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Ergonomics — Danger signals for public and work areas — Auditory danger signals

Ergonomie — Signaux de danger pour lieux publics et lieux de travail — Signaux de danger auditifs

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Foreword

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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 7731 was prepared by Technical Committee ISO/TC 159, *Ergonomics*, Subcommittee SC 5, *Ergonomics of the physical environment*.

This second edition cancels and replaces the first edition (ISO 7731:1986), which has been technically revised.

Introduction

This International Standard specifies criteria applicable to the recognition of auditory danger signals, especially in cases where there is a high level of ambient noise. It covers auditory danger signals, desigated in the text of this standard by the use of the phrase “danger signals”, which apply to emergency signals and warning signals (see Table 1).

Auditory danger signals can also be found in the following International Standards:

— ISO 8201 dealing with emergency evacuation signals;

— ISO 11429 dealing with auditory and visual danger signals.

Various types of danger signals and their responses are described in Table 1.

It should be noted that ISO 11429 covers this subject in greater detail.

Table 1 — Various types of danger signals

Type of danger signal	Response
Auditory emergency evacuation signal	Leave the danger zone immediately
Auditory emergency signal	Take urgent action for rescue or protection
Auditory warning signal	Take preventative or preparatory action

Correctly designed signals can reliably call attention to a hazard or a dangerous situation, even when hearing protection is worn, without causing fright.

Ergonomics — Danger signals for public and work areas — Auditory danger signals

1 Scope

This International Standard specifies the physical principles of design, ergonomic requirements and the corresponding test methods for danger signals for public and work areas in the signal reception area and gives guidelines for the design of the signals. It may also be applied to other appropriate situations.

The relevance given in the definitions as to the difference between an auditory emergency signal, auditory emergency evacuation signal and an auditory warning signal should be noted. The emergency evacuation signal is covered in ISO 8201.

This International Standard does not apply to verbal danger warnings (e.g. shouts, loudspeaker announcements). ISO 9921 covers verbal danger signals.

Special regulations such as those for a public disaster and public transport are not affected by this International Standard.

2 Normative references

The following referenced documents are indispensable for the application 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.

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

3 Terms, definitions and symbols

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

NOTE Definitions of symbols referred to in this International Standard are given in Annex A.

3.1
ambient noise
all sounds in the signal reception area not produced by the danger-signal transmitter

3.2
danger signals
depending on the degree of urgency and the possible effect of the danger on people, a distinction is made between three types of auditory danger signals: an auditory emergency signal, an auditory emergency evacuation signal and an auditory warning signal

3.2.1
auditory emergency signal
signal marking the onset and, if necessary, the duration and the end of a dangerous situation

3.2.2
auditory emergency evacuation signal
signal indicating the beginning or the actual occurrence of an emergency involving the possibility of injury and instructing the person(s) to immediately leave the danger zone in the recognized manner

NOTE The auditory emergency evacuation signal is the subject of ISO 8201.

3.2.3
auditory warning signal
signal indicating the possibility or actual occurrence of a dangerous situation requiring appropriate measures for the elimination or control of the danger

NOTE The auditory warning signal may also provide information concerning the conduct and courses of action to be taken.

3.3
effective masked threshold
level of auditory danger signal just audible over the ambient noise, taking account of the acoustic parameters of both the ambient noise in the signal reception area and the listening deficiencies (hearing protection, hearing loss and other masking effects)

3.4
octave
bandwidth of a filter which comprises a frequency range of a factor of two

NOTE That is to say, the cut-off frequency f_2 is twice the lower f_1 as specified in IEC 61260; e.g. for an octave-band centred on 500 Hz, the lower frequency is 353 Hz ($500/\sqrt{2}$), the upper frequency is 707 Hz ($500\sqrt{2}$).

3.5
1/3 octave
fractional-octave-band filter

bandwidth of a filter which comprises a frequency range of a factor of $\sqrt[3]{2}$

NOTE 1 That is to say, the cut-off frequency f_2 is $\sqrt[3]{2}$ times the lower f_1 (i.e. $f_2 = \sqrt[3]{2}\ f_1$ as specified in IEC 61260).

NOTE 2 A bandpass filter has a narrower frequency range than an octave filter. The octave filter can be subdivided into three 1/3 octave-bands.

3.6
reverberation time
time interval required for the sound-pressure level to decrease by 60 dB, after the emission by the source is stopped

3.7
signal reception area
area in which persons are intended to recognize and react to a signal

NOTE This International Standard does not deal with problems that might occur if the danger signals are heard from outside the signal reception area.

3.8
spectral content
overall frequency content of a signal, or of the ambient noise

4 Safety requirements

4.1 General

The nature of the danger signal shall be such that people in the reception area can hear and react to the signal as intended. If persons with hearing impairment (deafness) or hearing protection (helmets, ear plugs, etc.) are likely to be present, special care should be taken. The characteristics of the audible signal shall be adapted to take account of the characteristics relevant to the situation.

4.2 Recognition

4.2.1 Introduction

The reliable recognition of a danger signal requires that the signal be clearly audible, be sufficiently different from other sounds in the environment and have an unambiguous meaning.

In order of priority, any emergency evacuation signal shall take precedence over all other danger signals and danger signals shall take precedence over all other auditory signals.

4.2.2 Audibility

4.2.2.1 The danger signal shall be clearly audible. The effective masked threshold shall be distinctly exceeded. If relevant, the probability of hearing loss in the recipient population may be assessed and taken into account. If hearing protectors are worn, their levels of attenuation shall be known and introduced into the assessment.

To ensure its audibility, the A-weighted sound-pressure level of the danger signal shall not be lower than 65 dB at any position in the signal reception area.

In addition, at least one of the criteria in 4.2.2.2 to 4.2.2.4 shall be met.

4.2.2.2 For measurements of the A-weighted sound-pressure level [method a) in 5.2.2.1], the difference between the two A-weighted sound-pressure levels of the signal and the ambient noise shall be greater than 15 dB ($L_{S,\,A} - L_{N,\,A} > 15$ dB).

4.2.2.3 For measurements of the octave-band sound-pressure level [method b) in 5.2.3.1], the sound-pressure level of the signal in one or more octave-bands shall exceed the effective masked threshold by at least 10 dB in the octave-band under consideration ($L_{Si,\,oct} - L_{Ti,\,oct} > 10$ dB).

4.2.2.4 For measurements of the 1/3 octave-band sound-pressure level [method c) in 5.2.3.2], the sound-pressure level of the signal in one or more 1/3 octave-bands shall exceed the effective masked threshold by 13 dB in the 1/3 octave-band under consideration ($L_{Si,\,1/3\,oct} - L_{Ti,\,1/3\,oct} > 13$ dB).

4.2.3 Distinctiveness

Parameters of the danger signal (signal level, frequency spectrum, temporal pattern, etc.) shall be designed to stand out from all other sounds in the reception area and shall be distinctly different from any other signals. (See Clause 6.)

4.2.4 Unambiguity

The meaning of the danger signal shall be unambiguous.

4.2.5 Moving sources

The characteristics of a danger signal from a moving signal source shall be recognizable, regardless of the speed or movement direction of the source.

4.3 Review of the signal

The effectiveness of the danger signal shall be reviewed at both regular intervals and whenever a new signal (whether a danger signal or not) or a change in the ambient noise occurs, or any other relevant changes are made.

4.4 Recommended maximum level of the danger signal

If the A-weighted sound-pressure level of the ambient noise in the signal reception area exceeds 100 dB, the use of additional visual, rather than solely auditory, danger signals is recommended (e.g. visual danger signals according to ISO 11428 and ISO 11429). In any case, the maximum signal level should not exceed 118 dB(A) in the signal reception area.

5 Test methods

5.1 Measurement equipment

Measurements should be made with equipment conforming to IEC 61672 and IEC 61260.

For measuring the ambient noise and the signal, the maximum reading with time weighting “Slow” shall be used. Calculations shall be based on the samples taken from a representative number of measurements.

5.2 Objective acoustic measurements

5.2.1 General

Compliance with the following requirements shall be adequate for the auditory danger signal. (See 4.2.2.)

5.2.2 Weighted measurements

5.2.2.1 A-weighted measurements [method a)]

Measure the A-weighted sound-pressure level of the ambient noise ($L_{N,\,A}$).

Measure the A-weighted sound-pressure level of the danger signal ($L_{S,\,A}$).

Calculate $L_{S,\,A} - L_{N,\,A}$ and check compliance with the requirements given in 4.2.2.2.

5.2.3 Measurements made in the frequency domain

5.2.3.1 Octave-band measurements [method b)]

Measure the octave-band sound-pressure levels of the ambient noise ($L_{Ni,\,oct}$).

Determine the effective masked threshold ($L_{Ti,\,oct}$), according to Annex B.

Measure the octave-band sound-pressure levels of the danger signal ($L_{Si,\,oct}$).

Calculate ($L_{Si,\,oct} - L_{Ti,\,oct}$) and check compliance with the requirements given in 4.2.2.3.

5.2.3.2 Third octave-band measurements [method c)]

Measure the 1/3 octave-band sound-pressure levels of the ambient noise ($L_{Ni,\,1/3\,oct}$).

Calculate the effective masked threshold ($L_{Ti,\,1/3\,oct}$), according to Annex B.

Measure the 1/3 octave-band sound-pressure levels of the danger signal ($L_{Si,\ 1/3\,oct}$).

Calculate ($L_{Si,\ 1/3\,oct} - L_{Ti,\ 1/3\,oct}$) and check compliance with the requirements given in 4.2.2.4.

NOTE 1 By using methods b) or c), the difference between the signal-to-noise ratios can be smaller than in 5.2.2.1, method a).

NOTE 2 Methods b) and c) require more sophisticated measurement efforts.

NOTE 3 All other criteria according to Clause 6 also apply to the methods of measurement.

5.2.4 Measurement of the auditory signal with ambient noise present

Generally, the auditory signal is measured with the ambient noise absent, i.e. the source of ambient noise (e.g. machinery) shall be switched off during the measurement. If this is not possible (permanent ambient noise which would be measured along with the auditory signal), alternative methods of measurement should be employed, taking into account reduced accuracy.

5.3 Subjective test method

It is preferable to carry out objective acoustic measurements. In their absence, a subjective listening test may be used.

Details of the method for a listening test shall comply with Annex C.

6 Design criteria for auditory danger signals

6.1 General

When designing auditory danger signals the following are relevant:

— the sound-pressure level;

— spectral characteristics;

— temporal characteristics.

6.2 Sound-pressure level

Danger signals are deemed to be clearly audible in the signal reception area if their A-weighted sound-pressure levels exceed the sound-pressure level of ambient noise by 15 dB or more (4.2.2.2) and if the A-weighted sound-pressure level of the signal is not lower than 65 dB (4.2.2.1). Together, these two requirements are sufficient but not always necessary for unfailing recognition. If the frequency and/or the temporal distribution of the danger signal clearly differ from the corresponding characteristics of the ambient noise, a lower sound-pressure level of the signal may be sufficient. This level, however, shall comply with that specified in 4.2.2.

The maximum sound-pressure level of the danger signal should be designed so that the signal is clearly audible. Reactions due to fright (e.g. more than 30 dB in 0,5 s) may be caused by using too high a sound-pressure level. Fright may also be expected whenever there is an unexpected steep increase in the sound-pressure level.