressure level of the auditory signal to interfering sound ($L_{S,oct} - L_{N,oct}$) shall be 25 dB.

ii) The maximum upper end shall be 75 dB when the upper end exceeds 75 dB as a result of the setting in i).

iii) Make the upper-end level higher than the value specified in i) and ii) by 5 dB, to ensure signal perception in the case of end signals (case of hearing at a position distant from the product) and strong caution signals in accordance with the classification of auditory signals specified in Clause 5 of ISO 24500:2010.

5.3.3 Method using one-third-octave-band analysis

The range of the sound pressure level determined using one-third-octave-band analysis shall be as described below.

a) Lower end of $L_{S,1/3oct}$

The lower end of $L_{S,1/3oct}$ shall be determined as follows.

1) The relative sound pressure level of the auditory signal to interfering sound ($L_{S,1/3oct} - L_{N,1/3oct}$) shall be the value given in Table 4.

