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Road vehicles — Ergonomic aspects of transport information and control systems — Specifications for in-vehicle auditory presentation

Véhicules routiers — Aspects ergonomiques des systèmes de commande et d'information du transport — Spécifications concernant la présentation des informations auditives à bord du véhicule

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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

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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 15006 was prepared by Technical Committee ISO/TC 22, *Road vehicles*, Subcommittee SC 13, *Ergonomics applicable to road vehicles*.

This second edition cancels and replaces the first edition (ISO 15006:2004), which has been technically revised.

Introduction

The driver and the vehicle are an integrated system that includes the environment, the primary vehicle controls, the instrumentation, and the transport information and control systems (TICS). The driving task, and human capabilities and limitations, are other primary factors. TICS are intended to support the driver's primary task, and therefore it is expected that the overall workload of the driver will not be negatively influenced, while performance and comfort should be increased.

The multitude of information to be displayed to the driver through TICS may create the need to minimize visual load and make more and better use of the auditory channel. This International Standard provides ergonomic specifications for the design and installation of auditory displays presenting speech and tonal information while driving. The aim of these specifications is to help designers to provide auditory signals which meet usability, comfort and safety criteria.

Road vehicles — Ergonomic aspects of transport information and control systems — Specifications for in-vehicle auditory presentation

1 Scope

This International Standard establishes ergonomic specifications for the presentation of auditory information related to transport information and control systems (TICS) through speech or sounds. It applies primarily to the use of auditory displays to the driver when the vehicle is in motion, but it may also be applied when the vehicle is stationary. It presents a set of requirements and recommendations for in-vehicle auditory signals from TICS, and provides characteristics and functional factors for maximizing auditory signal intelligibility and utility while helping prevent auditory or mental overload.

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.

ISO 532, *Acoustics — Method for calculating loudness level* [1]

ISO 5128:1980, *Acoustics — Measurement of noise inside motor vehicles*

ISO/TS 16951, *Road vehicles — Ergonomic aspects of transport information and control systems (TICS) — Procedures for determining priority of on-board messages presented to drivers*

3 Terms and definitions

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

3.1
ambient auditory noise
auditory sensory stimulus bearing no informational relationship to the presence or completion on the immediate task that surrounds the driver in the vehicle's environment, including sound emanating from inside and outside the vehicle

3.2
audibility
degree to which an auditory signal can be heard by a person with normal hearing

3.3
auditory icon
auditory signal that represents an event or action

NOTE This auditory signal can be a synthesized sound that gives the impression of specific event or a recorded sound from everyday life.

3.4
auditory signal
tone or verbal cues emitted by an in-vehicle device, which provide information to the driver or passengers

1) The German standard DIN 45631 is largely identical to ISO 532. In practice, references for calculating loudness according to ISO 532 usually implement the code given in DIN 45631 [8].

3.5
broadband signal
complex sound whose acoustical energy is distributed over a wide range of frequencies

3.6
comprehensibility
characteristic of an auditory signal that enables the driver to understand its meaning in the context in which it is provided

3.7
diffuse field
sound field in which the sound pressure level is the same everywhere and the flow of energy is equally probable in all directions

3.8
distinguishability
characteristic of an auditory signal enabling the driver to perceive the differences between it and other audible signals within the driving environment

NOTE Other audible signals include warning signals and signal noise, but exclude ambient noise.

3.9
free field
sound field with no reflective surfaces over the frequency range of interest

3.10
loudness
sensation (perception) that is most closely related to the sound amplitude of an acoustical stimulus

NOTE In this International Standard, loudness is expressed in units of sones.

3.11
main audible component
tonal component with the most energy in the auditory signal

3.12
narrowband signal
sound whose acoustical energy is distributed over a narrow range of frequencies

3.13
narrowband spectrum
spectrum with a frequency resolution of 10 Hz or less

3.14
safety criticality
severity of the likely event that can occur if the driver is unable to avoid a specific hazard

NOTE Four levels of criticality, based on occupant (or other road user) injury and vehicle damage, are defined by ISO/TS 16951.

3.15
safety warning
auditory signal that is intended to prevent or mitigate injuries or vehicle damage

NOTE Navigation and route guidance instructions are not safety warnings even though they might also require the driver to take an action within a short time period.

3.16
signal-to-noise ratio
SNR
ratio of signal specific loudness spectrum to noise specific loudness spectrum

3.17
sone
subjective unit of loudness, as perceived by a person with normal hearing, equal to the loudness of a 1 000 Hz pure tone presented frontally with a sound pressure level of 40 dB, re 20 µPa.

NOTE 1 When measured in a free field, this definition for sone is sometimes designated as sone GF. For a diffuse (rather than free) field, the designation is sone GD. A vehicle interior may be characterized as free field or diffuse field depending on the location (e.g. instrument cluster, audio system speakers, turbulent noise on the windshield) and type of sound (e.g. chime, road noise, and wind noise).

NOTE 2 The loudness of a sound that is judged by a listener to be *n* times that of a 1-sone tone is *n* sones.

3.18
sound pressure level
SPL
local pressure deviation from the ambient pressure caused by a sound

3.19
specific loudness spectrum
distribution of loudness over the frequency axis

3.20
time-critical signal
auditory signal that requires a driver response to an imminent event measurable within a limited number of seconds

NOTE The signal may or may not pertain to a warning event.

3.21
tonal signal
simple sound or mixture of simple sounds with fixed frequency content

NOTE 1 A simple sound is a sinusoidal signal with fixed or single frequency content.

NOTE 2 A tonal signal can be a continuous sound or intermittent sound.

3.22
unit of information
individual or group of auditory signals regarded as a structural or functional constituent of a message

4 Signal specifications

4.1 Spectrum

4.1.1 General

The recommended frequency range for in-vehicle auditory signals is 200 Hz to 8 000 Hz.

4.1.2 Tonal signals

For tonal signals, the main audible component should lie between 400 Hz and 2 000 Hz to protect against decreased audibility due to age-related hearing loss [22].

A broadband signal or a mix of narrowband signals with distinctly separated centre frequencies should be used to improve the signal location detection and driver attention direction.

EXAMPLE A mix of two narrowband signals, with the main audible component centred around 800 Hz, and the other component centred around 3 000 Hz.

The urgency of a situation should be reflected by the character of the signal.

4.2 Signal levels

4.2.1 General

The selection of optimal sound amplitude is a matter of balancing listener comfort against signal audibility. The latter is primarily a function of the signal-to-noise ratio (SNR) between the auditory signal and the ambient auditory noise. It should be kept in mind that loudness depends on the level of the ambient auditory noise and on the level of the auditory signal within a given frequency band. Therefore, loudness at a given SNR increases with rising ambient auditory noise.

4.2.2 Measuring sound loudness

The method for measuring and evaluating the loudness of auditory signals shall be as described in Annex A. Specific details of the method are given in DIN 45631 [7].

This International Standard deals only with the loudness of stationary auditory signals, not transient (time-varying) signals. Nearly all auditory signals of interest in vehicles have on-times long enough for the signals to be characterized as stationary auditory signals.

NOTE Sounds are generally classified as stationary for loudness calculations if their duration is longer than 0,2 s. The on-time of most signals addressed by this International Standard is longer than 0,2 s, justifying the use of DIN 45631.

4.2.3 Audibility

4.2.3.1 General

The main criterion for selecting a sound level is obtaining maximum audibility, measured against the specific ambient auditory noise within a driving vehicle. For in-vehicle auditory signals, audibility should be as high as suitable. Sound levels that are too high could lead to defensive reactions or startle reflexes inappropriate for safe driving.

4.2.3.2 Range considerations

The auditory signal should be perceivable in all ambient noise conditions for which the signal is designed (see Annex A). The upper limit should be chosen to prevent startling of the driver and hearing damage.

4.2.3.3 Minimum masked specific loudness

The auditory signal should also contain sufficient spectral content above the ambient noise in order to be audible.

For minimum audibility in a noisy environment, the signal-to-ambient ratio of specific loudness spectra at the main component of a tonal signal shall be greater than 1,3 (see A.4).

NOTE 1 The masked specific loudness spectrum includes upward spread of masking effects, where low-frequency sounds can mask the audibility of high-frequency sounds.

NOTE 2 The masked specific loudness signal-to-noise ratio (SNR) can be calculated for most tonal sounds.

4.2.4 Appropriateness

Care should be taken to avoid defensive reactions or startle reflexes caused by one or more of the following sound level characteristics: sound levels that are too high, unexpected, unknown, or are ramped to full-scale loudness too quickly.

4.2.5 Time from onset to full loudness

For critical/warning sounds, the time from onset to full loudness should be less than approximately 30 ms, so long as 4.2.4 is satisfied.

5 Coding of information

5.1 General

Information may be delivered using speech or non-speech coding, or by a combination of both according to the temporal characteristics of the auditory signal.

5.2 Temporal classification of auditory signals

5.2.1 General

The following three time categories are based on the expected time for the driver to respond to an auditory signal:

a) short-term response: 0 s – 3 s;

b) medium-term response: 3 s – 10 s;

c) longer-term response: > 10 s.

To differentiate between the time categories, different patterns of acoustical parameters (e.g. sound level, frequency) can be chosen (see 5.3).

5.2.2 Time-critical safety warnings

Time-critical auditory safety warnings always have temporal priority over non-safety-critical auditory signals, even if the non-safety signals are otherwise time-critical.

NOTE Not all auditory signals that are time-critical are also safety-critical.

5.2.3 Timing for short-term response

The auditory signal should be sent to the driver immediately after a critical event is detected by the TICS.

EXAMPLE 1 An obstacle on the vehicle pathway is detected. The driver is warned to take evasive action immediately. This is a safety warning.

EXAMPLE 2 A navigation system is providing turn-by-turn instructions, and indicates that a routed turn is imminent. This is a time-critical message, but is not a safety warning.

5.2.4 Timing for medium-term response

Auditory signals in this category may be sent immediately, if there are no other competing signals, or with a time delay of up to 10 s.

EXAMPLE Route-guidance information, e.g. “300 m ahead, left turn”.

5.2.5 Timing for longer-term response

Auditory signals in this category may be sent immediately, if there are no other competing signals of higher priority or urgency, and may be delayed so long as the driver still has sufficient time to plan and execute an appropriate response to the auditory signal.

EXAMPLE Congestion 10 km ahead.