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

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

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Contents

Page

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.

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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.

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

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 in her/his 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 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 messages which meet usability, comfort and safety criteria.

Road vehicles — Ergonomic aspects of transport information and control systems — Specifications and compliance procedures 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 only to the use of auditory displays when the vehicle is in motion. It presents a set of requirements and recommendations for in-vehicle auditory messages from TICS, and provides message characteristics and functional factors for maximizing message 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 5128, *Acoustics — Measurement of noise inside motor vehicles*

ISO 11429, *Ergonomics — System of auditory and visual danger and information signals*

ISO/TS 16951[1)], *Road vehicles — Criteria for determining priority of TICS and other messages presented to drivers*

3 Terms and definitions

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

3.1
audibility
percentage of persons who are able to detect an auditory signal within a defined acoustical environment

3.2
comprehensibility
degree to which information conveyed to the driver is understood

3.3
loudness
sensation (perception) that is most closely related to the sound amplitude of an acoustical stimulus

3.4
orienting reaction
human behaviour in response to the novelty of a stimulus

NOTE If, in a given situation, factual and expected stimuli do not match, an orienting behaviour is released which in its amplitude is proportional to the degree of the stimulus' novelty. With increasing stimulus intensity, this behaviour changes to defensive reactions. In the case of very high and sharp stimuli, a startle reflex is released.

1) To be published.

3.5
perceptual discriminability
signal properties of a tonal signal which allow reliable classification of each signal in a given set of signals

3.6
safety critical message
message requiring immediate action by the driver in order to avoid imminent danger to persons or very serious damage to equipment

3.7
signal-to-noise ratio
SNR
ratio of signal intensity to noise intensity in octave (or one-third octave) bands

3.8
tonal signal
auditory signal with no identifiable spoken item

3.9
simple vocabulary
words commonly used and easily understood

4 Signal specifications

4.1 Signal spectrum — Recommendation

The recommended frequency range for in-vehicle auditory speech signals is 200 Hz to 8 000 Hz. For tonal signals, the recommended range lies between 400 Hz and 4 000 Hz. Pure tones should be avoided because standing wave patterns cause resonance and anti-resonance areas so that the audibility of a signal at the driver's head cannot be guaranteed. A broad band sound or a mix of narrow band sounds, with distinctly separated centre frequencies, should be used.

EXAMPLE A mix of two bands of frequency, one centred around 800 Hz, and the other centred around 3 000 Hz.

Good practice in measuring and evaluating the signal is provided in Annex A.

4.2 Signal levels

4.2.1 General

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

NOTE Methods for measuring loudness are given in ISO 532.

4.2.2 Audibility — Recommendation

The main criterion for selecting a signal level is obtaining maximum audibility, measured against the specific background noise within a driving vehicle. For in-vehicle signals, audibility should be as high as possible (usually 95 %). To reach this criterion, a loudness range between 50 dB(A-weighted) and 90 dB(A-weighted) should be used. Signal levels higher than 90 dB(A-weighted) should be avoided (see ISO 5128). In the normal case, an SNR of about 5 dB(A-weighted) ought to be sufficient to guarantee audibility. SNR values of 15 dB(A-weighted) and more should be avoided.

NOTE The expression “dB(A)” is used in industry but its use is not recommended. IEC 61672-1 gives details of A-weighting.

4.2.3 Appropriateness — Recommendation

Signal levels which are too high, unexpected signals or unknown signals, could lead to defensive reactions or startle reflexes inappropriate for safe driving. A gradual onset not higher than 1 dB/ms is recommended.

— 1 dB/ms is appropriate for messages requiring immediate driver attention, because a warning has to be issued and an immediate reaction is necessary [the relevant rise time is only 50 ms for the maximum SNR of 50 dB(A-weighted)].

— For less urgent messages, the rate of rise can be reduced to 0,75 dB/ms or 0,5 dB/ms, as only audibility and distinctness of the signal have to be guaranteed. If the presentation of the message has to be delayed and reaction to it is therefore urgent, the rate of rise for short-term messages should be applied.

— The rate of rise has no psychological relevance for messages where there is no urgency and the slope could be reduced by up to 0,33 dB/ms without creating problems (maximum relevant rise time: 150 ms). This would result in a pleasant onset of the signal and the perceived sound quality would mainly depend on other characteristics of the sound.

4.2.4 Flexibility of the signal level — Recommendation

Because of the large variation in background noise and large individual differences in the hearing capabilities of the drivers, there is a need for flexibility of the signal level. Therefore:

— the signal level should be adjustable within a range of ± 10 dB(A-weighted) about a nominally audible level;

— apart from safety critical messages, it should be possible to switch auditory displays on or off;

— the level should be automatically adjustable to the frequency spectrum of the background noise;

— a frequency-specific amplification should be provided which allows the driver to adapt the signal to her/his hearing capabilities, especially for speech signals.

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 message.

5.2 Temporal classification of signals — Recommendation

Signals should be classified according to the urgency (see ISO/TS 16951) of the intended driver's action. To differentiate between the time categories, different patterns of acoustical parameters can be chosen (e.g. sound level, frequency, see 5.3). Three time categories seem to be justified.

a) **"Short-term" category**: immediate action required. The message should be sent to the driver immediately after the critical event is detected by the TICS.

EXAMPLE An obstacle on the road is detected. The driver is warned to take evasive action immediately.

b) **"Medium-term" category**: the action should take place within a short time (10 s to 20 s). Messages in this category may be sent with a time delay.

EXAMPLE Route-guidance information.

c) **"Long-term" category**: a future behaviour is expected. Messages in this category may be sent with a time delay. The time within which the driver reacts to the message may be chosen within broader limits.

EXAMPLE Congestion 10 km ahead.

The choice between non-verbal and verbal signals should be made according to Table 1.

Table 1 — Non-verbal and verbal signals

Category	Tonal signal	Speech
Short-term	Suitable	Not recommended
Medium-term	Suitable	Suitable
Long-term	Suitable as announcement of a visual display or verbal message	Recommended (verbal message)

5.3 Non-speech coding — Tonal signals

5.3.1 General

A tonal signal has two functions: attracting attention and providing information. This information is usually very specific, such as “brake immediately”. However, tonal signals may also be selected to provide information of a general nature, such as "watch out" or "danger".

EXAMPLE 1 Announcement of a new message on a visual display. (Specific)

EXAMPLE 2 The driving situation has become dangerous. Be cautious. (General)

In addition, the number of tonal signals used in a vehicle should be limited to promote comprehensibility (see 5.3.2) and perceptual discriminability (see 5.3.4).

If redundant visual information exists, both visual and tonal information should be displayed at the same time.

5.3.2 Comprehensibility

5.3.2.1 Requirement

Each signal is intended to release a driver's behaviour (perceptual, cognitive or motor behaviour). This intended behaviour should be explicitly formulated by the designer of the signal.

Some auditory signals that reproduce a real sound that is meaningful for all drivers do not require learning by the driver and can be recommended. For other signals, it is necessary for drivers to learn the association between tonal signal and message. Especially in the case of rarely displayed tonal signals and system-initiated messages, regular exposure may be necessary to clarify and reinforce their meaning.

Comprehensibility shall be measured to ensure that the intended behaviour is achieved and does not cause any inappropriate reactions.

EXAMPLE 1 After a special sound, the driver recognizes that new information is available on the visual display.

EXAMPLE 2 After a special sound, the driver recognizes that evasive action needs to be taken immediately.

5.3.2.2 Compliance procedure

5.3.2.2.1 Test subjects

IMPORTANT — Any persons directly involved in designing, testing, manufacturing or selling TICS shall *not* be included in the test driver sample.

The driver sample shall include at least 10 persons, in a large range of ages including at least two persons over 50. If the TICS is dedicated to a specific kind of users (professional users, special needs users), the driver sample shall be selected from these target users.

5.3.2.2.2 Test objective

To provide a general presentation of the TICS functionality and test objective to each driver.

EXAMPLE Instruction for the test participants: “You are asked to give your opinion regarding a new system which helps you to keep a safe trajectory. You will have to answer three questions.”

5.3.2.2.3 Test conditions

Each auditory message shall be presented individually in the same context as in the driving situation, as follows.

a) If the message is intended to be displayed within a dialogue step or in response to a voluntary action of drivers, the test presentation shall be: description of action or simulation of the situation to the drivers, then delivery of auditory message.

b) If the auditory message is intended to be displayed at the same time as another perceptual presentation (pictograms, written message…), the test presentation shall be: simultaneous presentation of auditory and other perceptual message.

c) If the auditory message is intended to be delivered under the control of the system, the test presentation shall be delivery of auditory message with *no* complementary explanation.

Tests may be conducted in real or simulated traffic if the driving situation is relevant to the message.

5.3.2.2.4 Questionnaire

After the message presentation, each subject shall answer the following questions:

a) What does this mean to you?

b) What would you do about this?

c) When would you do this?

5.3.2.2.5 Data analysis

To be compliant with the requirement of comprehensibility, no responses shall be observed that increase the risk above the baseline in which no message is presented.

5.3.3 Acoustic coding of tonal signals

Some recommendations of ISO 11429 are relevant for various in-vehicle information signals. The following signal characteristics should be regarded as examples:

— short-term message: sweeping sounds, burst of sounds, alternating tone pitch, fast rhythm or dissonance;

— medium-term message: patterns of segments with constant pitch, the shortest at least 0,3 s;

— long-term message: two-times chimes, high-low non recurrent, followed by a verbal message or a visual display (seeTable 1).

5.3.4 Perceptual discriminability of tonal signals — Recommendation

It is important to make sure that there is no confusion among the various signals in the vehicle's tonal repertoire. When a new auditory signal is proposed or introduced in a vehicle, it should be verified that it will not be confused with existing signals, particularly if this signal is a safety critical message.

A possible procedure is provided in Annex B.

5.4 Speech coding

5.4.1 General

Speech coding should be used if the driver has sufficient time to listen to the full message before it is necessary to choose a course of action.

5.4.2 Vocabulary — Recommendation

The messages should have a consistent and simple vocabulary. Within each TICS application, the speech vocabulary should be consistent with the written vocabulary.

EXAMPLE 1 The same words are used for written and spoken messages.

EXAMPLE 2 Small differences exist when the written vocabulary includes non pronounceable abbreviations or symbols.

EXAMPLE 3 Risk of auditory confusion suggests use of other words for verbal message.

EXAMPLE 4 Language-specific differences between written and spoken messages.

5.4.3 Composition of message

A long auditory message imposes demands on attentional resources and short-term memory. Because of these and other limitations associated with human information processing capacity, the number of information units which compose a message should be limited.

NOTE The number of information units is not necessarily the same as the number of words, for example, [close to cityname] = three words, one significant unit of information.

Moreover, it takes a finite time to deliver a complete message and the message may not be understood until delivery is complete. Verbal messages should consist of not more than five units of information. If longer messages have to be given, they should be separated into meaningful information units also consisting of not more than five units of information. The more urgent the required action is, the fewer words should be used.

In the case of complex auditory information, the driver may be helped in different ways:

— sequencing the units of information in order of potential relevance:

  1) to help the driver to quickly decide whether to “tune-in” or “tune-out”, depending on the message content, e.g. [on A 18] [close to cityname] [congestion] [for 10 km], and

  2) placing the action-related unit of information at the end, e.g. [on A 18] [close to cityname] [congestion] [for 10 km] [take exit 7];

— providing key words (e.g. “traffic message”), prosodic cues and highlighting;

— providing redundant visual displays, at least for the principal units of information, particularly for long-term messages;

— providing a means for the driver to request that the message be repeated.

6 Hierarchy of message presentation — Recommendation

The following recommendation applies to each individual TICS, and to any TICS that are integrated. It is highly desirable that TICS be integrated so that all auditory messages can be managed across all the TICS in a vehicle. However, this recommendation should not be interpreted as mandating TICS integration in a vehicle.

If situations arise in which multiple auditory messages have to be presented simultaneously, these messages should not be presented concurrently, but should take account of the priority of each message.

EXAMPLE 1

— The presentation is sequential regarding priority, or

— only higher priority message is presented, or

— ongoing lower priority message is stopped and delayed/deleted, or

— one message will be presented through the auditory mode and the other one through the visual mode.

Priorities between information categories and within a specific category shall be pre-defined, taking into account safety relevant criterion, for example, according to the procedure given in ISO/TS 16951. These priorities strongly depend on the particular TICS: the area of messages that could be competitive, which messages could be competitive, in which specific situations, etc. The time delay between message delivery and critical events shall be selected according to the urgency of the intended action.

EXAMPLE 2 The highest priority is accorded to messages which require immediate action. Within this category, a safety critical message has a higher level of priority than a route guidance message.

The recommendation is satisfied if evidence is available by the manufacturer that — for each individual TICS and for any integrated TICS — tonal and speech messages are ranked according to their priority, that the highest priority message is presented first, and that there is no risk of simultaneous delivery of auditory messages.

Assistance for ranking the messages according to priority is given in ISO/TS 16951.

7 Safety critical messages

7.1 Requirement

A message concerning the safety of the driver or other people, and requiring immediate action of the driver, shall not be presented exclusively by auditory means, but shall also be presented using another sensory channel. This requirement is necessary because, owing to hearing impairment or masking background noise, all drivers will not be able to perceive the auditory messages.

Guidance in the process of identifying of safety critical message is available in ISO/TS 16951.

7.2 Compliance procedure

The requirements are satisfied if every auditory safety critical message is also presented in another perceptual mode. Other modes for presenting the information may be visual, haptic and/or kinaesthetic.

Annex A
(informative)

Measurement conditions and equipment

A.1 Measured quantities

According to ISO 5128, all readings of the sound level meter are to be taken with the dynamic characteristic "fast", and the values to be measured at the microphone are the A-weighted sound pressure level expressed in decibel or LAeq energetic level expressed in decibels, A-weighted.

A.2 Measuring equipment

The sound level meter is of the precision class according to IEC 60651.

For the measurement of noise spectra, the filters meet the requirements of IEC 60225.

A.3 Installation

The acoustical measurements are conducted either in a laboratory environment (i.e. a quiet environment) or, preferably, with sound-generating devices installed in the vehicle in the real location.

The microphone(s) used for the sound measurement will be located close to the driver's ears. The requirements of ISO 5128 shall be followed regarding the outside acoustical environment (see Clauses 6 and 7).

Annex B
(informative)

Compliance procedure for perceptual discriminability

The following procedure is a possible method for testing compliance with the recommendation of 5.3.4.

a) Identify or record all tonal signals of a vehicle.

b) Adjust the signals for equal loudness (subjectively or by measuring sound amplitudes).

c) Select 10 participants with normal hearing abilities.

d) In a training session, present the tonal signals to the test participants and let them select a nominator for each tonal signal. Training should have 10 repetitions or reach an error-free test cycle.

e) In a test session, 90 % correct answers are required for each signal to pass the discriminability condition.

Bibliography

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

[2] ISO 2575, *Road vehicles — Symbols for controls, indicators and tell-tales*

[3] ISO 7731, *Ergonomics — Danger signals for public and work areas — Auditory danger signals*

[4] ISO 9186, *Graphical symbols — Test methods for judged comprehensibility and for comprehension*

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

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

[7] IEC 61672, *Electroacoustics — Sound level meters*

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

[9] G. VAUGHAN, A. MAY, *A Human factors investigation of an RDS-TMC System*. HARDIE report 23/96

[10] M. WILLIAMS, E. HOESKSTRA, P. GREEN, *Development and evaluation of a Vehicle Monitor Driver Interface*, UMTRI-93-22, September 1993

[11] M.-P. BRUYAS, *Reconnaissance et compréhension de pictogrammes et symboles routiers*, Université de Lyon, 1997

[12] B. HAGERMAN, Clinical measurement of speech reception threshold in noise, *Technical audiology* ISSN 0280-6819, Report TA N107 (1983) 13

[13] O. HELLER, H.P. KRÜGER, Recommendations for the proposal ISO/TC22/SC13. Auditory information presentation, Interdisziplinäres Zentrum für Verkehrswissenschaften an der Universität Würzburg, Psychologisches Institut, 03/96

[14] H. KISHI, S. SUGIURA, *Human factors consideration for voice route guidance*, FISITA n 930553

[15] G. PACHIAUDI, M. VERNET, A. FOTI, *Noise and speech interference in light automotive vehicle*, FISITA, Dearborne, U.S.A. 1988 n 885118

[16] R.D. PATTERSON, Auditory warning sounds in the work environment, *Phil. Trans. R*. Soc. Lond.B 328, 485-492 (1990)

[17] R.D. PATTERSON, *Guidelines for the design of auditory warning sounds*, Proc. I.O.A., Vol.11, Part 5, pp. 17-24, 1989

[18] H. STEENEKEN, *Subjective and objective intelligibility measures, Speech processing in adverse conditions*, Proceedings of ESCA-ETRW, Cannes, 10-13 November 1992

[19] Ergonomic criteria for in-car man machine interface, DRIVE/ STA MMI del. 2, part 2, June 1990. DRIVE1-V1037, CEC DG 13, European Commission Host Organisation, CORDIS, Customer Service B.P. 2373, L-10243 LUXEMBOURG

[20] K.C. PARSONS, Ergonomics of the physical environment, International ergonomic standards concerning speech communication, danger signals, lighting, vibration, and surface temperatures. *Applied ergonomics*, Vol. 26, N° 4 pp. 281-292, 1995

[21] T. ROSS, K. MIDTLAND, M. FUCHS, A. PAUZIE, A. ENGERT, B. DUNCAN, G. VAUGHAN, M. VERNET, H. PETERES, G. BURNETT, A. MAY, *HARDIE Design Guidelines Handbook, Human factors Guidelines for Information Presentation by ATT Systems*. HARDIE del.20; DRIVE II, CEC DG 13. European Commission Host Organisation, CORDIS, Customer Service B.P. 2373; L-10243 LUXEMBOURG; March, 1996, p. 320

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